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Technical Evaluation Letter Report

Evaluation of Transamerica Delaval Inc. Diesel Generators

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ABSTRACT

The purpose of this report is to review the technical requirements for Transamerica Delaval Inc. (TDI) emergency diesel generators in the context of information supplied by the TDI Owners Group and information developed in the Nuclear Plant Aging Research Program and the application of current NRC regulatory concepts and knowledge. Reliability, maintenance, and aging information relationships are reviewed and compared to special license conditions imposed on TDI engines. The central question addressed is, can the TDI engines be regulated the same as the engines of all other manufacturers.

This report documents and spans the technical progress from the published regulatory documents affecting TDI engines to the current knowledge of TDI engine performance and reliability.

The Pacific Northwest Laboratory (PNL) has performed this analysis for the Nuclear Regulatory Commission's Office of Nuclear Reactor Regulation, Division of Engineering.

EVALUATION OF TRANSAMERICA DELAVAL INC. DIESEL GENERATORS

EXECUTIVE SUMMARY

Background

Beginning in 1983 the Pacific Northwest Laboratory (PNL) provided technical support to the U.S. Nuclear Regulatory Commission (NRC) staff in addressing questions regarding the adequacy of Transamerica Delavel Inc. (TDI) diesel-generators. These questions stemmed from serious problems with TDI diesels at nuclear power plants. Also as a result of the problems, a group of U.S. nuclear utilities formed the Transamerica Delaval, Inc. Diesel Generator Owners Group in order to address operational and regulatory issues relative to TDI emergency diesel generators (EDG).

The Pacific Northwest Laboratory supplied technical information was documented in a Technical Evaluation Report, PNL-5600, REVIEW OF RESOLUTION OF KNOWN PROBLEMS IN ENGINE COMPONENTS FOR TRANSMERICA DELAVAL INC. EMERGENCY DIESEL GENERATORS. The information in PNL-5600 along with staff evaluations and other information sources were compiled into NUREG-1216, SAFETY EVALUATION REPORT RELATED TO THE OPERABILITY OF EMERGENCY DIESEL GENERATORS MANUFACTURED BY TRANSAMERICA DELAVAL, INC.

In response to the background status and licensing conditions described in NUREG-1216, the TDI Owners Group sent to the NRC a licensing submittal on December 8, 1992 requesting a review of licensing conditions applied to TDI engines. In this submittal the Owners Group presented their rationale that the TDI EDG's be regulated in the same manner as any other diesel-generator in service in the nuclear industry. The purpose of this PNL technical report is to evaluate the TDI Owners Group Submittal, current knowledge of the best EDG management practices, and regulatory concerns related to these engines.

At the conclusion of the first TDI evaluation effort, the staff concluded that the TDI diesel-generators could safely perform their intended safety related function. The soundness of this decision has been upheld in that the TDI engines have not generated additional operational problems. Data from the Institute of Nuclear Power Operations (INPO) shows that the current reliability of the TDI engines is about one percent better than the industry average for all diesel engines. In general, for all of the many different inspections required by license conditions, the typical inspection results were shown to reveal no defects or indications of problems.

Results Summary

Criteria were developed and used to determine that adequate justification exists for removal of component-based license conditions. PNL recommendations are based on how well the criteria for changing license conditions were satisfied, as shown in this study. The criteria applied and their results are:

1. Adequate reasons should exist for changing applicable license conditions for the TDI engines. The reason criterion is satisfied in that good and logical reasons exist for considering a license change. These are:

   - NRC sponsored research (NUREG/CR-5057) has indicated the potential negative results of intrusive inspections on component and engine reliability.

   - Some inspections require bearings and other components with sliding fits and lubricated surfaces to be physically disturbed. In the best practice sense to achieve the lowest risk following such inspections, the engines really are not ready to respond to a plant emergency until after a break-in period.

   - To ensure public safety, NRC management has always had to direct regulatory attention to areas of greatest need. Changing the special attention and inspections currently applied to the TDI engines, in view of their good performance record, seems to be an opportunity for improving regulatory effectiveness.

2. Since the original regulatory issue was improvement of TDI engine reliability, the current TDI engine reliability should be equal to or better than the industry average. The criterion for a good record of reliability is satisfied.

   - The current TDI engine reliability was found to be equal to or better than the industry average. The current median reliability is 0.9906. This is about one percent better than the nuclear industry average, and well above NRC's highest goal of 0.975.

3. Because specific surveillances/inspections were imposed by regulation to ensure that acceptable engine conditions were being maintained, the inspection results should show no unacceptable findings. The criterion for an absence of inspection findings was achieved.

   - Specific surveillances/inspections were imposed by NRC regulations to ensure that acceptable TDI engine conditions were being maintained.

   - The results from these required inspections have shown no unacceptable findings, in fact most inspections are not showing any indications that need to be addressed as discussed in this report.

4. The owners group should have an active diesel management program with elements that are judged by the regulatory staff to be reasonably and equally effective in maintaining diesel reliability. The criterion for an effective engine management program is satisfied.

   - An active diesel-generator maintenance program is proposed by the TDI group backed up by specific plant procedures that would follow typical NRC regulations for all other manufacturers units and be

subject to normal NRC oversight procedures. The staff through regional inspectors and other usual regulatory practices could judge the effectiveness of this new TDI group approach in maintaining diesel reliability.

5. The underlying source or technical basis for the proposed regulatory change should be equal in authority to the current regulatory requirements. The criterion for a defendable regulatory basis is satisfied.

   - The underlying source or technical basis for the proposed regulatory change is equal in authority to the current regulatory requirements. Note that the underlying source or technical basis for the original regulatory conditions in NUREG-1216 was the information and recommendations by the TDI Owners Group with support from the manufacturer, so there is no change in the source of the technical requirements.

Review of Engine Components

Sixteen engine components detailed in the TDI submittal were reviewed by PNL and diesel expert reviewers. In general, inspections did not reveal hidden defects with a potential for an imminent failure, especially none with potential catastrophic results. Normal wear was found and some indications that were dispositioned as acceptable for additional service.

The TDI engines currently exhibit a general level of performance that is equal to or better than those of other manufacturers. In addition, the staff has new information, completed NRC research results, and even a new station blackout resolution reliability goal to help regulate diesel generator performance. Based on these two key points of good TDI engine performance and adequate regulatory tools, the staff is capable, through regional inspectors and other normal regulatory practices, to judge and regulate the effectiveness of the TDI group approach in maintaining diesel reliability.

Conclusions of the Diesel Experts

Three experts were used for this study; Paul Louzecky, Adam Henriksen, and B. J. Kirkwood. Together they represent well over 100 years of large diesel engine experience. They were of the opinion that there was no adverse data, the inspection results were good, and the TDI report represented adequate understanding of inspection and maintenance needs. On this basis along with their vast experience, they recommended consideration of realignment of the TDI engine regulatory requirements more to those regulatory practices considered normal for such equipment. This implies consideration of their observations of correct diesel management, and continued application of TDI specific information by the Owners Group.

1.0 INTRODUCTION AND BACKGROUND

The Pacific Northwest Laboratory (PNL) has provided technical support as needed since 1983 to the U.S. Nuclear Regulatory Commission (NRC) staff in addressing questions regarding the adequacy of Transamerica Delavel Inc. (TDI) diesel generators used to provide standby power for safety-related systems in several nuclear power plants. These questions stemmed from a crankshaft failure at the Shoreham Nuclear Power Station in August 1983, and from less serious problems with other TDI diesels at nuclear power plants.

