February 27, 1985

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
THE CLEVELAND ELECTRIC	)	Docket Nos. 50-440 OL
ILLUMINATING CO. ET AL.	)	50-441 OL
	)	
(Perry Nuclear Power Plant,	)	
Units 1 and 2)	)	

OCRE RESPONSE TO APPLICANTS' MOTION FOR SUMMARY DISPOSITION OF ISSUE 16

I. INTRODUCTION

On February 5, 1985, Applicants moved for summary disposition in its favor on Issue #16, which states:

> Applicant has not demonstrated that it can reliably generate emergency on-site power by relying on four Transamerica Delaval diesel generators ["TDI DGs"], two for each of its Perry units.

The basis for this contention is the extensive adverse operating experience of TDI diesel engines in nuclear, stationary, and marine service and the poor or totally lacking TDI quality assurance program, as revealed by the findings of Staff and Applicants. See, e.g., Board Notifications BN-83-160, BN-83-160A, BN-84-018, BN-84-020, BN-84-021, BN-84-024, and BN-84-051. Virtually every major TDI engine component (crankshafts, pistons, cylinder heads, connecting rods, push rods, block, base, bearings, fuel lines, turbocharger, jacket water pump) has a history of failure.

Despite this adverse experience, Applicants have continually claimed that the TDI DGs are reliable and fit for nuclear service, and now seek to prevail on the issue, asserting that no issues of material fact exist for hearing. Intervenor Ohio Citizens for Responsible Energy ("OCRE") opposes Applicants' motion. The discussion below demonstrates that there are genuine issues of material fact to be heard and that the TDI DGs are still inherently unreliable, despite all the paperwork generated by Applicants and their consultants in a desperate attempt to prove otherwise. Applicants' motion must be denied.

II. STANDARDS FOR SUMMARY DISPOSITION

The burden of proof lies upon the movant for summary disposition, who must demonstrate that no genuine issues of material fact exist. In fact, the record and pleadings must be viewed in the light most favorable to the opponents of summary disposition. Public Service Co. of New Hampshire (Seabrook Station, Units 1 and 2), LBP-74-36, 7 AEC 877 (1974).

In an operating license proceeding, where significant health and safety or environmental issues are involved, a Licensing Board should grant a motion for summary disposition only if it is convinced that the public health and safety or the environment will be satisfactorily protected. Cincinnati Gas and Electric (Wm. H. Zimmer Nuclear Station), LBP-81-2, 13 NRC 36, 40-41 (1981).

It is improper to grant summary disposition of a safety issue before the issuance of the Staff's SER on that issue. Duke Power Co. (Wm. B. McGuire Nuclear Station, Units 1 and 2), LBP-77-20, 5 NRC 680 (1977).

Finally, 10 CFR 2.749(d) states that

> (t)he presiding officer shall render the decision sought if the filings in the proceeding, depositions, answers to interrogatories, and admissions on file, together with the statements of the parties and affidavits, if any, show that there is no genuine issue as to any material fact and that the moving party is entitled to a decision as a matter of law.

For the reasons stated below, Applicants' motion fails. They have not met their burden of demonstrating the absence of a genuine issue of material fact, and they have not demonstrated that the public health and safety will be satisfactorily protected.

III. DISCUSSION

A. Applicable Regulatory Standards

It is axiomatic that nuclear licensees meet all of the Commission's regulations. See, e.g., Maine Yankee Atomic Power Co. (Maine Yankee Atomic Power Station), ALAB-161, 6 AEC 1003 (1973), and Vermont Yankee Nuclear Power Corp. (Vermont Yankee Nuclear Power Station), ALAB-138, 6 AEC 520 (1973) (it cannot be argued that a facility not meeting the Commission's regulations is safe anyway, as such argument is an impermissible challenge to the regulations). It is thus appropriate to address the regulations applicable to this issue.

The applicable regulations, which Applicants have violated, are Appendix B to 10 CFR Part 50 and General Design Criteria 1 and 17, Appendix A to 10 CFR Part 50. GDC 17 requires the Perry facility to have an onsite electric power system [which the DGs are to supply] with the capacity to ensure that fuel design limits and reactor coolant pressure boundary design conditions are not exceeded and that the core is cooled and containment integrity and other vital functions are maintained in the event of an accident. Appendix B and GDC 1 require that the DGs be designed and manufactured to appropriate quality standards and in accordance with an appropriate quality assurance program.

Applicants' noncompliance with these regulations is detailed below.

1. GDC 17

The inherent unreliability of the TDI DGs is such that the Commission has determined that facilities using these DGs are not in compliance with GDC 17. Long Island Lighting Co. (Shoreham Nuclear Power Station), CLI-84-8, 19 NRC 1154 (1984) (GDC 17 must be complied with even for low-power operation, and Shoreham, using TDI DGs, did not comply). See also BN-84-024 (SECY-84-34), which states that "the operating history of TDI engines and the QA program of the manufacturer . . . [call] into question the reliability of all TDI diesels."

See also Exhibit 1, in which these principles are applied to the Grand Gulf facility. ("On the basis of the problems associated with TDI diesel engines . . . the onsite electrical supply systems at Grand Gulf do not meet GDC 17"). Grand Gulf utilizes TDI's DSRV-16 engines, one of which served as the prototype for the Perry DGs. It thus must be concluded that the Perry onsite electrical power system is likewise in noncompliance with GDC 17.

Of further relevance is the commitment Applicants have made with regard to their onsite power system and specifically the DGs. FSAR Section 8.3.1.1.3.2 states that the DGs have a continuous rating of 7000 kw, with a short time rating of 7700 kw. The procurement specification, SP-562-4549-00, supplies additional, more specific requirements. For example:

> the minimum continuous rating of the engine shall be 7000 kw net output; the engine with its generator and exciter shall be engineered and designed as a complete unit and shall be free of all deleterious critical speeds or torsional vibration for any operating speed within the range of 90% to 110% of rated speed at any load from 0 tp 100% of rated output; the engine shall be able to operate at 110% of its continuous rating (7700kw) for a period of 2 hours out of every 24 hours without affecting the normal life of the unit. SP-562, Section 2.06.1

> all equipment and services offered by [TDI] shall be of such quality as to make the equipment safe with high availability. To this end, all items offered, including all accessories, shall be of proven reliability. SP-562, Section 1.04.

> equipment supplied under this Specification shall be in accordance with applicable codes and standards. SP-562, Section 2.05. The codes and standards cited include NRC Regulatory Guides, ANSI standards, ASME code, and the standards of DEMA, IEEE, AWS, NFPA, and others.

It is thus clear that these commitments are the appropriate criteria by which to judge whether compliance with the regulations has been achieved, since they comprise Applicants' own standards for determining DG reliability.

2. GDC 1 and Appendix B

Applicants imposed quality assurance program requirements on TDI through attachment specification SP-706-4549-00, attached to SP-562-4549-00, the procurement specification for the DGs.

However, Applicants own documents, such as DARs, nonconformance reports, and surveillance reports demonstrate that this standard was never met.

Applicants admit that 28 DARs have been written to document significant deficiencies discovered with respect to the TDI DGs. Christiansen affidavit at 19. Many more nonconformance reports have been written to document conditions of noncompliance. OCRE has attached as Exhibit 2 a summary of some of the more significant nonconformance reports ("NRs") concerning the TDI DGs. Most of the deficiencies have involved poor welding practices, poor alignment of equipment, lack of documentation or identification, and damage in shipping and handling. Exhibit 3 is Applicants' list of NRs generated as a result of the engine inspection as part of the DR/QR effort.

