UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

APPLICANTS' DIRECT TESTIMONY OF
EDWARD C. CHRISTIANSEN ON ISSUE NO. 16

1. My name is Edward C. Christiansen. I am employed by The Cleveland Electric Illuminating ("CEI") Company as a Senior Design Engineer. My business address is Perry Nuclear Power Plant ("PNPP"), 10 Center Road, Perry, Ohio, 44081. As a Senior Design Engineer, I am responsible for the Electrical Unit of the PNPP Nuclear Construction Engineering Section. This responsibility includes the coordination of engineering and licensing activities involved with the standby power facilities (diesel generators and associated equipment) at PNPP. It has also included acting as CEI's technical representative to the Transamerica Delaval, Inc. ("TDI") Diesel Generator Owners Group. As such, I was involved in the identification and resolution of potentially generic problems associated with TDI engines (Phase I of the Owners Group Program Plan) and the

development of the Design Review/Quality Revalidation ("DR/QR") Program (Phase II), including the additional component inspections and testing as described in Applicants' Direct Testimony of John C. Kammeyer on Issue No. 16 ("Kammeyer Testimony"). I have also acted as liaison to the consultant hired by CEI to review the Phase I Program for PNPP, as discussed at ¶ 7.

2. I have been employed by CEI for sixteen of the last seventeen years, beginning in 1968. During this period I spent one year (1981-1982) working for the Davy McKee Corporation as a Senior Electrical Engineer. I started on the Perry project as a Senior Engineering Technician responsible for the preparation of equipment specifications. As I have progressed through the project's organization, I have handled different engineering assignments, as needed, in support of the construction of the plant. Prior to my assignment to Perry, I was involved in a CEI system automation project.

3. I am a cum laude graduate of Cleveland State University with a Bachelor of Science degree in engineering technology. My major was in electronics. In addition to my formal education, I have completed numerous short courses and seminars relating to my assignments at PNPP, including a course in "Diesel Generator Controls and Protective Devices" (conducted by Basler Electric Company). I am a registered professional engineer in the State of Ohio. I am also a member of the Institute of Electrical and Electronic Engineers Society.

4. The following testimony addresses Ohio Citizens for Responsible Energy's ("OCRE") contention regarding the TDI diesel generators in place at PNPP. As admitted by the Licensing Board, Issue No. 16 states:

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

The following testimony illustrates that the Owners Group program, as implemented at PNPP, in conjunction with PNPP's preoperational testing program, provide assurance that the PNPP TDI diesel generators will reliably perform their intended safety related functions for the life of the plant.

I. IMPLEMENTATION OF THE OWNERS GROUP PROGRAM PLAN AT PNPP

A. Phase I Recommendations

5. Phase I of the Owners Group Program was designed to address the potentially generic concerns associated with TDI diesel generators. Results of the Phase I effort are incorporated in a series of thirty-six reports (fifteen subject reports plus supplements) which also contain the Owners Group conclusions as to overall adequacy of each component's design, recommendations for maintenance, inspection, testing, and recommendations concerning operating procedures and procurement

specification requirements. The final Phase I reports and supplements, date of issuance, and applicability to PNPP are listed below:

PHASE I FINAL REPORTS WITH SUPPLEMENTS

REPORT	REPORT DATE	APPLICABILITY TO PERRY (Y/N)
a. CONNECTING ROD BEARING SHELLS	March 1984	Y
b. ROCKER ARM CAPSCREWS:		
(1) Shoreham only	March 1984	N
(2) All other engines	July 1984	Y
c. CYLINDER HEAD STUDS:		
(1) Shoreham only	April 1984	N
(2) All other engines	May 1984	Y
d. AIR START VALVE CAP-SCREWS:		
(1) Shoreham only	March 1984	N
(2) All other engines	April 1984	Y
e. PUSH RODS (ALL ENGINES)	April 1984	Y
f. CRANKSHAFTS:		
(1) DSR-48	April 1984	N
(2) DSRV-16	May 1984	Y