The following Introduction outlines the 1983 to 1985 activities, and the Background text is intended to furnish more recent information.

1.1 INTRODUCTION

A group of U.S. nuclear utilities formed the Transamerica Delaval, Inc. Diesel Generator Owners Group in order to address operational and regulatory issues relative to Transamerica Delaval emergency diesel generators (EDG) used for backup power supplies in some U.S. nuclear power plants. The TDI Diesel Generator Owners Group established a comprehensive program, through a combination of design reviews, quality revalidations, engine tests and component inspections, to provide an in-depth assessment of the adequacy of the respective utilities' TDI diesel generators to perform their intended safety related functions.

The first major program element was characterized as Phase I and involved the resolution of generic known problems with TDI engines. A review of the accumulated operational experience resulted in the conclusion by the Owners Group technical staff that a limited number of components warranted priority attention and consideration as known problems with potentially generic applicability. Final reports for each of these components were submitted by the Owners Group to the NRC for review. The conclusion of this Phase I review was that with implementation of the report recommendations, TDI diesel-generators could reliably perform their intended function.

The second major program element, Phase II, involved design reviews and quality revalidations of selected engine components. The Owners Group Design Review and Quality Revalidation Program (DR/QR) was established to perform these examinations for each owner's engine in order to assess each engine's ability to reliably perform its intended design function. The effort was conducted by a centralized team of engineering personnel with specialized skills in appropriate fields including diesel generator design, operation, and manufacture.

The Pacific Northwest Laboratory provided technical support to the U.S. Nuclear Regulatory Commission staff in addressing questions regarding the adequacy of (TDI) diesels used to provide standby power. The scope of PNL's effort encompassed reviews of TDI engine-related information submitted to NRC by the TDI Diesel Generator Owners' Group and by individual licensees, and reviews of disassemblies and inspections of TDI engines at nuclear power plants. Participants in this effort included consultants to PNL who had

substantial experience in diesel engine technology. The PNL effort was documented in a Technical Evaluation Report, PNL-5600, REVIEW OF RESOLUTION OF KNOWN PROBLEMS IN ENGINE COMPONENTS FOR TRANSMERICA DELAVAL INC. EMERGENCY DIESEL GENERATORS.

The PNL-5600 report documented PNL's reviews of the resolution of problems identified by the Owners' Group in 16 components of TDI engines. PNL also addressed these components in earlier technical evaluation reports on TDI engines at seven nuclear power plants, and in several reports on the components themselves. The report reflected PNL's evaluation of all of the information that became available on the 16 components during these reviews. The information in PNL-5600 along with staff evaluations and other information sources were compiled into NUREG-1216, SAFETY EVALUATION REPORT RELATED TO THE OPERABILITY OF EMERGENCY DIESEL GENERATORS MANUFACTURED BY TRANSAMERICA DELAVAL, INC.

1.2 BACKGROUND

PNL was recently asked to provide additional technical support to the (NRC) staff in addressing questions regarding the license related inspections of TDI diesels. The scope of PNL's effort is to review TDI engine-related information submitted to NRC by the TDI Diesel Generator Owners Group and by individual licensees, and to evaluate the results submitted of required inspections of TDI engines, and to prepare recommendations for staff consideration.

At the conclusion of the Phase I and II effort (1983-1985) by the TDI Owners Group, the staff concluded that the TDI diesel-generators could safely perform their intended safety related functions and operating licenses were issued. The soundness of this decision has been upheld in that the TDI engines have not generated additional quality or operational problems. Data from the Institute of Nuclear Power Operations (INPO) shows that the reliability of the TDI engines is about one percent better than the industry average for all diesel engines. In general, for all of the many different inspections required by license conditions, the typical inspection results were shown to reveal no defects or indications of problems. In the few cases where indications were noted, they were dispositioned as fit for further service.

The staff is currently more aware of the influence of availability of the EDG system on plant safety. There is an improved safety benefit when both EDG reliability and availability are very high. This is true even when the plant is in a refueling mode. Many of the required TDI inspections cause the EDG system to be unavailable for relatively long periods. In addition, recent NRC sponsored studies (Hoopingarner et al. 1988 and 1989) have shown the negative influence of inspections requiring partial engine disassembly.

In response to the background status described, the TDI Owners Group sent to the NRC a licensing submittal on December 8, 1992 requesting a review of licensing conditions described in NUREG-1216. In this December submittal the Owners Group presented their rationale that the TDI EDG's be regulated in the same manner as any other EDG in service in the nuclear industry. The purpose

of this PNL report is to evaluate the current revised TDI Owners Group Submittal, knowledge of the best EDG management practices, and regulatory concerns applicable to diesel engines.

2.0 PNL ANALYSIS OF TDI OWNERS GROUP SUBMITTAL

The Pacific Northwest Laboratory used the experience discussed above as a basis for providing an analysis and technical support to the U.S. Nuclear Regulatory Commission staff in review of the TDI Owners Group submittal. PNL's principal investigator, Ken Hoopingarner, has determined that the TDI diesel-generators could be managed to safely perform their intended safety related functions within the boundaries of the Owners Group proposal to modify operating licenses.

PNL was able to prepare recommendations relative to each inspection requirement indicating that there is adequate and defendable justification for removal of the present component-based licensee conditions, based on the data available from the TDI Owners Group and with their present level of good cooperation. While this report scope is limited to TDI engine components with current license conditions, the criteria and methodology presented may be used in the future to review any TDI component with inspection or safety concerns. This should position the regulatory staff to consider regulating TDI engines in the same uniform manner as all other emergency diesel generators.

2.1 OWNERS GROUP SUBMITTAL AND MEETING

The TDI Owners Group sent to the NRC a licensing submittal for review of licensing conditions imposed by NUREG-1216, on December 8, 1992. On April 14 and 15, 1993 NRC and Pacific Northwest Laboratory (PNL) representatives met with the Owners Group in a meeting in Charlotte, N.C. at the offices of Duke Engineering and Services. The regulatory objectives for this meeting were: to review the data base, review the TDI submittal for additional information needed, and to ensure that all known regulatory concerns were addressed.

Another important purpose of Charlotte meeting from the NRC's viewpoint was to review in detail the submittal with the TDI Owners Group representatives to insure communication and understanding. This was accomplished on a page-by-page basis. The results of the page-by-page review were described by PNL in a letter report, which was transmitted to the NRC.

The Owners Group presented their justification and rationale that the TDI EDG's be regulated in the same manner as any other EDG in service in the nuclear industry. Their presentation included those components that do not have licensing conditions as well as those that do have licensing conditions associated with them.

Appendix A and B of the Owners Group Submittal gives the data that primarily was used to review the inspection requirements and results. Appendix A gives the specific inspection requirements in the Generic Maintenance and Surveillance Program and Appendix B gives the results of each of these

inspections. In general, the specific inspection results were typically given as, "No defects were found". Appendix B also listed the number of inspections made for each component.

At the review meeting in Charlotte, April 14-15, with the TDI Owners Group and the PNL and NRC representatives, missing information was noted and discussed as the submittal was being reviewed. The TDI Owners Group agreed to correct these deficiencies and this has been done. The latest revised submittal is much improved and supplied the missing information needed.