Many of these latest findings are similar to the deficiencies discovered earlier. It also appears that some of them should have been discovered and corrected earlier. That these engines, which would have been used as is were it not for the DR/QR inspection, contained so many deficiencies at this late date is evidence of the ineffectiveness of TDI's and Applicants' QA programs. It must be noted that Applicants also failed to ensure that TDI imposed QA requirements on the manufacturer of exhaust silencers for the PNPP DGs, contrary to specification requirements. Applicants were not even aware of this until the Staff discovered it in its vendor inspections, reported in BN-

84-020.

See Applicants' response (March 8, 1984) to OCRE Interrogatory 11-2.

These breakdowns notwithstanding, Applicants claim that the large number of discovered deficiencies proves that their QA program is working. Applicants' motion at 14. However, there is a point beyond which this argument is invalid. Even if all deficiencies are corrected, there remains the question of whether there has been a pervasive QA failure of sufficient dimensions so as to raise legitimate doubt as to the overall integrity of the DGs. See Union Electric Co. (Callaway Plant), ALAB-740, slip op. at 2.

Applicants' own documents indicate they they themselves realized that that point was reached some time ago. (Their concern was unfortunately too late to do any good.) Exhibit 4 is DAR 139, which expresses some concern about having 10 DARs on TDI in the last 3 years. Exhibit 5 is an audit of TDI dated April 12, 1982, which outlines TDI's history of noncompliance and concludes:

> the audit team feels that the quality assurance program in effect at the time work was performed for CEI and the one presently in place at Delaval does not meet the requirements contained in SP-562 and SP-706. Even if the program described in the Q.A. Manual was effectively implemented it would not meet the requirements of SP-562. The attitide towards quality assurance is one of tolerance, not support. It is evident from review of the contract history presented above that this has been the case since the contract's inception.

This conclusion is remarkably similar to that of the NRC

Staff in its Inspection Report Nos. 99900334/83-02 and 83-03 (BN-84-021):

> It is apparent from the results of these and prior inspections that serious deficiencies have existed in the implementation of your committed quality assurance program for manufacture of emergency diesel generators. What concerns us greatly is that certain of these findings are of a nature which brings into question both the adequacy of existing manufacturing process controls and the level of complianceby manufacturing and quality control personnel. When reviewed in the context of the numerous deficiencies which have been identified to the NRC in 10 CFR Part 21 and 10 CFR Part 50.55(e) reports, we believe that significant concern is warranted with respect to [TDI DG reliability].

It is thus clear that both Applicants and the NRC Staff consider TDI to be in noncompliance with GDC 1 and Appendix B. This situation has significance beyond that of regulatory noncompliance. As discussed below, the poor TDI QA renders invalid the assumptions of the DR/QR effort which is supposed to compensate for this problem.

B. The TDI Owners Group Plan

As explained by Applicants in their motion, they and other utilities owning TDI DGs have formed an owners group with the purported goal of addressing the regulatory concerns about TDI DG reliability. This Owners Group has formulated a program plan by which it hopes to resolve these concerns. The program consists of 4 elements; Phase I, the resolution of 16 "known problems"; Phase II, Design Review and Quality Revalidation ("DR/QR") of all components deemed important to DG reliability; engine inspection and testing; and maintenance and surveillance programs.

In this section OCRE addresses the adequacy of this plan, the Staff's evaluation of this plan, and the true motives of the Owners Group. Specific findings with respect to Phase I and II efforts are discussed in subsequent sections.

1. The Staff's SER

On August 13, 1984 the NRC Staff issued its SER on the Owners Group Program Plan. See BN-84-152. (The Staff also intends to issue an SER on each of the Phase I components, but has not yet done so.) It is the Staff's opinion that the Owners Group Program Plan incorporates the essential elements needed to ensure compliance with GDC 1 and GDC 17. These essential elements include Phase I resolution, Phase II DR/QR, appropriate engine inspections and testing, and maintenance and surveillance programs. SER at 6.

The Staff also outlined an interim basis for licensing those plants which have not completed all the elements of the Program Plan. However, this is not applicable to Perry, as this is a contested proceeding in which the Staff cannot argue that something less than full compliance with the regulations is also safe. Vermont Yankee, supra. In any event, Applicants have not requested any exemptions from the regulations for interim licensing, and have committed to implementing the entire plan, including full pre-operational testing, before plant licensing and operation. Motion at 12. See also Exhibit 6, from Applicants' January 17, 1985 submittal of their TDI Program

Plan.

Exhibit 7 is Applicants' schedule for implementing the Program Plan, again rom the January 17 submittal. Note that results from engine inspections after the pre-operational testing will not be available until June. Thus, it is not possible to determine whether the Perry DGs meet the standards the Staff has set forth for regulatory compliance until that time.

Engine testing and inspection is the key to verifying engine reliability. See Battelle Pacific Northwest Laboratory evaluation of the Program Plan, part of BN-84-152, at 11. However, PNL considers the tests outlined by the Owners Group to be insufficient. PNL recommends that a "lead engine" be operated at qualified load for 10 million (1E7) cycles. This is equivalent to 750 hours for an engine speed of 450 rpm. Engine disassembly and inspection is to follow. If any key compnent should fail the test., the root cause should be identified, corrective action taken, and the component should be retested for another 1E7 cycles.

The testing should also include 10 modified starts to at least 40% of qualified load, 2 fast starts to qualified load, and one 24 hour run at qualified load. These tests are in addition to those required by Reg. Guide 1.108.

Applicants' pre-operational testing is described in the Leidich affidavit. Basically, Applicants have committed to the testing requirements of Reg. Guide 1.108, with a few additions, such as a torsiograph test and engine vibration survey. Applicants place great reliance on the "lead engine concept" and on the operation of the lead engine, at Comanche Peak, for 100 hours, and of the Catawba V-16 engines (not lead engines) for 1600 hours.

First, if Applicants are to be consistent, they can only take credit for the one lead engine, Comanche Peak, which does not have the required 750 hours of operation. Secondly, to be in accordance with PNL's standards, the cited operational hours must have been failure-free. If not, they are meaningless, as retesting to another 1E7 cycles is needed. Applicants do not claim that these tests have been successful. In fact, the PNPP component tracking system cites failures of components at Comanche Peak and Catawba, such as cylinder heads, fuel injection pumps, turbocharger, and subcovers.

The whole concept of "lead engines, following engines" is flawed. It assumes that there is sufficient consistency in design, manufacturing, and assembly among engines to extend favorable findings from the operation of one engine to all engines of that type. I.e., it assumes an effective QA program. Since the poor QA at TDI is one of the causes of DG unreliability, it is most inappropriate to base the requalification program on an assumption of consistent quality. Furthermore, all TDI V-16 engines are not identical. The 2

Perry Unit 1 engines have crankshafts supplied by 2 different companies. The only logical approach is to treat each engine as a lead engine; each engine must run for 750 hours without failure. Only then can a finding of regulatory compliance be made.

2. The TDI DG Owners Group

In evaluating the Owners Group Plan, the true nature of the Owners Group must be discerned. Applicants have portrayed the Owners Group and its consultants as an independent, disinterested entity devoted to an impartial evaluation of TDI DG reliability. The truth is that the Owners Group is more of a political body, driven by economic considerations, having as its goal NRC acceptance of the TDI DGs and the avoidance of licensing delays.

The true nature of the Owners Group is illustrated by Exhibits 8 through 13. Exhibit 8 is a portion of the minutes of the Owners Group meeting held November 29, 1983. Note that the Group is to make no decisions that could affect DG manufacturer competition in the future. This would necessarily preclude a finding that TDI DGs are unreliable.