REPORT	REPORT DATE	APPLICABILITY TO PERRY (Y/N)
(3) DSRV-12 & 20	June 1984	N
g. JACKET WATER PUMPS:		
(1) DSR-48	April 1984	N
(2) DSRV-12 & 16	June 1984	Y
(3) DSRV-20	July 1984	N
h. FUEL OIL INJECTION TUBING (ALL ENGINES)	April 1984	Y
i. BASE AND BEARING CAPS:		
(1) DSR-48	April 1984	N
(2) DSR-48, REV. 1	July 1984	N
(3) DSRV (ALL)	August 1984	Y
j. CYLINDER HEADS (ALL ENGINES)	August 1984	Y
k. PISTONS:	July 1984	Y
(1) AE/AF Pistons (initial)	February 1984	Y
(2) AE/AF Pistons (final)	May 1984	Y
(3) AF/AE Pistons (Influence of Thermal Distortion on Fatigue Performance)	June 1984	Y
(4) AN/AH Pistons	November 1984	Y (Applicable

REPORT	REPORT DATE	APPLICABILITY TO PERRY (Y/N)
		prior to the date PNPP changed to AE-type pistons)
1. WIRING AND TERMINATIONS:		
(1) Shoreham	April 1984	N
(2) Grand Gulf	June 1984	N
(3) Comanche Peak	May 1984	N
(4) River Bend, Rancho Seco, Midland, Perry, Shearon Harris, and San Onofre	July 1984	Y
m. CONNECTING RODS:		
(1) DSR-48	April 1984	N
(2) DSRV - (all), preliminary	May 1984	Y
(3) DSRV - (all), final	August 1984	Y
n. TURBOCHARGER:		
(1) DSR-48, DSRV-16	May 1984	Y
(2) DSRV-12 & 20	July 1984	N
(3) Supplemental report (valves and cap-screws)	November 1984	Y

REPORT	REPORT DATE	APPLICABILITY TO PERRY (Y/N)
o. ENGINE BLOCK AND LINER		
(1) Initial Report	June 1984	Y
(2) Additional Metallurgical Testing and Refinement Analysis	December 1984	Y

6. PNPP has incorporated all of the applicable recommendations of each of the Phase I reports into its TDI engine program. For example, connecting rod bearing shells on the PNPP engines were inspected by the use of radiography, eddy current and liquid penetrant examination as well as by visual checks. Some bearing shells were replaced so that all shells presently installed in the engines meet the acceptance criteria established by the Owners Group. Likewise, the engines' fuel oil injection tubing was examined by eddy current testing for fabrication flaws similar to those found at Grand Gulf. No such flaws were discovered on the PNPP fuel lines. As an additional precaution, PNPP will install shroud lines around the tubing. A summary of the results of the PNPP inspections performed on the Phase I items is contained in the "PNPP TDI Diesel Generator Program Plan" submitted to the NRC on January 17, 1985.

7. CEI also employed an independent engineering consulting firm, Southwest Research Institute ("SwRI") to review,

evaluate, and independently verify the methodology employed, results, and conclusions of each of the Phase I studies. SwRI's overall conclusion, with regard to the Phase I effort, was that the Owners Group reports were accurate in their evaluation of the potentially generic problems. See Applicants' Direct Testimony of Charles D. Wood III on Issue No. 16.

B. Phase II Recommendations

8. The DR/QR portion of the Owners Group effort was developed to examine the important engine components not covered in Phase I of the Program. The components evaluated in Phase II did not have a history of potentially generic problems. The 171 PNPP diesel generator components subjected to the DR/QR program were determined by a Component Selection Committee, as discussed in the Kammeyer Testimony at ¶¶ 16 to 18. The PNPP component selection was also based on PNPP site-specific experience and requirements, as well as the selections previously conducted for the Shoreham, Comanche Peak, Catawba, and Grand Gulf diesel engines.

9. Following classification of components as either Type A, Type B, or Type C, the Component Selection Committee established appropriate design review or quality revalidation requirements. Id., ¶¶ 19-23. These requirements were forwarded to the Owners Group Design Review Group and Quality

Revalidation Group for preparation of task descriptions, id. ¶ 24. The quality revalidation requirements were then implemented by PNPP personnel as described in the following paragraphs. The design review requirements were implemented by the Owners Group technical staff. Id. The final DR/QR report was transmitted to PNPP by the Owners Group on December 31, 1984. PNPP transmitted this report to the NRC on January 17, 1985.[1/]

10. Component Revalidation Checklists ("CRCs") were prepared for each of the Phase II components designated for quality revalidation at PNPP. These checklists formed the basis for the field inspections which were then conducted during the engine revalidation effort. For example, the valve spring and retainers required a quality revalidation inspection. The Owners Group had identified a certain color-coded spring as being unacceptable. All springs on the Unit 1 engines were, therefore, visually inspected to verify the color coding. All springs on the two engines were found to be acceptable. Results of the inspection were recorded on a Quality Assurance Checklist ("QAC"). In addition to the springs, the flexible and overspeed trip couplings were also quality revalidated. The component's CRC required a visual examination of the couplings for signs of wear, deterioration, or any other

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1/ Revision 1 of the DR/QR Report was submitted to the NRC by letter dated March 18, 1985.

discontinuities. The field inspection found the couplings to be in new condition. Results were also documented on a QAC.