PNL has determined that the quality and quantity of information is adequate at this time for an informed judgement on the TDI Owners Group Submittal. Perhaps later some questions may arise, but the Owners Group has been very responsive to the NRC's need for correct information. Therefore, this should not result in any problems, nor delay the NRC decision effort.

Both the NRC and the TDI Owners Group agreed that the engine components that do have licensing conditions are the highest priority and concern. These Phase I components that do have licensing conditions recommended by NUREG-1216 are:

- Connecting Rods
- Crankshafts
- Block
- Turbochargers
- Cylinder Heads

Phase II components were also reviewed that do not have licensing conditions recommended by NUREG-1216 these are:

- Air Start Valve Capscrews
- Cylinder Head Studs
- Cylinder Liners
- Engine Base & Bearing Caps
- Engine Mounted Electrical Cable
- High Pressure Fuel Injection Tubing
- Piston Skirts
- Push Rods
- Rocker Arm Capscrews
- Connecting Rod Bearing Shells
- Jacket Water Pumps

2.2 TDI ENGINE OPERATION RESULTS SUMMARY

Valid research results depend on statistically adequate data and supporting information. PNL and the diesel expert investigators ideally would prefer a very large set of engines with many thousands of operating hours on each engine in the review of component performance. Realistically a judgement was made that with a Grand Gulf engine having operating time in excess of 2200 hours and a Catawba engine having operating time in excess of 1600 hours and with the other engines adding up to 9000 hours total operating time,

defendable decisions could be made. For fatigue concerns in ferrous materials after 3 X 10^6 cycles failures essentially cease, and 1 X 10^7 stress cycles is used as a very safe number for regulatory use. This translates to 750 hours of operating time for the regulatory safe number for the TDI engines and about 300 hours to reach 3 X 10^6 cycles. All engines in the set are past the operating time needed to minimize fatigue questions. Wear always has to be judged as to what is normal for the operating time accumulated.

2.3 REVIEW OF INSPECTION RESULTS

The component inspections required by current licenses are listed and described in Appendix A of the TDI submittal. Appendix B gives the results of each of the required inspections. For each component reviewed in this section, the number of different kinds of inspections (Appendix A) is shown first, followed by the total number of individual (Appendix B) inspections. The required different inspections have various frequencies such as once-a-month, once each refueling cycle, and other shorter and longer schedules. Therefore, the total number of all inspections shown is only intended to give an idea of the effort involved. Due to the vast schedule differences one has to review Appendix B to determine how many times a given inspection was performed and what detailed results were found. To assist in the review, NRC sponsored research on aging of diesel components (Hoopingarner, et al. 1987) was used in comparing service experience for these components.

Review of Connecting Rods

The 12 different connecting rod inspections are primarily intended to detect signs of fatigue, bearing wear, and fastener (bolt) defects. Two indications were found and one missing stud bolt. The indications were dispositioned as; no defect - acceptable for further service. The missing bolt did not result in an operational problem, and was dispositioned as; abnormal, but acceptable from an engine operability viewpoint. The bolt was replaced as were the components with indications even though they were capable of further safe operation. A total of 721 individual inspections did not result in detecting any potential component defects or serious problems with connecting rods.

Review of Crankshafts

The five different crankshaft inspections are primarily intended to detect signs of fatigue and bearing wear. One indication, minor pitting, was found. The indication was dispositioned as; no defect - acceptable for further service. About 530 individual inspections did not result in detecting any potential crankshaft defects or problems.

Crankshaft fatigue is a very early failure mechanism, usual failures are during break-in. Excessive bearing wear is a late failure item. Thus, the lack of inspection findings is to be expected.

Review of Blocks

The two required block inspections are primarily intended to detect signs of cracking. No problems were found in 264 individual inspections. This matches the NRC's aging data base on diesels where engine blocks had a very low failure rate, and most of these are early failures, usually in the startup period (Hoopingarner, 1987).

Review of Turbochargers

The seven different turbocharger inspections are primarily intended to detect signs of bearing wear, missing parts, and general performance indicators. Some bearing wear and missing parts were found in about 700 individual turbocharger inspection activities. The bearing wear indication was dispositioned by the manufacturer as; normal - acceptable for further service.

There is a belief indicated in the Owners Group Submittal that turbocharger broken or missing bolts and stationary vane material passed through the rotating elements. This is most likely correct due to the Quality Revalidation Program, where parts now missing were previously determined to be in place. Because loose parts in the rotating elements are a typical and very common failure mode which most often makes them inoperable, the diesel experts at first thought that these missing parts were probably manufacturing errors that were detected in these inspections.

Since these turbocharger conditions have been resolved as high cycle vibration, there is little reason to believe that continued regulatory required inspections at fixed intervals will result in finding additional parts that are damaged enough to detect, but not yet failed. Simply stated for fatigue considerations, the components with conditions leading to failure have already failed, and those surviving do not have these conditions.

In perspective, the Elliott turbochargers purchased for the TDI engines are also purchased by other manufacturers for use on their engines. So regulatory attention only on the TDI engine turbochargers may be technically more difficult to defend. Original TDI quality problems, including turbochargers, have been resolved by the TDI Owners Group Quality Revalidation Program.

Review of Cylinder Heads

The four different cylinder head inspections are primarily intended to detect signs of cracking and leakage, valve performance, and general performance indicators. Some valve degradation was found in about 700 individual cylinder head inspection activities, which was dispositioned as acceptable for further service.

Other than normal valve wear, head problems tend to be an early failure item. Cracking especially was a concern typical of early failures. Valve leakage on the other hand is a late failure type of problem, but engine monitoring is very effective in detecting it.

Review of Other Engine Components

Eleven engine Phase II components that do not have licensing conditions recommended by NUREG-1216 were reviewed by PNL and diesel expert reviewers. While these 11 components are not the focus of this report, it seems appropriate to at least summarize the many different inspections and overall results. In general, inspections did not reveal hidden defects with a potential for an imminent failure, especially none with potential catastrophic results. Normal wear was found and some indications that were dispositioned as acceptable for additional service.

Water pumps on TDI engines see high torsional vibration, up to 3 degrees at the pump. No surprise that high gear wear has been found. The gears, shafts, and keyways fail more often, as a result of this specific design, than the water pumps of the other manufacturers engines. Each manufacturer has their own specific weak engine components, so this is not an unusual situation. The TDI Owners Group is aware of this water pump weakness, due to shared experiences, as are the other owners groups of the other manufacturers of their specific weakness(es). The TDI Owners Group and the manufacturer are working on design, periodic replacement, and other potential resolutions to the water pump vibration problem.

2.4 PROPOSED TDI ENGINE MANAGEMENT PROGRAM

It is not recommended that the inspections required as part of current licenses be completely deleted. The Owners Group is not proposing this. They are only proposing that they be removed from the license conditions.

Appropriate inspections must continue, but schedules, scope, and especially the amount of intrusive inspections involving disassembly would be changed to match the current NRC philosophy on unavailability and licensee responsibility. Inspections would be planned to respond to monitoring and trending results where problems are indicated. Inspections would be performed where other maintenance activities make the component accessible, such as in response to failures of nearby components or where monitoring is indicating an end of component life conditions. The Owners Group will have to continue some appropriate inspections, especially those not involving engine disassembly. Inspections need to be defined and included as part of any well managed engine program. Elements of correct engine management have been reported previously to the NRC and industry (Hoopingarner, 1991).