Exhibit 9 is a memorandum to Owners Group members from the Shoreham applicant. This memorandum illustrates the Owners Group's main concern, obtaining rapid NRC acceptance of the DGs.

Exhibit 10 is a memoramdum to the Owners Group from its technical program director. This document shows the Owners

Group's efforts to get the NRC Staff to reject the recommendations of its technical consultant, PNL, and to develop "realistic" DG loading curves to replace the "ultra-conservative" FSAR commitments.

Exhibit 11 is the Owners Group Executive Committee meeting minutes for January 9, 1985. Described therein is the success the Owners Group has had in influencing the NRC Staff. Exhibit 12 similarly cites this success. The Staff is willing, no doubt due to the political pressure exerted by the Owners Group, to relax the 185 BMEP interim licensing restriction and to relax the maintenance and surveillance restrictions from the DR/QR reports.

Exhibit 13 is a proposal for closure of the TDI Owners Group. Note the concerns about raising additional generic concerns and the "visibility of the Owners Group [which] sets the TDI diesel generators apart from other make diesel generators and other plant equipment as needing special consideration."

Applicants' attitude closely parallels that of the owners Group. Cpmpare Applicants' response to OCRE's Interrogatory 11-11(d), in which Applicants state that there is no number or type of failure or quality deficiency which they consider unacceptable for the DGs, and that it is not a purpose of the Owners Group to draw conclusions with respect to the fitness of any particular TDI DG or TDI DGs in general.

Because of the political nature of the Owners Group and the success it has had in influencing the NRC Staff, the findings of neither the Owners Group and its consultants nor the NRC Staff should be uncritically accepted. Nor should CEI's employment of "an independent engineering consultant, Southwest Research Institute" (motion at 10) be considered as a disinterested verification of the Owners Group findings. Exhibit 14 indicates that Southwest Research Institute was hired for advocacy purposes.

The nature of the Owners Group's "lobbying" activities demands that an independent evaluation be made of the Perry DGs. Both Staff and Applicants must be held to their commitments and to the strictest standards. For example, the DR/QR report is said to form the basis for concluding that the TDI DGs are capable of performing their safety function as described in the Perry FSAR. DR/QR Report at 1-1. Appendix II of the DR/QR , Report "contains a comprehensive set of maintenance and surveillance recommendations for each component." That program is supposed to maintain the qualification of the DGs for the life of the plant. DR/QR Report at 2-6. Applicants have committed to

incorporating all the DR/QR maintenance and surveillance recommendations. January 17, 1985 submittal at 22. Because of the Owners Group's political influence with the NRC, the danger is that these commitments are hollow promises to be quickly rescinded after licensing. It must be ensured that Applicants will be held to their commitments, or it must be assumed that FSAR requirements will not be met.

3. Reliance Upon TDI

It is important that any evaluation of TDI DGs be independent of TDI's own commercial interests and influence. Applicants claim that all technical evaluations were preformed independent of TDI, and that the Owners Group program was independent from TDI's QA program. Motion at 8. While it is not clear what role TDI played in the direction of Owners Group policy (TDI officials have attended Owners Group executive meetings), it is clear that Applicants have relied extensively on TDI, and continue to do so.

Reliance upon TDI is particularly dangerous, as TDI has supplied false information to Applicants. See Exhibit 15, in which TDI refers to the "successful" operation of TDI engines in stationary and marine service.

Unfortunately, Applicants have relied upon TDI's recommendations in implementing the DR/QR program. Specific examples are addressed in subsequent sections devoted to that program. This uncritical reliance on TDI makes it all the more imperative that an independent evaluation of the Perry DGs be performed.

C. Phase I

"Phase I" is that portion of the Owners Group Program Plan which deals with the 16 known, generic problem components. These components include piston skirts, connecting rod bearing shells, rocker arm cap screws, air start valve capscrews, cylinder head studs, push rods, high pressure fuel lines, crankshaft, turbocharger, connecting rods, engine base and bearing caps, cylinder heads, cylinder liner, cylinder block, engine-mounted electrical cable, and jacket water pumps. Most Phase I analyses were conducted by Failure Analysis Associates ("FaAA") for the Owners Group.

The proper standard by which to evaluate the Phase I reports is that outlined by PNL in Exhibit 16. The essence of this standard is that the analysis address the problem in a manner that is logical, complete, thorough, and technically correct. The Owners Group has failed to accomplish this with the most critical components.

OCRE has addressed below the most significant components. Inspection and DR/QR results pertaining to these components are also addressed herein, and not in the subsequent section on the DR/QR.

1. Crankshaft

Applicants claim that the FaAA analysis of the V-16 crankshaft demonstrates the adequacy of the PNPP crankshaft. Wood Affidavit at 80. In actuality, FaAA did not reach such a conclusion. FaAA conducted an evaluation of crankshafts at Shoreham and Gránd Gulf (R[illegible] FaAA-84-3-16). The

Statement of Applicability for that report specifically cautions:

> This report addresses the structural integrity of the crankshafts in Transamerica Delaval Inc. DSR-48 engines at the Shoreham Nuclear Power Station and DSRV-16-4 engines at the Grand Gulf Nuclear Power Station. In view of possible differences in generators, flywheels, and engine operating conditions, the results may not necessarily apply to other engines of the same model. These plant-specific differences, where they exist, will be evaluated in separate reports.

It is not clear whether a "separate report" was ever issued for Perry; OCRE is not aware of any. In fact, the Christiansen Affidavit identifies the May 1984 DSRV-16 crankshaft Phase I report as being applicable to Perry. (The FaAA report referenced above is dated May 1984.)

PNL agrees with FaAA that crankshaft analyses "apply only to engines of the same type that are rated for the same load, and that are equipped with generators and flywheels with the same torsional vibration characteristics." BN-84-152, PNL Report at 7.

It is not clear what differences exist between Perry and Grand Gulf engines, but Perry has a larger size flywheel than its designated lead engine at Comanche Peak (90 inch diameter at Perry, 68 inch at Comanche Peak). Other differences undoubtedly exist which affect the crankshaft analysis.

The claimed success of Catawba torsiograph tests (Wood Affidavit at 80) is therefore totally irrelevant to the adequacy of the Perry crankshafts.

The report on Grand Gulf does not give much assurance that

V-16 crankshafts are suitable for nuclear service. This report identifies 3 failures of V-16 crankshafts in non-nuclear stationary service. The failures were attributed to torsional fatigue cracks initiating in the oil holes in main journal numbers 6 or 8. The Perry Component Tracking System also identifies other V-16 crankshaft failures. In the V-16 stationary engine at Glencoe, MN, cracks were found in the No. 5 crankpin. It is postulated that the cracks may have resulted from manufacturing flaws. The V-16 stationary engine at St. Cloud, FL suffered a broken crankshaft, supposedly due to other failures.

The failures identified in the FaAA report resulted in design changes by TDI. The failed engines had a 4th order critical speed at 446 rpm, very close to the operating speed of 450 rpm. Counterweights were added to the crankshaft which moved the 4th order critical speed cown to about 430 rpm. Grand Gulf is said to have a 4th order critical speed of about 430 rpm. Applicants admit that the Perry 4th order critical speed is 438 rpm, even closer to the operating speed. Wood Affidavit at 79.

There is also a 3-1/2 order critical speed in V-16 engines which creates larger stresses than the 4th order, said to be in the 500 rpm range. See Exhibit 17, from BN-84-182. Note that this speed is below the overspeed trip setting of 518 rpm, and that the DR/QR maintenance recommendations for the overspeed trip call for running the engine at no load up to this trip point at every refueling outage.

The DR/QR Report for the governor mentions a critical speed of 496 rpm.