11. In order to perform the required quality revalidation ("QR") inspections on the PNPP engines, a task force was established consisting of project personnel from PNPP organizations such as:

(a) Nuclear Construction Engineering Section,

(b) Nuclear Test Section,

(c) Perry Plant Technical Department,

(d) Perry Plant Operation Department, and

(e) Nuclear Quality Assurance.

This task force was responsible for coordinating and implementing the disassembly, inspection, procurement of parts (as necessary) and reassembly of the TDI diesel engines. To expeditiously resolve day-to-day questions arising during the testing and revalidation effort, key task force members and technical support staff were moved to a single work area. Approximately forty individuals have been assigned full time to support this activity. Since early September, 1984, a meeting has been held each day to discuss progress and plan the next day's work-effort. Each of these key task force members is exclusively assigned to the diesel generator testing and revalidation effort and will remain so until all testing is completed.

12. The revalidation (tear-down, inspection and reassembly) of the Unit I PNPP TDI diesel engines was performed in accordance with PNPP's Quality Control Program. See ¶ 22. Procurement of parts to support the revalidation effort was also conducted in accordance with specified quality assurance standards as discussed at ¶ 21. The results of the revalidation inspections were forwarded to the NRC by letter dated February 8, 1985.

C. The Engine Revalidation Effort, Testing and Inspection

13. While the engines were disassembled, routine inspection and maintenance were also performed in accordance with PNPP site-specific procedures and the manufacturer's instructions. Changes recommended by TDI for the PNPP engines in its Service Information Memos ("SIMs") were incorporated at this time. For example, connecting rod bolt washers located between the connecting rod bolt head and the master rod's face were reported to gall, via an SIM. The problem washer was replaced with a harder washer, as specified by TDI in its SIM.

14. All unfavorable inspection results were evaluated according to established PNPP procedures, and, in some cases, by the Owners Group. Non-Conformance Reports documenting hardware-related problems and Action Requests, documenting programmatic concerns, were written up and resolved in each case.

15. Only two notable concerns were encountered during this revalidation effort. During the inspection it was discovered that four rocker arms on the Division I engine and eight rocker arms on the Division II engine had come in contact with the swivel pad, indenting the rocker arm forging. The indention, or lip, restricted the movement of the hydraulic lifters. It appears that the problem occurred during the factory-run tests and was caused by improper adjustment of the lifter adjusting screw. The rocker arms have been restored to operating condition following procedures recommended by the Owners Group and TDI.

16. The second concern was detected when eddy current inspection of the oil holes on the crankshaft by an Owners Group consultant indicated excessive machining marks in the unpolished surface at a depth greater than 1 inch. All crankshaft oil holes were polished to a depth of 3 inches. The eddy current test was repeated on the polished oil holes. The test indicated that the oil holes were free of defects.

D. Engine Maintenance

17. PNPP is implementing all applicable Owners Group recommendations resulting from Phase I and Phase II of the Owners Group Program. The Owners Group recommendations, when performed during the revalidation inspections, were listed on

CRCs. If the Owners Group recommended ongoing maintenance for a component, this requirement was listed in the PNPP Maintenance Matrix. Both the CRCs and the Maintenance Matrix are part of the PNPP DR/QR Report. The SwRI recommendations will also be incorporated into the PNPP preventative maintenance program, as noted below.

18. Maintenance recommendations listed in the PNPP Maintenance Matrix, as well as SwRI's recommendations, will be logged on PNPP's computer-based preventative maintenance program (the "Repetitive Task System"). As the required maintenance period approaches, the computer will generate a work order describing the task and schedule for completion. The maintenance work will then be performed by the appropriate site-personnel.