The manufacturer is currently involved in revisiting maintenance and inspection schedules with the Owners Group. The Owners Group is also developing a generic diesel management program and plans to meet with the manufacturer during 1993 to discuss maintenance issues and perhaps finalize this activity. Typical NRC oversight procedures for diesel engines can support this proposed change to an active TDI Owners Group maintenance program backed up by plant procedures (U.S. NRC, 1979, Regulatory Guide 1.9).

3.0 PNL REGULATORY ANALYSIS

In the general approach used by PNL, a focus was maintained on those five components with license conditions as requested in the Task Order Statement of Work. This technical report while focused on the five components with license conditions may be applied to any engine component as to the criteria and conclusions.

Both the NRC and PNL agree that the engine components that do have licensing conditions are the highest priority and concern. These diesel engine components that were reviewed as part of the original TDI study and that do have licensing conditions are identified in NUREG-1216.

Another key part of the approach was to use observations and information from the April 14 and 15, 1993 Owners Group meeting in Charlotte, N.C. at the offices of Duke Engineering and Services attended by NRC and Pacific Northwest Laboratory (PNL) representatives. The meeting objectives of the NRC and PNL representatives included the review and understanding of the inspection data base and results to ensure that all regulatory concerns were addressed.

3.1 CRITERIA FOR RECOMMENDATIONS

This technical evaluation report presents three general and five specific criteria for judging the advisability of changing the regulatory basis for the TDI engines. All criteria were fulfilled, as discussed in this report.

General Criteria

Criteria were developed and used to determine that adequate justification exists for removal of component-based license conditions. General criteria for changing any license condition are usually based on three positive findings; a) there should be a good and logical reason(s) for the change, b) a good experience and record of performance must be demonstrated, and c) a defendable regulatory basis must exist, usually involving past proven methods and technology. These three general criteria were satisfied in this study, as discussed in the report section on the justification for changing the component-based license conditions.

Specific Criteria

In addition to the three general criteria, five specific criteria were developed to guide the justification and review process. The specific criteria are as follows:

1. Adequate reasons should exist for changing applicable license conditions for the TDI engines.

2. Since the original regulatory issue was improvement of TDI engine reliability, the current TDI engine reliability should be equal to or better than the industry average.

3. Because specific surveillances/inspections were imposed by regulation to ensure that acceptable engine conditions were being maintained, the inspection results should show no unacceptable findings.

4. The owners group should have an alternative to the license-based-inspections diesel management and program elements that are judged by the regulatory staff to be reasonably and equally effective in maintaining diesel reliability.

5. The underlying source or technical basis for the proposed regulatory change should be equal in authority to the current regulatory requirements.

3.2 OVERALL TDI ENGINE RELIABILITY DATA

The current TDI engine reliability was reported in the TDI submittal to be equal to or better than the industry average. For the TDI group of engines for the period January 1990 to December 1992 the median reliability is 0.9906, as determined from INPO data. This is about one percent better than the nuclear industry average reliability, and well above NRC's highest goal of 0.975.

3.3 PROPOSED TDI ENGINE REGULATORY OVERVIEW

The TDI engines currently exhibit a general level of performance that is considered at least equal to those of other manufacturers, at this time. In addition, the staff has new information, completed NRC research results, and even a new station blackout resolution reliability goal to help regulate diesel generator performance (U.S. NRC. 1988). Based on these two key points of good TDI engine performance and adequate regulatory tools, the staff is capable, through regional inspectors and other normal regulatory practices, to judge and regulate the effectiveness of the TDI group approach in maintaining diesel reliability.

The Owners Group should have a diesel management program with elements that are judged by the regulatory staff to be reasonably effective in maintaining diesel reliability. The TDI Owners Group should propose a combination of monitoring and trending, continued appropriate inspections, and continued involvement by the manufacturer .

The staff needs to be aware of the potential conflict of interest in manufacturers recommendations. Engine overhauls generate considerable revenue for the manufacturers. For this reason the manufacturers as a group have very little motivation to increase schedules to longer periods between overhauls. This is not in harmony with the knowledge that overhauls often lead to lower reliability for a period until all of the new problems are worked out of the system (Hoopingarner et al. 1988 and 1989). Thus, the staff will have to balance and decide on the best schedule for overhauls to ensure that public safety is maintained.

To ensure that public safety is being maintained and not having unlimited resources, NRC management has always had to direct regulatory attention to areas of greatest need. In view of good reliability and the absence of significant inspection finding results, changing the special attention and inspections currently applied to the TDI engines seems to be an opportunity for improving regulatory effectiveness.

3.4 PNL RECOMMENDATIONS

Criteria were developed and used to determine that adequate justification exists for changing license conditions by removal of component-based license conditions. PNL recommendations are based on how well the criteria for changing license conditions were satisfied. The three general and five specific criteria were satisfied as shown in this study.

a) There should be a good and logical reason(s) for the change.

The answer for this general criterion is the same as for specific criterion 1. There are three regulatory reasons for considering license changes. First, in accordance with the Commissions stated policy and to be able to comply in the future with the Maintenance Rule seems to indicate that the typical diesel engine regulatory basis (as applied to engines of different manufacturers) is more consistent and necessary for licensee compliance. Second, NRC sponsored research (NUREG/CR-5057) has indicated the potential negative results of intrusive inspections on component and engine reliability. Third, when bearings and other components with sliding fits and lubricated surfaces are physically disturbed, a break-in period with lower loads is considered the best practice. In the best practice sense and with the lowest risk, the engines really are not ready until after the break-in-period to respond to a plant emergency. Thus, criteria a) and 1. are satisfied in that good and logical reasons exist for considering a license change.

b) A good experience and record of performance must be demonstrated.

The answer for this general criterion is the same as for specific criteria 2 and 3. The current TDI engine reliability was found to be equal to or better than the industry average. For the TDI Owners Group for the period January 1990 to December 1992 the median reliability is 0.9906. This is about one percent better than the nuclear industry average, and well above NRC's highest goal of 0.975 (U.S. NRC. 1988)

Specific surveillances/inspections were imposed by NRC regulations to ensure that acceptable TDI engine conditions were being maintained. The inspection results discussed in this letter report have shown no unacceptable findings, in fact most inspections are not showing any indications that need to be addressed as discussed in this report.

Note that the Owners Group is not proposing that the inspections required as part of current licenses be deleted. Appropriate inspections must continue, but schedules, scope, and especially the

amount of intrusive inspections involving disassembly would be changed to match the current NRC philosophy on unavailability and licensee responsibility. The Owners Group will have to continue some inspections, especially those not involving engine disassembly, and is working with the manufacturer in revisiting maintenance and inspection schedules for the group.

Since all TDI engine owners belong to the group and are participating in the process, a certain amount of beneficial peer pressure is to be expected. An example can be found in the INPO experience. The INPO industry group formed for the purpose of improving reactor performance by shared information and experience. After this performance data was tabulated and shared, it seemed that utilities with lower performance improved the most. Observers of this process thought it was because the lower performers did not want to be seen by their peers to be in the bottom of the group. The TDI group dynamics should have the same results. This is an important safety benefit.

c) A defendable regulatory basis must exist, usually involving past proven methods and technology.