DEMA recommends that no harmful torsional vibratory stresses occur within 5% above and below the rated speed. For a 450 rpm engine, the range in question is 427.5 to 472.5 rpm. The Perry DG procurement specification has even more stringent standards, that the DG shall be free of all deleterious critical speeds or torsional vibrations within 10% above and below the rated speed at any load from 0 to 110%. SP-562 Section 2.06.1. This speed range is 405 to 495 rpm.

Applicants claim that the 4th order stresses are not "harmful" because the components from the right and left banks almost cancel, and assuming a one degree delay in right bank timing, the stresses are below the DEMA allowables. Wood Affidavit at 78-79. The Owners Group's analytical assumptions, however, should not be accepted without scrutiny.

FaAA developed a torsional model of the V-16 crankshft for the Grand Gulf report. The harmonic loading on the crankshaft is admitted to be sensitive to firing pressure, reciprocating inertia, and frictional loads. However, the firing pressures used in the analysis were those measured for the Shoreham engine. The peak firing pressure there was about 1600 psig. Applicants admit that peak firing pressures for the Perry engines may reach 1700 psig. Wood affidavit at 24. FaAA then assumed firing pressures to be the same, except for the timing difference, between the left and right banks. Factory test data for the Perry engines indicates that this is not a conservative assumption. Exhibit 18 is the record of factory test runs for the Unit 1 engines. Exhibit 19 is OCRE's analysis of the firing pressure variations exhibited in these tests. Note the considerable variation in firing pressure among the cylinders. This variation is within TDI's allowable range, which permits a difference in maximun and minimum pressures of 150 psi. See Exhibit 20, from TDI's instruction manual. Note also that the average firing pressure for the two banks can vary considerably.

FaAA "found" the reciprocating mass of the V-16 connecting rod and piston to be 820 lbs for each connecting rod. This number is remarkably identical to the reciprocating mass used for the in-line crankshaft analysis, despite the differences between connecting rod designs. See Exhibit 21, from the TDI Instruction manual, which gives the approximate weights and configurations of the V-16 articulated connecting rod design. The master and link rods do not weigh the same.

FaAA agrees that these differences between the 2 banks affect the imbalance driving the 4th order critical. See Exhibit 22, from the June 22, 1984 meeting between the NRC and the Owners Group. It is not clear that these effects have been considered, nor that the suggested "cure-all", the torsiograph test, will adequately evaluate them.

The factory test data showed erratic behavior with regard to firing pressure differences. A torsiograph test may or may not "catch" the worst-case situation. Indeed, it was found for the San Onofre V-20 engine that the initial position of the crankshaft had a significant effect on stresses, in that for some positions stresses are in phase. See BN-84-182 at 65-75. Presumably the timing of DG loading could have the same effect.

Applicants state that the torsiograph test will be performed on only one PNPP engine at 0%, 25%, 50%, 75%, and 100% of nameplate rating. CEI January 17, 1985 submittal at 18. 110% load will apparently not be considered, even though it is a FSAR and SP-562 requirement. Nor is it clear that transient loading conditions will be considered.

It is these conditions that may be the most taxing for the DGs. FSAR 8.3.1.1.3.2 states that "sequencing of large loads at 5 second intervals ensures that large motors will have attained rated speed and that voltage and frequency will have stabilized before succeeding loads are applied. The decreases in frequency and voltage have been verified by qualification testing to be not greater than 5 and 20 percent of nominal, respectively." Since the frequency of an AC generator is directly proportional to the speed of its prime mover, a 5% decrease in frequency means that DG speed will drop to 427.5 rpm. Every time a large load is added to the DGs, they will pass through the 4th order critical speed of 438 rpm.

Actual loading conditions may be even more severe than those postulated by the FSAR. The NRC's Integrated Design Inspection found that there is no specification requirement that large motors reach rated speed within 5 seconds. In fact, the ESWS pump considered by the inspectors requires 9 seconds to reach rated speed. BN-85-02 at p. A-277. The result is that the DG may have to supply motor starting currents for more than one motor at once, which heavily loads the DG and lengthens the time spent at the critical speed. The actual conditions will not be known until actual DG operation with actual loads.

More severe conditions than those analyzed by FaAA would also be produced if the engine were to misfire. See Exhibit 23 from the June 22, 1984 NRC-Owners Group Meeting. Engine misfiring is a serious problem for the V-16, is likely to occur, and is considered in marine applications. Exhibit 24, from TDI's Instruction Manual, also illustrates the large number of factors affecting cylinder balance. Misfiring thus should be evaluated.

The only appropriate standards by which to evaluate crankshaft design are those of the ship classification societies. These standards, of which Lloyd's Register of Shipping is the most conservative, consider a large number of inputs, including engine misfiring. See Exhibit 25, from the Joint Testimony filed by Suffolk County on July 31, 1984 in the

Shoreham proceeding. An independent evaluation must be performed according to these conservative standards.

Only an independent evaluation and realistic testing of the most severe DG operating conditions (for both DGs) will determine whether the Perry V-16 crankshafts are suitable for nuclear service.

2. Pistons

The Owners Group has identified 6 functional attributes of pistons. See Exhibit 26. Most of these have not been verified by the Owners Group, which has only actively addressed the fatigue cracking of the piston skirt stud attachment boss area. Other piston problems which could adversely affect engine performance have not been evaluated.

For example, the strength of the piston crown has never been analyzed, even though the Component Tracking System has identified piston crown cracking on an engine in nuclear service (Kuosheng, Taiwan) and on the M/V Gott. A hole, said to be caused by "secondary shrinkage", was discovered on an engine piston crown. These failures, their causes, and actions needed to prevent further failures, were not addressed by the Owners Group.

Similarly, there have been numerous instances of fretting between the skirt and crown. This has not been evaluated by the Owners Group.

Piston rings and pins are known to be susceptible to flaking of their chrome plating. This has been observed at Perry (pin, see Exhibit 27) and Comanche Peak (pin, see Exhibit 28). No analysis of the root cause of this problem has ever been performed, nor is there any solution for preventing the problem. Chrome flakes can cause scoring of the cylinder liner, resulting in piston blowby, which can eventually cause piston seizure.

The PNPP DR/QR report for pistons is written for the wrong skirt type, AH instead of the AE skirts actually used.

However, Applicants do take credit for the FaAA report on AE piston skirts. These analyses are seriously deficient, as demonstrated by Exhibit 29, from the Suffolk County testimony in the Shoreham proceeding. Summarized, the testimony shows that FaAA neglected a number of significant factors, including use of underestimated peak firing pressure (acknowledged to be 1700 psig by Applicants; 1670 was used in the evaluation); use of skirt-to-crown gap (and other dimensions) unverified by measurement, except on a sample basis (see Exhibit 30); use of ideal assumptions, such as isotropic material and uniform skirt temperatures; reliance on Kodiak engine (1200 psig firing pressure) and R-5 experimental engine operating experience, with only a sample of AE skirts; neglect of piston side thrust; and the effects of tin skirt plating, which can collect detritus which will cause liner scoring, leading to piston blowby and possibly piston seizure. Note that liner scoring was observed in the PNPP DGs after a few hours of factory testing. See Exhibit 31.

TDI has not demonstrated an ability to produce defect-free piston skirts. Linear indications have been found by liquid penetrant and magnetic particle testing on new Perry AE skirts (see Exhibits 30, 64, and 66) and on Comanche Peak AE skirts (Exhibit 65). Although these indications were removed, there is no assurance that subsurface flaws are absent, since the inspection techniques are only capable of detecting surface or near-surface indications.