19. An example of Owners Group recommended maintenance requirements is provided below for the intercoolers and the turbocharger:

	Preventative Maintenance Recommendation	Daily	Monthly	Outage	5 Year
Inter-coolers	1. Evaluate heat exchanger performance by checking engine operating parameters.		X		
	2. Clean/inspect shell and tube sides every outage or as necessary.			X	
	3. Visually inspect for external leaks.		X		
	4. Verify inter-cooler inlet plenum drain connection is open and clean.	X			
Turbo-charger	1. Measure vibration and check with baseline data.			X	
	2. Clean impeller and diffuser.			X	
	3. Measure rotor end play (axial clearance) to identify trends of increasing clearance, i.e.; thrust bearing degradation.			X	
	4. Perform visual and blue check inspections of the thrust				X

Preventative Maintenance Recommendation	Daily	Monthly	Outage	5 Year
bearing.				
5. Disassemble, inspect and refurbish.				X
6. Perform a spectrochemical engine oil analysis to assist the bearing monitoring program. To further expand/clarify chemical analysis, ferrographic analysis may be utilized. Particular attention shall be paid to copper level, and particulate size, which could signify thrust bearing degradation.			X	

E. Conclusion

20. As the NRC staff noted in its "Safety Evaluation Report-Transamerica Delaval, Inc. Diesel Generator Owners Group Program Plan," August 13, 1984, the Phase II DR/QR effort is a comprehensive review of all of the important diesel engine components, other than those covered by Phase I, to assure that their design and manufacture, including specifications, quality control, quality assurance, and operational surveillance and

maintenance, are adequate. PNPP has worked and will continue to work within the guidelines established by the Owners Group to ensure that each of these important components is, and will continue to be, adequate throughout the life of the PNPP diesel generators.

II. SUPPLEMENTAL QUALITY ASSURANCE PROGRAM IN PLACE AT PNPP

A. Supplemental Quality Assurance at TDI

21. Because of past concerns identified by both the NRC and the Owners Group, PNPP has supplemented its normal quality assurance ("QA") review of TDI-supplied equipment by various measures. A PNPP QA representative was assigned full-time to TDI to witness factory inspections and hold points as specified in the procurement documents (which included the Owners Group CRCs) for each safety-related component ordered to support the revalidation effort. Witnessed were procedures such as heat treatments, non-destructive examinations and inspections of individual components (such as re-worked cylinder heads and AE-type piston skirts). The PNPP representative also performed dimensional and visual checks, reviewed documentation packages, and verified cleaning, coating, painting, and tagging of components, prior to their final acceptance.

B. Conduct of Engine Revalidation

22. PNPP Site Quality Assurance was responsible for the inspection effort during the quality revalidation portion of the DR/QR effort, previously discussed. Their program assured that the work was performed as described below:

(a) All engine tear-down/reassembly activities were conducted in accordance with test work procedures and work authorizations approved by the lead test engineer and concurred in by the unit supervisor of the Operational Quality Section;

(b) Component inspections were planned, performed, documented, and reported by the Operational Quality Section in accordance with PNPP Procedure 1-1004 (Operational Quality Section Inspection Program);

(c) Hardware deficiencies were documented and evaluated on PNPP Non-Conformance Reports;

(d) Programmatic concerns were documented on PNPP Action Requests;

(e) Inspection results were indicated as either satisfactory or unsatisfactory;

(f) Information required by CRCs was obtained during inspections for evaluation by Site Engineering or the Owners Group;

(g) Replacement engine components (other than those inspected by the PNPP representative at TDI as previously discussed), were inspected on-site per the requirements of the CRCs;

(h) Final closure of inspection results is handled per PNPP Procedure 1-1004;

(i) Copies of all documents (i.e., PNPP Non-Conformance Reports, Inspection Reports, etc.) generated as a result of the inspection program are being provided to the Owners Group consultants for their review.

III. PROCUREMENT OF REPLACEMENT PARTS

23. Replacement parts for the TDI diesel engines are being procured in accordance with established PNPP procedures. These procedures allow for several methods of procurement, including the procurement of an item as identified by part number and environmental conditions or per an entirely new procurement specification. Applicable Owners Group requirements, in addition to PNPP-unique requirements, will be specified in all purchase requisitions. Quality assurance requirements (i.e., maintenance of a QA program meeting the requirements of 10 C.F.R. Part 50, App. B, a commitment to the requirements of 10 C.F.R. Part 21, the right of PNPP to perform audits, etc.) will also be specified in all procurement documents.