The answer for this general criterion is the same as for specific criteria 4 and 5. The underlying source or technical basis for the proposed regulatory change is equal in authority to the current regulatory requirements. Note that the underlying source or technical basis for the original regulatory conditions in NUREG-1216 was the recommendations by the TDI Owners Group with support from the manufacturer, so there is no change in the source of the technical requirements.

The Owners Group is developing a recommended diesel management program with the manufacturer and plans to meet with the manufacturer to discuss maintenance issues and perhaps finalize this activity in 1993. An active diesel-generator maintenance program backed up by specific plant procedures would follow typical NRC regulations for all other manufacturers units and be subject to normal NRC oversight procedures. The staff through regional inspectors and other usual regulatory practices may judge the effectiveness of this new TDI group approach in maintaining diesel reliability.

At the April 14 and 15, 1993 Owners Group meeting in Charlotte, N.C. at the offices of Duke Engineering and Services attended by NRC representatives, the group agreed to be guided by the generic group submittal. The generic licensing submittal should address each EDG license requirement that is being removed as a license condition. The group agreed in principle that each member utility would adopt the group's proposed resolution or mitigating action and that all actions were intended to be acceptable to the manufacturer.

The five specific criteria to guide the justification and review process were satisfied as described above.

1. Adequate reasons should exist for changing applicable license conditions for the TDI engines. Three good reasons are presented in this report.

2. Since the original regulatory issue was improvement of TDI engine reliability, the current TDI engine reliability should be equal to or better than the industry average. Current TDI reliability was shown to be better than the industry average.

3. Because specific surveillances/inspections were imposed by regulation to ensure that acceptable engine conditions were being maintained, the inspection results should show no unacceptable findings. The surveillances/inspection results were quite good in that no impending failures were discovered and generally good engine conditions were confirmed.

4. The Owners Group should have a diesel management program with elements that are judged by the regulatory staff to be reasonably effective in maintaining diesel reliability. The TDI Owners Group has proposed a combination of monitoring and trending, continued appropriate inspections, and continued involvement by the manufacturer. These elements are part of the TDI engine management group approach.

5. The underlying source or technical basis for the proposed regulatory change should be equal in authority to the current regulatory requirements. As discussed in this report, the same technical source, the TDI Owners Group, is supplying the basic information. That source was also used in NUREG-1216 for the original requirements.

4.0 DIESEL EXPERT REPORTS

Independent diesel generator experts were used to ensure that the TDI submittal was carefully reviewed. Three experts who were used on the original TDI investigation and were also had experience with the NPAR aging program data and information were used for this review of the submittal.

The diesel engine experts were requested to determine that they had adequate information needed to make an informed judgement. They generally wished to see more operating hours, but were satisfied that operational information was adequate to judge that TDI engine operation at authorized loads could be regulated within normal NRC regulatory oversight procedures for emergency diesel generators. At 300 operating hours, stress cycles are about 3×10^6, which is past the fatigue curve bend for iron alloys. It appears all TDI engines have this milestone.

4.1 CONCLUSIONS OF THE DIESEL EXPERTS

Telephone discussions with the EDG experts regarding inspection requirements and their letter reports are summarized here. Three experts were used for this study; Paul Louzecky, Adam Henriksen, and B. J. Kirkwood. Together they represent well over 100 years of large diesel engine experience. They were of the opinion that there were no adverse trends in the data, the inspection results were good, and the TDI report represented adequate understanding of inspection and maintenance needs. On this basis along with their vast experience, they thought that consideration of realignment of the TDI engine regulatory requirements more to those regulatory practices considered normal for such equipment was a positive action.

The diesel engine experts confirmed that the regulatory requirements on TDI engines may be reconsidered by the NRC at this time. They based this judgement on information on the current reliability of TDI engines, on the results of inspections of the last several years, and on their own experience with large diesel engines. It was pointed out by these experts that each manufacturer has strengths and weaknesses in their design. In perspective, all owners groups must address the unique maintenance needs for their specific engine to keep reliability numbers acceptable. With a current median unreliability of 0.0094 the TDI Owners Group seems to understand the maintenance needs of this engine, and are managing their program well.

After review of the diesel engine expert's reports it can be concluded that there are no new concerns or issues in these reports. Individual diesel expert reports cite TDI engine management practices, inspections, or precautions to be taken. However, these comments are either known regulatory issues or responsibilities of the owners. To be sure these observations by the experts are incorporated in any TDI resolution, PNL has been instructed by the NRC Technical Manager to supply this information directly to the TDI Owners Group. This information transfer has been completed.

4.2 SPECIFIC RECOMMENDATIONS

Paul Louzecky offered these specific recommendations:

- Power output should be limited to current authorized loads for the River Bend station due to torsional vibration considerations and Grand Gulf due to connecting bolt size. Power output is a normal regulatory matter and no plans for changing loads are under consideration.

- Due to the pump location, TDI engines have a water pump torsional vibration wear problem. He recommends that the Owners Group inspect/replace/refurbish these pumps on a schedule that will avoid failures. Design changes may also be considered.

- On the 16 cylinder engines, it is recommended that connecting rod bolts be checked for tightness every other refueling as part of the TDI Owners Group program.

- He noted that even after ten years in nuclear service engines do not have many accumulated hours compared to more normal service engines. With correct monitoring and supporting program elements, it seems unnecessary to have mandatory overhauls at ten-year intervals. Supporting program elements include the completion of some 10-year inspections and good inspection results.

PNL concurs with these observations by Paul Louzecky. Power output is a standard technical specification regulatory requirement, so any change to a more normal NRC regulatory environment will still include specified power. The water pump problem is known to the Owners Group and it is their responsibility to control. Bolt loosening and overhaul periods are typical maintenance items within station management control. However, Regulatory Guides require overhauls to be as recommended by the manufacturer. Extending the overhaul period will require convincing the NRC that this is safe and prudent. In general, this will require some acceptable percentage of the engines to have completed a ten-year overhaul to make a completely convincing case. The percentage number will be somewhat dependent on overhaul results and findings, with absence of degradation results tending to a lower number.

Adam Henriksen offered these specific recommendations:

- Deterioration of the "O" ring seals between the cylinder liner and the engine block is a special consideration in establishing the correct overhaul period. He noted the this seal deterioration is primarily a function of time and to some degree it may be affected by excessive piston slap. Pulling samples of liners to determine this "O" ring condition is the only way to monitor this issue in considering an extension of the overhaul period. Within the current ten-year period, leakage of this seal is not expected. In this application of static "O" ring service, considerable elastic property loss can occur before danger of leakage occurs.

- Adam recommended that connecting rod bolts be checked for tightness every five years as part of the TDI Owners Group program. He also was concerned that the turbochargers be managed properly within the Owners Group responsibility.

- Recommendations were given on how to manage engines that exceed power ratings by more than insignificant time/power parameters or that operate at critical torsional conditions. He recommended a 750 hour operational run to verify absence of new fatigue sensitivity that could be caused by the abnormal operation. He also noted that as each unit completes 750 hours of operation, crankshaft and other fatigue based inspections could be eliminated.

- He recommended surveillance as outlined in NUREG/CR-5057 as important. To these surveillances he added, cylinder compression and maximum pressures and cylinder leak-down testing (cold engine) during refueling outages.