Contrary to Applicants' belief, reasonable assurance that the AE piston skirts "are adequate for unlimited life under full load conditions" simply does not exist. A thorough evaluation addressing all the piston functional attributes identified by the Owners Group has never been conducted, and must be conducted by an independent, disinterested entity before the DGs are considered acceptable for nuclear service.

3. Cylinder Heads

FaAA has divided cylinder heads into 3 groups, depending on when they were cast. Heads cast before October 1978 (Group I heads) were not stress relieved and are subject to fatigue crack growth in thin sections and/or from fabrication-induced defects. Heads cast before September 1980 (Group I and II) were subject to core shift, inadequate control of solidification, and inadequate control of the Stellite valve seat weld deposition process. Heads cast after September 1980 (Group III) are supposedly free of these defects. FaAA Cylinder Head Report at ii, 1-2.

The Perry DGs are using Group I heads, which were returned to TDI for stress relief. Wood Affidavit at 44. Stress relief, however, does not solve problems such as core shift and inadequate control of solidification. In fact, stress relieved heads have cracked in marine service (M/V Gott), according to the PNPP Component Tracking System.

Nor is it clear that TDI's manufacturing abilities have improved. Exhibit 32 is a portion of a report of an inspection conducted by Applicants at TDI facilities for the purpose of witnessing inspections on reworked cylinder heads. Five out of 19 heads were rejected for lack of fusion, hot tears, and inclusions, discovered by magnetic particle testing.

It should be noted that other nuclear facilities (Shoreham, Comanche Peak) have replaced Group I or II cylinder heads with Group III heads. Nothing less should be expected from Applicants.

The DR/QR report for cylinder heads states that a design review is not necessary due to the FaAA report. It also states that, for increased head reliability, the engine should be "blown-over" after each operation of the engine, and the fuel injection port visually inspected for water leaks during the monthly engine run. This approach is flawed on several grounds.

First, FaAA never conducted a design review of TDI cylinder heads. See p. 3-1 of FaAA's report, which states "no attempt was made to perform a detailed design review of the cylinder head." The reason for this was that the head geometry is too complex for such an analysis. Instead, the fire deck only was modeled as a flat plate. The numerous flaws in this analysis are detailed in Exhibit 33, from the Suffolk County testimony in the Shoreham proceeding.

The Shoreham testimony also demonstrates that there is no assurance that the Group III heads will be reliable either; indeed, the head design is inherently defective, and TDI's casting process has not improved. Nearly all heads cast in 1982-83 had defects. TDI's inspection techniques will not detect subsurface cracks.

Wide variations in fire deck thickness make cracking more likely to occur. TDI ignores the maximum fire deck thickness, which should be 0.515 inch except between the intake valve ports, where 0.765 inch is required. Exhibit 34, a record of UT inspection of PNPP cylinder head fire deck, illustrates the wide variation in fire deck thickness and the routine violation of the maximum thickness standard.

There is inadequate evidence to support the claim that Group III heads have never cracked. TDI never evaluated its files in the past 2 years to determine whether head failures have occurred.

Cylinder head cracks can occur during cold shutdown of the engines and may not be detected before engine start is attempted. Cylinder head cracks can lead to catastrophic DG failure, turbocharger damage, and "air-lock" of the head water passages. Water leakage into the cylinder is very dangerous; even small amounts of leakage can impair cylinder lubrication. Compare Exhibit 35, from TDI's Instruction Manual, which warns of the serious consequences of water in cylinders.

The barring-over or blowing-over (see Exhibit 36 for a description) procedure is inadequate for detecting the presence of water in cylinders. Performing this procedure after each engine run will not detect leakage occurring after the test but before the next engine start. Obviously such procedures cannot be performed prior to an emergency DG start.

Given the extensive history of TDI cylinder head cracking in nuclear, stationary, and marine service (see Exhibit 37, from the PNPP Component Tracking System), the defective Owners Group analyses, the inherently flawed head design, the lack of assurance that manufacturing problems have been solved, the severe consequences of head cracks, and the inability to detect cracks before they cause damage, the use of TDI cylinder heads for nuclear service cannot be justified.

4. Connecting Rods

A large number of connecting rod failures has been observed in TDI engines. See Exhibit 38, from the PNPP Component

Tracking System. Due to this adverse experience, connecting rods were evaluated under the Owners Group Phase I program. Exhibit 39 is the Owners Group's Task Description for connecting rods.

The Owners Group has failed to fulfil its commitments in that task description. For example, buckling strength, while examined for the in-line rod, was never evaluated for the articulated design used at Perry.

Similarly, the Owners Group has not adequately addressed wrist pin bushing failures. FaAA's report on in-line connecting rods included an analysis of wrist pin bushings (since extensive cracking was discovered at Shoreham), but this analysis may not be conservative (no indication of the peak firing pressures used was given) or applicable to V-16 engines (due to inertial load differences in the exhaust stroke). An independent analysis is necessary to ensure the suitability of TDI wrist pin bushings.

The extensive cracking observed at Shoreham, even in new bushings, is yet further evidence of the inherently poor quality and unreliability of TDI engines. The recommended NDE inspections for wrist pin bushings (LP testing) in the Perry DR/QR report will not detect subsurface flows that could propagate to failure.

The problem most thoroughly addressed by Applicants is that of rod box or bolting failures. However, their own analysis shows that even the supposedly superior 1-1/2 inch bolt configuration used at Perry is marginal (factor of safety = 1.08.

But we are told not to worry because of favorable field experience with 1-1/2 inch bolts. Wood Affidavit at 84.

The truth is that field experience has not been favorable. FaAA conducted a survey of Vee engine connecting rod experience. Out of a population of 148 connecting rod assemblies, two 1-1/2 rods have cracked; four 1-7/8 rods have cracked; six 1-7/8 rod bolts have cracked "with no apparent damage to the rods." FaAA-84-3-14 DSRV-4 Connecting Rod Report at 1-3 to 1-5. No statistical analysis was performed to determine whether the data could support a conclusion as to the superiority of the 1-1/2 inch design. Applicants admit that there must be "substantial operating experience and/or experimental data to confirm the design integrity." Wood Affidavit at 81. Neither exists.

The results of inspections of the Perry connecting rods likewise do not inspire confidence in their reliability. Exhibit 40 is a nonconformance report describing galling of the rod box threads. Note that the cause of this problem has not been determined, and no efforts to prevent recurrance are in progress. Exhibit 41 is a nonconformance report describing fretting on the connecting rod rack teeth. No cause of the problem was determined, and the rods were used as-is based on TDI's disposition. This is an example of Applicants' continued uncritical reliance on TDI for technical evaluations.

FaAA believes that 1-1/2 inch rods are acceptable for use provided rods with pre-existing flaws are eliminated. FaAA Report at 2-15. The use of the fretted and galled rods violates this criterion.

The Perry DR/QR Report, Appendix II, the maintenance matrix, states that if connecting rod rack teeth fretting is found an engineering evaluation should be performed. None was done here.

It must be concluded that no assurance exists that the Perry connecting rods are suitable for nuclear service. The Owners Group's own analysis, which may not be conservative, demonstrates that the rods are marginal. Adequate experience of successful rod operation does not exist. Indications found during inspection of the PNPP rods have not been dispositioned in a technically valid manner.

5. Connecting Rod Bearing Shells

Exhibit 42 is the PNPP Component Tracking System for connecting rod bearing shells. Note the wide variety of failure mechanisms involved. Failures have been attributed to bad alloy makeup, connecting rod fretting, and loss of bearing crush. Many of the failures identified did not give the cause. Applicants have only addressed the type of failure occurring at Shoreham.