PNL concurs with these observations by Adam Henriksen. All of these observations have been discussed with both the Owners Group and the NRC. The "O" ring concern is especially important, since there is no way to monitor the condition of this component without partial engine disassembly. Resulting seal leakage can be detected, but this is not the best way to discover the problem. Extending the overhaul period will require a resolution of this "O" ring aging process to a known useful time period. This will have to be done by a structured and orderly process to arrive at a safe period for "O" ring performance.

B. J. Kirkwood offered these specific recommendations:

- He noted that with current information the ten-year inspection of nuclear service TDI engines is important. It seems necessary to have completed at least a few TDI engine overhauls after ten-year intervals, to be able to judge the further adjustment to another time period. This position appears to be certainly defendable. This overhaul extension process could still be accomplished by the Owners Group within more normal regulatory provisions.

- Turbochargers remain a concern. The risk of severe damage/failure is great from loose metallic components being ingested into rotating turbo sections. He believes that current inspection items 2, 5, and 6 are important and should be continued by the Owners Group. Similar to the above engine overhaul, it seems necessary to have completed at least a few TDI turbo overhauls after five and ten-year intervals, to be able to judge the adjustment to another inspection schedule. His position appears to be defendable. This also could be accomplished by the Owners Group within more normal regulatory provisions.

- He noted that connecting rod issues did not seem to be completely resolved. He cited incomplete data and drew from his knowledge of the original quality problems/resolution effort on the importance of these technical issues. PNL has obtained additional information through meetings and revised TDI information to minimize the rod concerns.

PNL generally concurs with these recommendations by B. J. Kirkwood as outlined here. Extending the overhaul periods will require a structured approach to get the needed aging process information and to arrive at a known useful time period. While these items have already been discussed in this letter report, it may be noted how these experts, acting independently, both confirm current regulatory knowledge and extend the details of a good owners group program.

4.3 LETTER REPORTS FROM EDG EXPERTS.

Letter reports from the diesel generator experts to support this report are shown in Appendix B. However, please note that there are two important considerations to take into account in reviewing these letters. First, each

expert was reached several times by telephone to discuss details of the task results. Some of this telephone information is included in the PNL concurrence text and elsewhere. This PNL evaluation report is intended to complete the expert review process and to resolve any differences, due to PNL's more direct involvement in the Task and overall diesel regulatory knowledge. For example, the experts did not have direct access to the Owners Group to be able to judge the group intent and commitment and to ask questions. Also due to subcontracting guidelines, the experts were restricted in time and scope and instructed to spend more time in analysis and telephone discussions and less in the letter report effort.

The attached diesel consultant letters generally support NRC observations and the normal regulatory overview process. They also confirm that the Owners Group must continue to manage the engine aging process in an effective way through monitoring and trending and other supporting program elements.

5.0 OVERALL CONCLUSIONS

This technical evaluation report addressed the TDI Owners Group licensing submittal sent to the NRC for review of licensing conditions imposed by NUREG-1216, on December 8, 1992. In this submittal, and revisions to it, the Owners Group presented their justification and rationale that the TDI EDG's be regulated in the same manner as any other EDG in service in the nuclear industry. Their presentation included data on all important engine components. Appendix A and B of the Owners Group Submittal gives the data that primarily was used to review the inspection requirements and results.

PNL determined that the quality and quantity of information was adequate at this time for an informed judgement on the TDI Owners Group Submittal. Data from the Institute of Nuclear Power Operations (INPO) showed that the current median reliability of the TDI engines was about one percent better than the industry average for all diesel engines. In general, for all of the many different inspections required by license conditions, the typical inspection results were shown to reveal no defects or indications of problems. Inspections did not reveal hidden defects with a potential for an imminent failure, especially none with potential catastrophic results. In the few cases where indications were noted, they were dispositioned as acceptable for additional service.

A total of about 3,000 individual engine inspections were reported by the TDI group. This number seemed adequate to recommend that the TDI engine was performing in an acceptable fashion for regulatory purposes.

The conclusions of the PNL and the consultant diesel experts were that there was no adverse data, the inspection results were good, and the TDI report represented adequate understanding of inspection and maintenance needs. On this basis along with their vast experience, they thought that consideration of realignment of the TDI engine regulatory requirements was appropriate. It is recommended that those regulatory practices considered normal for all other engines be adopted for the TDI engines.

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U.S. NRC. 1979. Regulatory Guide 1.9: Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants. Revision 2. U.S. Nuclear Regulatory Commission, Washington, D.C.

APPENDIX A

OWNERS GROUP MEETING, ACTION ITEMS

NRC/TDI Group Close-Out Meeting

On April 14 and 15, 1993 NRC and Pacific Northwest Laboratory (PNL) representatives met with the TDI Owners Group in a meeting in Charlotte, N.C. at the offices of Duke Engineering and Services. At the conclusion of the first days meeting with the TDI group members, Mr. Jai Rajan of the NRC and Mr. Ken Hoopingarner of PNL discussed the meeting Results. The objective of this discussion was to ensure that the TDI Owners Group had a written list of action items that stated the regulatory concerns. The following list was developed for presentation to the Owners Group.

NRC/PNL
LIST OF PROPOSED ACTION ITEMS
DATED 4-15-93

1. The Owners Group will update the December 8, 1992, generic licensing submittal as discussed in detail on April 14, 1993, by 5-3-93.

2. The Owners Group has responsibility to review NUREG-1216 for each component concern to ensure that in the above referenced submittal, the concern is either answered fully in the license submittal, or the Owners Group has an action to supply the data or answer needed.

3. The (revised) Generic Licensing Submittal must address that for each EDG license requirement that is being removed, as a license condition, the Group agrees in principle to adopt the Group's proposed resolution or mitigating action and that all actions are acceptable to the manufacturer.

APPENDIX B

DIESEL EXPERT'S LETTER REPORTS

May 5, 1993.

Adam J. Henriksen
7731 N. Fairchild Rd.
Fox Point, Wi. 53217.

Battelle - PNL
Sigma 3 Building
3160 George Washington Way
Richland, Wa. 99352.
Att. Mr. Ken Hoopingarner
Sr. Research Scientist.

Subject: TDI Owners Group.
Generic Licensig Submittal for Emergency Diesel Generators. Conditions of License for Utilities with Enterprise Engines.

Dear Mr. Hoopingarner,

Receipt of your letter dated April 27, 1993 with the attached TDI Owners Group report is hereby acknowledged. Comments on the report are as follows:

NRC SUBMITTAL ADDITION. Suggested addition to the Executive Summary
Since the manufacturer in this case must have somewhat limited experience with these engines, itis suggested that PNL be allowed to review the revised maintenance program before it is finalized..

3.1 Engine Overhaul Frequency.
a. The 9000 hrs of operating experience averages out to 1000 hrs per utility or approximately 300 - 400 hrs per engine, which is not all that great for a data base on reliability.
b. Before making a decision to do away with the 10 year overhaul as currently required by NUREG 1216, the condition of piston rings and cylinder to block sealing "O" rings should be determined. With the number of starts being close to the number of operating hours the piston ring wear is bound to be relatively high. To some degree piston wear may be monitored through compression pressure, crankcase vacuum and cylinder leak - down data. Some correlation between hours of operation/No of starts and piston ring wear may be established in order to determine when it would be prudent to re-ring the pistons. Deterioration of the liner to block "O" rings is primarily a function of time and to some degree by engine operation if there is significant piston slap. Unfortunately, there is no other way to establish the"O" rings condition than to pull liners and determine the condition of the rings. Pulling a few liners at random at various sites may help in determining a time limit for when the "O" rings need to be replaced.