While the DR/QR report recommends a number of NDE tests (radiographs, eddy current, liquid penetrant, visual, and dimensional verification), no verification of alloy type is required. In addition, Applicants are using as-is bearings which have failed the FaAA inspection criteria. Relying instead on information from TDI, they accepted bearings with linear indications and scoring and galling. See Exhibit 43, inspection results for connecting rod bearing shells. Note that even though the acceptance criteria clearly stated that surface cracks, linear indications, scoring and galling are unacceptable, Applicants accepted bearings exhibiting such flaws because TDI's service representative accepted them.

It cannot be concluded that the Perry connecting rod bearing shells are acceptable when they include obvious nonconforming indications, the cause of which is unknown. Not all of the failure mechanisms found in field experience for connecting rod bearings have been studied. Nor has it been demonstrated by an independent disinterested analyst that the evaluation of the Shoreham bearing failures is conservative. Reasonable assurance that the PNPP DG connecting rod bearing shells are suitable for nuclear service does not exist.

6. Engine Base and Bearing Caps

Applicants claim that the engine base and bearing caps are adequate for nuclear service, based on FaAA's evaluation. There is no evidence that this analysis is conservative, as the FaAA report is an inscrutable document.

For example, the FaAA report states that the primary function of the base assembly is to align, support and react the crankshaft loads at the bearing saddles, and to react the firing forces transmitted by the through bolting. The loads imposed by the crankshaft include crankpin, piston, and rod inertia and the firing loads. FaAA-84-4-1 Rev. 1 at 5. But it is never explained just how these loads are modelled in the stress analysis. It cannot be determined whether e.g., the firing pressures are conservative.

Applicants state that the nut pocket failure was due to impurities in the casting material. Wood Affidavit at 16. FaAA never determined this; this was TDI's conclusion. "TDI reported that this failure was due to impurities in the casting material that reduced the engine base strength. They reported that the impurities were traced to non-ferrous components among the scrap iron used for the castings." FaAA Report at 10. FaAA's analyses apparently assumed that base materials were of specified composition and strength, which, given this failure, is not a conservative assumption.

A complete analysis of the engine base and bearing cap failures has never been performed, and needs to be performed by an independent disinterested entity before the suitability of this component can be determined.

The DR/QR report also fails to ensure the adequacy of these components. If a failure has been attributed to casting material impurities, then a logical approach to revalidating the engine would include a determination of the chemical composition and material properties of the base for each engine. The DR/QR report does not recommend this; the only inspections required are a verification of bearing cap stud nut torque and visual and LP inspection of only the No. 5 main bearing saddle area on only one engine.

The Perry DGs failed even this limited test. See Exhibit 44, which shows that linear indications have been found on the No. 5 saddle of the Unit 1 Division 1 engine. Applicants accepted these indications as-is and have not tried to determine the cause of these indications, whether they will propagate in service, or, through expanded inspections, whether other nonconforming conditions exist in other saddles.

In light of these findings, there can be no assurance that the Perry engine bases are suitable for nuclear service.

7. Turbochargers

The Elliott 90G turbochargers used at PNPP have had unfavorable experience. See Exhibit 45, from the PNPP Component Tracking System. Note that the problems encountered include thrust bearing lubrication, excessive vibration, surging, and nozzle ring vane breakage. The Owners Group has focused only on the thrust bearing and nozzle ring problems. Other turbocharger problems have been ignored.

FaAA's analysis of nozzle ring vanes did not prove that these components are acceptable. FaAA concluded, based on vane failures observed at Shoreham, Kuosheng, Comanche Peak, and Grand Gulf, that the nozzle may indeed experience vane failures, But, because these failures have not yet resulted in engine shutdown, FaAA concludes that vane failures should not significantly affect turbocharger operation. FaAA recommends that Elliott consider its findings in future nozzle ring designs.

PNL apparently disagrees with the conclusion that vane failure is harmless. Appendix M of SSER 6 for Grand Gulf, NUREG-0831, is PNL's evaluation of the reliability and operability of the Grand Gulf TDI DGs. Therein (P.19) PNL states "there is a high probability of damage to the turbocharger if the vane breaks in service." The Owners Group also realizes that loose and broken parts can damage the turbocharger. See Exhibit 46.

The Division 1 engine turbocharger was found to be severely damaged upon inspection and was replaced. See Exhibit 47. The cause of the damage was not determined; it was merely attributed to the factory testing (only a few hours). There is no guarantee that damage will not occur during subsequent engine operation.

PNL attributes excessive vibration at Grand Gulf to turbocharger misalignment. SSER 6, Appendix M at 17. Misalignment is a problem at Perry as well. See Exhibit 48. Note that Applicants have again relied exclusively upon TDI for technical information. No analysis of the proposed disposition (elongating bolt holes) was conducted to determine the effect upon turbocharger operation.

The Perry turbochargers are inadequate. They are likely to experience nozzle ring vane breakage, which could damage the unit, have been damaged by an unknown mechanism, and do not align properly with their mounting brackets.

8. Cylinder Blocks and Liners

TDI cylinder blocks have experienced numerous failures. These failures include ligament cracking, stud-to-stud cracking, stud-to-end cracking, circumferential cracking at the liner counterbore lip, and creep and thermal distortion. Applicants have only evaluated the cracking problems; no analysis of the distortion and creep was performed.

Applicants imply that cylinder block failures at Perry can be avoided if the blocks are found to have acceptable material properties and microstructure and if liner proudness is reduced. First, it has not yet been determined that the PNPP engine blocks are free of substandard material. Secondly, FaAA never recommended reducing liner proudness:

> Modification of liner collar counterbore vertical fit (liner proudness) to the reduced level currently specified by TDI will result in reduced probability of circumferential cracks. Quantification of the exact impact of this modification on stress perpendiculat to ligament, stud-to-stud, and stud-to-end cracks has not been performed. Therefore, no recommendation is offered regarding the overall desirability of reduced liner proudness. FaAA-84-9-11, "Design Review of TDI R-4 and RV-4 Series Emergency Diesel Generator Cylinder Blocks", Dec. 1984 at v.

In fact, it would seem that reducing liner proudness would lead to loss of liner crush, which has occurred in TDI engines. Loss of crush could cause liner fretting or leakage of exhaust gases into the coolant or leakage of cooling water into the cylinder. The deleterious effects of these events have been described above in the discussion on cylinder heads.

FaAA's evaluation predicts that cracks will initiate in the cylinder blocks, even those of normal microstructure. FaAA concluded that cracking of the block top may initiate at 100% nameplate load due to high frequency fatigue or after 100 starts to full power due to low cycle fatigue. Ligament cracks are more likely to initiate than stud-to-stud or stud-to-end cracks, but once ligament cracks form the other cracks are more likely to occur. FaAA report at 5-2.

The cause of this propensity for cracking is the inherently defective design of the blocks. See Exhibit 49, the M/V Columbia Engine Rebuild Report, which concludes that circumferential cracks will be recurring due to the number of causative factors , including high comoressive stresses on the counterbore lip; localized stress from the sharp internal lip corner; nearby drilling for waterjacket or stud; termination of stud treading at the same level; creep deformation; and fatigue. 'Because the design stresses were so high, there was no forseeable way to prevent failures from occurring without a signicant redesign of the liner-block landing surfaces.' Ex. 49 at II-9.

Similarly, FaAA found that increasing the radial clearance between the block and liner will reduce the block top stress and reduce the likelihood of cracking (the liner expands thermally more than the block). Apparently realizing the need for redesign, TDI has modified block design in its R-5 engines. These modifications include increasing the block top thickness from 2.5 to 3 inches, providing deeper stud bosses and stud hole threads, and upgrading the block material from Class 40 to Class 45 cast iron. FaAA report at 1-6.

TDI has also increased the radial clearance between the block and liner, from 0.008/0.0045 to 0.0105/0.0070 (upper gap; lower gap was also increased). FaAA Report Figures 1-6, 1-7, and 1-8. The PNPP engines, however, do not have the benefit of these improvements.

FaAA does not predict unlimited block life. Rather, a cumulative damage index has been developed to determine the length of time an engine can operate. This calculation utilizes engine operational history (time at load), and predicted operational characteristics, included those for a LOOP/LOCA event. The Perry DR/QR report references Exhibit 50, apparently for the purposes of this calculation. Note that Exhibit 50 was prepared in response to Exhibit 10, which bemoans "ultra-conservative" FSAR load data and urges "realistic" load profiles, perhaps taking credit for operator action in removing loads from the DGs.

Thus, the loads assumed in Exhibit 50 may not be conservative. Nor is it clear that this load profile was assumed for LOOP/LOCA only and not also for normal DG testing. If so, this contradicts draft Technical Specification commitments to test the DGs at least once every 31 days by running at 7000 kw for 60 minutes, and at least once every 18 months by running at 7000 kw for 24 hours. See Exhibit 51.

Also, it is not clear that the calculation has considered the possibly more severe starting conditions discussed above, concerning the ability of large motors to reach rated speed before additional loads are added. There thus is no assurance that the cumulative damage algorithm will conservatively predict safe operating life of the cylinder block.

Exhibit 52 is FaAA's flowchart for applying the cumulative damage procedure. Note that for a crack-free block, continued operation is dependent upon the block material being typical for gray cast iron, the block and liner dimensions being "satisfactory", and the engine having significant operational history. It has not yet been determined whether the PNPP engine block material is acceptable. The engines also lack significant operational history (only a few hours of factory testing). No accetance criteria are given for "satisfactory" block and liner dimensions. These are given, however, in Exhibit 53. Incredibly, the acceptable dimensions are all those in use by TDI, including

the early dimensions for liner/block radial gap which increase the likelihood of cracking. A conservative assumption would be that there are no satisfactory standards for these dimensions. The flowchart for Perry thus leads to the conclusion "no analytical basis for continued operation."

Additionally, FaAA's entire methodology with respect to block cracking, including the cumulative damage calculation, is faulty. This is thoroughly discussed in Exhibit 54, from the Suffolk County testimony in the Shoreham proceeding.

FaAA also believes that any cracks that may initiate are harmless. This too is a fallacious assumption which is rebutted by the Suffolk County testimony. This testimony shows that all types of observed cracking are very dangerous and can lead to catastrophic engine failure.

Applicants identify "the ability to withstand reactive side forces without evcessive wear or scuffing" as a functional , attribute of the cylinder liner. Wood Affidavit at 55. This has never been analyzed for the TDI liners, despite adverse experience with scuffing and distortion due to piston side thrust.

Applicants may have created a new problem affecting cylinder liner reliability. See Exhibit 55. Applicants failed to ensure that liner and block matchmarks were aligned when installing the liners. Alignment is necessary as there is a cutout at the liner bottom for connecting rod travel. The misalgnment is as great as 7/16 inch; however, Applicants accepted this situation as-is because TDI's service representative accepted it. TDI accepted 7/16 misalignment even after recommending that 1/4 inch be the maximum misalignment. This is yet another example of Applicants' continued reliance on TDI for technical input. There is no assurance that engine damage will not result from this situation.

There is no evidence that the PNPP DG cylinder blocks and liners will perform their functions without failure. An adequate analysis of block cracking and its consequences has never been performed, and other observed failure modes have not been analyzed at all. It must be concluded that these components are not suitable for nuclear service.

D. Phase II DR/QR

The DR/QR program is supposed to verify the reliability of engine components other than those evaluated in Phase I. 171 components were selected for the Perry engines; however, only 14 of these received a full design review. The others were deemed not to require design review because of supposed similarity to the lead engines at Comanche Peak.

The heavy reliance on the lead engines is illustrated by the following statements from Applicants' January 17 submittal of their DG Program Plan:

> Upon completion of the DR/QR Program on the lead engine, the results . . . were factored into the follow-on engines such as PNPP. A separate design review was not required, for example, on a common component for follow-on engines. However, an

> inspection may be required to verify that the component is actually the same as the one reviewed for the lead engine. Likewise, quality revalidation inspections completed on a component in a lead engine would serve as a basis for either increasing or decreasing inspections for a follow-on engine, depending on the lead engine inspection results. (P. 5)

> Expanded testing or inspections will generally be focused on the "lead" engine, with less stringent requirements for following engines of the same type if warranted by preceding results. (P. 6)

This concept is inherently flawed due to the poor or totally lacking quality assurance at TDI. Using the lead engine concept for design reviews might be justified if TDI's design control were acceptable. However, this is not the case. An example of this is the front gear case bolting, component #02-335B. The Perry DR/QR report for this component states:

> a QC inspecion at Shearon Harris (CP&L NCR 84-1777) showed two bolts internal to the gearcase that were not evident on the parts manual drawing. . . The CP&L inspection found that no positive means of locking was provided. Considering the damage these bolts could cause if they loosen, it is recommended that these bolts be inspected at Perry and positive locking features (bent tab or lockwire) be added. . .

Were it not for the fortuitous inspection at another site, these bolts would have gone undetected, as TDI's parts manual failed to identify them. TDI's QA is such that other unidentified differences between the parts manual and the engines (or among engines) exist. They will not be detected unless complete inspections are performed. Thus, an inspection must be done for each component to ensure that it is identical to that on the lead engine.

Any relaxation in QR inspections or testing based on favorable results at lead plants is likewise improper and without technical justification. Because of TDI's ineffective QA program, favorable results at one engine does not guarantee favorable results for all engines. Inspections on a sampling basis are similarly meaningless.

Many components (listed below) received no QR. OCRE believes that these items must be inspected and/or tested to ensure their reliability. Components receiving no QR include:

F-068, Intercooler; 02-380A, Exhaust Manifold; 02-805D, Flex Connections; 00-420, Lube Oil Pressure Regulating Valve; 02-307A,B,D, Lube Oil Fittings; 02-420, Lube Oil Pump (engine-driven); 02-465A, Lube Oil Lines; 02-467A, Turbocharger-Lube Oil Fitting Piping; 02-540 A,C, Lube Oil Sump Tank, Strainer, & Hardware; 02-540B, Lube Oil Sump Tank misc. fittings, gaskets, pipe, and bolting; 02-717F, Aux. Sub Base Oil & Water Piping; 02-717I, Aux. Sub Base piping supports, mounting hardware; 02-820B, before & after Lube Oil Pump; 02-820G, Lube Oil Heat Exchanger; 02-310C, Thrust Ring Bearing; 02-315D, Jacket Water Manifold Piping;

02-315G, Cylinder Block/Liner seals and Gaskets; 02-441A, Starting Air Manifold Piping, Tubing, & Fittings; 02-441C, Starting Air Manifold Supports; 02-835B, Starting Air Tank; 02-345C, Fuel Pump Base Assembly; 02-350B, Camshaft Bearing; 02-390E, Bushings; 02-330A, Flywheel; 02-330B, Flywheel Bolting; 02-410D, Overspeed Trip Vent Valve; 02-695B, Engine Shutdown Equipment; 02-316C, Jacket Water Inlet Manifold; 02-435A, Jacket Water Fittings; 02-435B, Jacket water Supports; 02-437, Turbo Water Piping & Fittings; 02-700A, Jacket Water Standpipe pipe, fittings & gaskets; 02-700C, Jacket Water Standpipe supports;

02-700F, Jacket water standpipe bolting; 02-717V, Aux. Sub Base Pipe couplings, fittings, etc.; 02-717D, Aux. Sub Base JW gaskets & bolting; 02-717E, Aux. Sub Base Supports; 02-810B, JW Heat Exchanger; 00-621A, Fuel Oil Drip Tank; 02-365D, Fuel Injection Supports; 02-450A, Fuel Oil Header piping; 02-717J, Aux. Sub Base Fuel Oil Piping and Fittings; 02-717L, Aux. Sub Base Fuel Oil Bolting & Gaskets; 02-825A, Fuel Oil Day Tank; 02-650A, Generator; 02-650C, Generator Shaft & Bearings; 02-550, Foundation Bolts; 02-717A, Aux. Sub Base.