3.51 Connecting Rods, DSR - 48 Inline Engines.
Recommend checking conrod bolt torque every 5 years.

3.52 Connecting Rods, DSRV - 16 Engines.
Recommend checking conrod bolt torque every 5 years.

3.81 Crankshafts - DSR - 48 Series Engines.
Should any engine exceed its maximum rating as dictated by critical torsional condition, a 750 hour run at its maximum rating followed by a complete inspection of the crankshaft should be required before the engine is placed back in service.

3.82 Crankshafts - DSRV - 16 Engines.
Eliminate units from inspections as they complete 750 hours of operation at the designated maximum rated load and are cleared by the final inspection.

3.16 Turbocharger.
I have heard it all before and I still find the statements contradictory. First of all, I do not believe it is possible for pieces the size of guidevanes to go through a turbocharger operating at around 15000 RPM without creaming the turbine. Secondly, should this, against all odds, happen, the turbocharger performance and efficiency would deteriorate. Failure to recognize this can only be due to either that the turbo nozzle ring came without the vanes in question, or the recorded data is insufficient to make this determination. Refering to ATTACHMENT 1, PART A, TABLE 1 it is obviuos that the necessary data for turbocharger performance evaluation are not recorded. It is suggested that the data required for such evaluation be included in their hourly surveilance parameters. Refer to NUREG/CR - 5057, APPENDIX A, page A.3 Air to Engine and page A.4 Exhaust.

ATTACHMENT 1, Part A, TABLE 1.
In addition to data suggested above, also iclude Cylinder Maximum and Compression Pressures during the 24 hour endurence run at re-fueling time.

ATTACHMENT 1, PART A, TABLE 2.
INclude cylinder leak-down test with cold engine during re-fueling.

Adam J. Henriksen.

COVENANT ENGINEERING

PO Box 788
Buena Vista, CO 81211
719/395-6056

May 12, 1993

Mr. Ken Hoopingarner
Battelle / Pacific Northwest Labs
PO Box 999
Richland, WA 99352

Re: TDI/OG Report on Licensing Conditions

I have reviewed the documentation from the TDI/Owners Group concerning their request for relief on the special conditions for DR/QR and ongoing M/S for these TDI/Enterprise EDG units.

In several instances I find their proposals acceptable. However, I do have some uncertainties, in general and on a few specific components; these are outlined below. Some might be relieved via more complete information -- either to us who are making these technical reviews, or at least to you (as B/PNL) or to appropriate staff of the Nuclear Regulatory Commission in final determinations.

GENERAL:

1 Much is made of the fact that these units have now been positioned for over ten years (although I believe not all nuclear units they serve have been in operation that long). Emphasis is also given to the number of EDG units involved, and citation is made of the **combined** number of operating hours. But while all this is supportive, I find these statistics largely uncompelling.

What counts more are the number of hours run by the individual units, and in many situations the character of such operation (principally loads experienced in those hours). It would appear from computation that few have exceeded 750 hours of loaded operation (during which time fatigue problems might have arisen, since to reach 10^7 cycles at 400 rpm, on 4-cycle units, requires nearly 750 hours). I believe one or more were run to over 750 hours in the 1984 era; without failures in the suspect parts this somewhat substantiates this request; but what of others?

Furthermore, none or few have reached the ten-year **in-service, operational** milestone for a major inspection under the M/S criteria operative to this point. So, it appears to me this may be a 'last-ditch' effort to avoid this milestone inspection (which might very well itself then clear all concerns which might yet lurk).

To me all of this is not an adequate 'experience envelope'. Indeed, there is ongoing hearsay evidence of problems with TDI units in other service that continues to raise a caution flag -- maybe not inordinate or unexpectable problems, but nonetheless worthy of reflection in these deliberations.

Indeed, I am troubled by this whole endeavor (although I will acknowledge that much of what they offer as supporting evidence -- evidence that in the documentation we have is more qualitative than technically quantitative -- is rather supportive of their request).

2 In Sections 4 and 5, on Unreliability and Unavailability, statements are made that more input from five different plants is needed in order to complete the statistical picture. This implied inadequacy of data is of concern. To reinforce this concern, it is evident that some of the units are exhibiting over four times the unreliability/unavailability of the "median" levels of this population. No comments are incorporated to adequately explain this pattern.

[Is the term "median" properly used? That would be the unit index in the middle of a rank order, and in neither case is the figure cited actually such. But neither are they the 'mean' (average) of the figures cited (although it could be the average weighted by hours, for example). This may not be significant, but should be explained.]

3 In Sec 5, re: Unavailability, the closing paragraph gives a possibly self-serving/self-fulfilling argument that by largely eliminating the special TDI inspections the unavailability indices would be improved. To me that is a spurious argument: although probably true, it merely enhances a statistic and ignores the underlying reasons the inspections were required initially. If a PM action is actually justified by a need for safety -- and to assure reliability -- it shouldn't be avoided/eliminated merely to show a better record. [If this line of thinking underlies this whole endeavor to reduce/eliminate the special TDI inspections, then the need for such may actually be greater than we realize.]

SPECIFIC:

1 **3.1 -- Engine Overhaul Frequency** -- See point General-1 above for comments applicable to the gross number of hours of operation, as cited in their para 2. I do not feel the statistics provided justify the conclusions reached and request made.

In their para 1 mention is made of the shift from 5-year to 10-year overhaul and inspection. But most of the units have not reached ten years. So even though few problems have been found via other inspections and occurrences, it is not established that the ten-year requirement would not reveal such. [Furthermore, my recollection of development of the shift to ten, from five years was

that this would reduce the down-time and costs, and would be backstopped by the condition/performance monitoring, et al. We technical experts used at that time were reluctant, as I recall, to adopt this. But now we are asked to forego even that. Absent better justification, I am hesitant.]

On page 7 note is made "the manufacturer" endorses the suggested change. However, this is not the **same** manufacturer, not the **same** people (except maybe in rare cases) who were involved in original design, installation and problem solving. The present "manufacturer" has little at risk should they err in this judgment.

2 **3.2 Air Start Valve Capscrews** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

3 **3.3 Engine Mounted Electrical Cable** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

4 **3.4 Engine Base and Bearing Caps** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

5 **3.51 Connecting Rods - DSR Inline Engines** -- What is the disposition of PM item #3, as cited in para 1? How might it affect the instant question?

The conn rod problem involved relates, in part, to fatigue life. There is no evidence provided (in the extant documents) to prove that a substantial number of conn rods have achieved the necessary cycles (10^7), at appropriate stress levels (engine loads). This is especially true for these inline units, since so few are in operation. Hence, I do not think the request is supportable.

6 **3.52 Connecting Rods - DSRV Engines** -- (See second para in #5 immediately above, also applicable here. In fact, there is no evidence adduced which assures these were not all from the same engine, or maybe only one plant.)

If the request is granted, the provision concerning Grand Gulf is acceptable.

7 **3.6 Connecting Rod Bearing Shells** -- Under the circumstances noted in the report, no comments are possible, except to say the case is not proven.

8 **3.7 High Pressure Fuel Injection Tubing** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

9 **3.81 Crankshafts - DSR-Inline Engines** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience, and specifically including evidence of adequate cycles and concurrent loadings.