The above is not an exhaustive list of items receiving no

QR; excluded were items wuch as valves, filters, and other components not produced by TDI which are of standard design and are used extensively in the industry, and electrical components such as switches, wiring, thermocouples, terminals, etc. Items such as these do not need QR.

Specific comments on the components in the DR/QR Report are given below.

1. 02-500A, Control Panel Assembly Cabinet/System

The DR/QR Report for this item addresses Georgia Power Company's Vogtle Plant and not PNPP.

2. 02-717C, F, and I Aux. Sub Base Piping, Supports, and Mounting Hardware

These components are part of the jacket water and lube oil systems. These systems are required to be designed and built in accordance with ASME Code Section III, Class 3. SP-562, Sections 2.06.7 and 2.06.8.

The DR/QR Reports for these components all contain the following statement:

> The lead engine report does address site specific modifications to the skid piping and/or supports. Generic application of these modifications is not required for Perry since the Comanche Peak modifications were not required for piping operability. The lead engine modifications were recommended in order to meet the intent and philosophy of the ASME Code for the boundary conditions and assumptions used in the Owners Group Analysis. These boundary conditions and assumptions may be somewhat different from those used in the original manufacturer's analysis.

Since the lube oil and jacket water systems must be designed and built to the ASME code, if modifications are required to meet the ASME code then they are required at Perry. Whether they are required for operability is irrelevant.

3. 02-317 A&B, 02-435A, 02-437, 02-467A, 02-467A, 02-717C, 02-717F

These components are lube oil and jacket water fittings. These items are to be visually inspected for leaks, and should they occur, the existing Dresser Style 65 couplings should be replaced with Dresser Style 90 couplings equipped with Viton gaskets. The reason for this is that the maximum suggested operating temperature of 150 degrees-F may be exceeded. The Style 90 coupling can withstand 212 degrees-F.

It is not conservative to wait until leaks occur before taking corrective action. The couplings should be replaced before plant operation.

4. 02-360B, Intake and Exhaust Valves

The DR/QR Report admits that the primary adverse experience associated with the valves has been chrome plate flaking, scuffing, scoring, and exhaust gas blowby due to lack of concentricity of valve and seat. However, no modifications are required for the valves, since the problems are not expected to "noticeably affect engine performance" due to the small number of hours the DGs are expected to operate between inspections.

The maintenance recommendations for the valves in Appendix II of the DR/QR Report include 3 items. One is a one-time-only inspection for evidence of exhaust gas blowby after 500-600 hours of operation. The other 2 inspections, a visual inspection for pitting, distortion, concentricity or other abnormalities, and measurement of valve head thickness, are to be performed once every 5 years. This is not frequent enough to detect the problems which have occurred.

The design reviews for the lead engines (the valves did not receive a PNPP-unique DR) apparently did not determine the root cause of these problems, nor were any corrective actions formulated.

The consequences of these valve problems are far from benign. Chrome flakes from valve stems could be drawn into the cylinder, causing liner scoring, piston blowby, and eventually piston siezure. Blowby past te valves will result in a loss of cylinder power, and the hot combustion gases may cause further thermal stresses in the already substandard cylinder heads, thereby accelerating cracking.

The adverse operating experience for the valves demonstrates that they are not suitable for nuclear service. The DR/Qr Program has failed to properly evaluate and revalidate these components.

5. Components Improperly Excluded From Review

(a) 02-530A,B,C,&D, Platforms, Ladders, Stairs, and Supports

These items received no DR or QR. Evaluation should have been made as to whether the failure of these items during a seismic event could adversely affect other components necessary for proper engine operation.

(b) Foundation

This item was not even included in the Component Tracking System (and thus received no DR or QR) despite adverse PNPP experience, which is evidenced by Exhibit 56. After the Unit 1 engine foundations were grouted, it was discovered that some of the chock plates did not meet TDI's 85% bearing requirement. Some plates had as little as 10-15% bearing. Applicants accepted the condition as-is on the basis of a calculation performed by TDI, and provided that crankweb deflection checks are performed prior to startup, and at 20 hours and 168 hours of operation.

TDI's Instruction manual states that the foundation is to be constructed to the highest accuracy, and that the engine must be aligned before grouting, and that the engine weight should be distributed evenly on all sole plates. See Exhibit 57.

Engine misalignment can cause excessive crankweb deflections, which TDI admits can cause catastrophic crankshaft failure. See Exhibit 58. Another example of failures caused by insufficient contact between the engine and chock plates is given in Exhibit 59, from the PNPP Component Tracking System. Note that the corrective action was to grind the chock plates to achieve full contact.

A "loose" foundation will also lead to excessive vibration, which can cause other casualities. See Exhibit 60, the report of a Coast Guard investigation into failures of TDI engines on the icebreaker Northwind. Loose foundation bolts caused the following vibration-related failures:

> fractured 4 turbocharger mounting bracket bolts; fractured 3 exhaust bellows; many lube oil and water pump failures, with associated piping failures; one exhaust pipe failure; 3 governor failures. Ex. 60, Finding of Fact #46.

(Note also that this investigation found that crankweb deflection measurements, to be meaningful, must be taken when the engine is hot, i.e., after running 8-12 hours under load. Finding of Fact #26. It is not clear that Applicants are aware of this requirement.)

The Coast Guard's investigation of the Northwind foundation has produced evidence that casts doubt on the conservatisms, if any, in TDI's calculation. Exhibit 61 indicates that TDI doesn't "pay much attention to area of chock vs. bolt torque", in contrast to the Classification Societies and the chock supplier. Exhibit 62, information from the chock supplier, indicates that the maximum possible chock area should be used, and that, for the resin chocks in question, compressive stress should be limited to 500 psi, despite its compressive strength of 19,000 psi. This results in a factor of safety of 38. TDI's calculation assumes a factor of safety of 2.

Exhibit 63 is a calculation according to Lloyd's Rules of chocking and bolting criteria. It is not clear whether these criteria are specific to chock type; i.e., allowable loads may be higher for the steel chocks used at PNPP. However, given the inherent cons :vatism of the Classification Societies, as discussed above, the adverse experience resulting from insufficient chock bearing (Ex. 59), and the potential for catastrophic crankshaft failure, it is prudent to determine the adequacy of the as-built PNPP foundation according to Lloyd's Rules. Until proven otherwise, this should be considered an unacceptable condition.

IV. CONCLUSION

From the discussion above, it is clear that serious problems exist with the PNPP TDI DGs. They do not comply with GDC 1 and GDC 17. The Owners Group program has failed to resolve the significant design and quality problems. Applicants have failed to demonstrate the absence of a genuine issue of material fact. Their Motion for Summary Disposition of Issue #16 must be denied.

Respectfully submitted,

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