10 **3.82 Crankshafts - DSRV Engines** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience, and specifically including evidence of adequate cycles and concurrent loadings.

[Maybe not so incidentally, in para 1 of "Background" mention is made of "... 16 pistons driven by 8 articulated connecting rod sets." (emphasis added) One wonders if the person writing the request knows anything about engines. By extension, one wonders if the underlying objective represents good intentions, or merely a self-serving desire to avoid an onerous and expensive license provision.]

11 **3.9 Jacket Water Pump** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

12 **3.10 Cylinder Block / Liners** -- The suggested change in PM and M/S is acceptable (assuming observations are made with engines warm and under nominal full-load), with due recognition of the above caveats on number of years and hours of experience.

13 **3.11 Piston Skirts** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

14 **3.12 Cylinder Heads** -- In second para of "Background" a reference is made to "... the air start cocks open ...". The comment above, in point #10, applies here also. **"Cylinder cocks"** are to be opened; these have nothing to do with the air start system per se.

Urder "Results of Inspections" there is reference to the "... root cause of the excessive valve lash ... attributed to back pressure in the exhaust system during the start sequence ...". This sounds improbable. Of course, regardless of the actual cause, it is good that the inspections were made, or the problem might have grown more serious.

Under "Conclusions" comment is made that "... major disassembly, such as head removal, may result in increased unreliability ...", citing previously referenced NUREG reports (presumably NUREG/CR-5078, PNL-6287 -- see their pg 6). I question the applicability of this reference to this subject, and hence the seemingly self-serving conclusion drawn.

15 **3.13 Push Rods** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

16 **3.14 Cylinder Head Studs** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

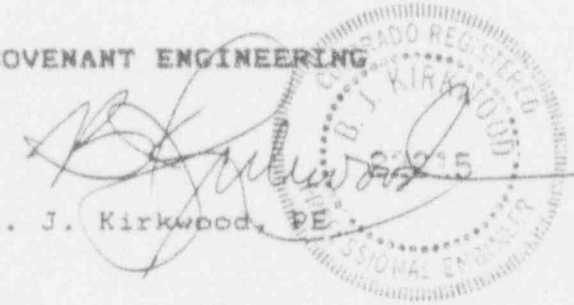
17 **3.15 Rocker Arm Capscrews** -- The suggested change in PM and M/S is acceptable, with due recognition of the above caveats on number of years and hours of experience.

18 **3.16 Turbochargers** -- I remain greatly disturbed that metallic components from the pre-turbo system, or the stationary blades themselves, continue to fail and be ingested into/through both the stationary and rotating turbo sections. The risk of severe failure is great, despite **apparent** lack of serious damage to date. I believe PM items 2, 5 and 6 should continue as previously stipulated.

Furthermore, if the problem of failing stationary vanes has never been addressed (as I strongly urged in 1984 and 1985), then there has been a failure of proper operational, engineering and management concern, at **all** levels.

Please advise if further evaluation and comment is desired.

COVENANT ENGINEERING



B. J. Kirkwood, PE

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ENGINE SYSTEM ANALYSTS AND PROBLEM DETERMINATION

ENGINE DESIGN SPECIALISTS AND ENGINE SERVICES

May 3, 1993

Dr. Ken R. Hoopingarner
Senior Research Engineer
Battelle Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington 99352

Subject: Owners Group Licensing Submittal To NRC on The T.D.I. Emergency Diesel Engines.

Dear Mr. Koopingarner:

The Owners Group report on the Transamerica Delaval Emergency Diesel Engines on their prescriptive tear downs and inspections as a means of licensing and as submitted in their letter of December 8, 1992, and the NRC document NUREG-1216 were reviewed. It is agreed that after more than 5 years of engine condition monitoring and the Owners (DR/QR) effort the NRC directive on the emergency diesel engines is restrictive. The Nuclear Power people have had sufficient experience to understand the engine problems, and because the engine problems have been no greater than those experienced by other emergency diesels, the request to ease the monitoring requirements is timely.

Based on this Owners Group report showing their condition monitoring and my vast experience, the TDI engines have shown sufficient reliability. The NUREG-1216 should be relaxed allowing the Nuclear Power Plants with the TDI engines to operate in a normal manor without these specific engine restrictions.

After all these years of engine operating experience, and specific detailed parts inspection and condition monitoring the continued inspection practice can be relaxed and handled the same as other typical engines.

The TDI engines are equipped with crankpin and main bearing alarms and the engine oil is monitored for wear metals, so complete dismantling of the engines, even after 10 years seems unnecessary and even detrimental. The inspection (boroscope) of the liners and a compression and firing pressure check of each cylinder will indicate the engines condition. Even after 10 years these engines have not accumulated very many hours.

There are however a few specific restrictions that should be considered, that are specific to these engines, as follows:

1. The power output limit, for River Bend should be maintained due to torsional vibrations.

2. The power output for Grand Gulf should also be limited because of the connecting rod bolt size.

3. The engine water pump drive on all these engines should be inspected every other refueling for drive gear tooth scuffing and pump impeller tightness, a torsional problem.

4. Continue checking the connecting rod bolts for tightness on the 16 cylinder engines, every other refueling.

Sincerely yours,

Paul J. Louzecky

Paul J. Louzecky

Some General Problems Relating To The Nuclear Power Plant Emergency Diesel Engines.

The TDI Enterprise Engines

1. Continue the oil analysis for wear metals, Total Base Number and Pentanes.

2. Continue to inspect the liners for wear and scuffing. This problem is monitored by the oil analysis and the boroscope inspection and the liner inspection through the crankcase door openings. The use of a synthetic oil such as Mobilgard 120 seems to solve the scuffing problem.

3. Inspect the inside of the crankcase for bearing metals.

4. Could pressure check, the engine cooling system for water leaks say every ten years. The air check is a little better than a water check.

5. The engine exhaust valves tend to stick. Apparently the valve guide recess in the cylinder head part of the guide, packs with carbon causing the sticking problem. When the cylinder heads are removed these recesses should be cleaned out.

6. Increase the emergency starting time as much as possible to reduce the turbocharger bearing wear and reduce the exhaust manifold expansion joint problems.

7. Check out the entire front gear train for gear tooth scuffing due to torsional vibrations, say once every 10 years.

8. Add a manual throttle control to the engine so it could be controlled from the engine room for starting and operation.

9. Recommend slow starting of the engines once a week to keep the cylinder liners lubricated and ready for an emergincy start.

10. Continue to use a straight run distillate fuel oil or the use of an additive to prevent the jelling of the fuel.

11. Change to an electronic governor such as the Woodward 701 which makes engine room operation much easier.

12. Keep the engine manifold temperature above 130 F to prevent the formation of condensate in the manifold. Provide air and water bleeds at both ends to drain out the condensate.

13. Replace the pneumatic system with electric relays. This change will eliminate many of the emergency control and shut down problems.

Fairbanks Morse Engines

Lubricate the upper crankshaft better in an emergency start.

Cooper Bessemer Engines

1. The corrugated liner sealing bellows called Wrinkle Bellies, crack and fatigue allowing water to leak into the crankcase oil.

2. The engine after cooler, cools the manifold air below the dew point. The condensate collects in the manifold and enters the cylinders. The air temperature should be raised to about 130 F.

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