IV. PNPP FUTURE SURVEILLANCE PROGRAMS

24. Surveillance programs presently in place at PNPP will continue to monitor any problems with TDI-supplied equipment. These programs include those established pursuant to 10 C.F.R. Part 21 and 10 C.F.R. § 50.55(e). When a component is found to be defective with a potentially significant impact on the performance of the TDI diesel generators, it will be reported pursuant to 10 C.F.R. § 50.55(e). Also, any applicable information received by CEI through 10 C.F.R. Part 21 reports on equipment/components in place at PNPP, will be reported pursuant to 10 C.F.R. § 50.55(e). All nuclear safety-related equipment procured from TDI has been bought, and will continue to be bought, in compliance with 10 C.F.R. Part 21. Each purchase requisition will continue to incorporate the requirements of Part 21 and to mandate TDI compliance. When PNPP becomes operational, any significant item will be reported pursuant to the requirements of 10 C.F.R. § 50.73 which governs Licensee Event Reports ("LERs").

25. Other methods of feedback, such as INPO reporting, will also be utilized to assure that the highest quality equipment and parts will continue to be used at PNPP. TDI's program supplying owners with information on potential problems and product enhancements (SIMs) will continue to be used to supplement PNPP's surveillance program.

V. PNPP DEVIATION ANALYSIS REPORTS

26. Nonconformance Reports at PNPP are written for any type of equipment hardware deviations, including those as minor as paint scratches or typographical errors on nameplates. All PNPP Non-Conformance Reports written against TDI equipment have been reviewed for reportability to the NRC. Where it was determined that a condition was possibly reportable, a Deviation Analysis Report ("DAR") was prepared. The DAR was then evaluated by PNPP Site Engineering and Quality Assurance for reportability to the NRC. Where the condition was determined to be significant, it was reported per established PNPP procedures.

27. To date, 28 DARs have been written with respect to the TDI diesels.[2/] 22 of these DARs have been reported to the NRC as significant pursuant to 10 C.F.R. Part 21 and/or 10 C.F.R.§50.55(e). Of those reported, 19 involved equipment supplied or designed by TDI. The three remaining DARs

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2/ Because DAR's are written to record all possibly significant deficiencies and to elevate the problem identified to a higher level of review, some DAR's turn out to be inapplicable to PNPP. For instance, 10 C.F.R. Part 21's reported by the manufacturer and received at PNPP are treated as possible significant deficiencies requiring further evaluation. These evaluations sometimes turn out to be inapplicable to PNPP or of a minor nature. While this procedure increases the number of DAR's written, it also serves as a conservative approach to monitoring the quality of safety-related equipment.

concerned equipment designed by others. Below is a complete listing of the DARs (noting those which are not TDI-related), their reportability status, and their status with the NRC:

DAR#	CONDITION	REPORTABLE (Y/N) DATE	STATUS
17	Anchor bolts for DG high voltage cabinets not designated safety related/design control.	N	Closed out on 11/9/79. Anchor bolts are custom made. A follow-up TDI audit by PNPP confirmed the status of the bolts.
38	Potential link rod deficiency.	Y 10/08/80	Closed out on 01/20/83.
44	Turbocharger lubricating oil system defect (thrust bearings).	Y 12/30/80	Open. Work is complete - (Unit 1 only). NRC has reviewed and found acceptable. Awaiting NRC staff documentation to close out.
56	Nonsafety sensing lines on safety-related receiver tanks (starting air system).	Y 06/12/81	Open. Hardware installed. Awaiting testing.
65	Intake & exhaust valve springs supplied by Melrose Spring Co.	N	Closed out on 9/9/81. Springs reported in the 10 C.F.R. Part 21 were not used at PNPP.
79	Starting air system check valve failed during seismic qualification (Wm. Powell).	Y 12/18/81	Closed out on 06/01/84.

DAR#	CONDITION	REPORTABLE (Y/N) DATE	STATUS
81	Location of governor lube oil cooler.	Y 01/14/82	Open. Work is complete - NRC has reviewed and found acceptable. Awaiting NRC staff documentation to close out.
83	ASME Code Data Reports (TDI-related).	Y 02/23/82	Closed out on 09/22/82.
89	ASME Code piping welds.	Y 03/29/82	Closed out on 11/10/83.
99	Capscrew length in starting air valve assembly.	Y 06/15/82	Closed out on 1/27/84.
101	Isoporene material used for governor drive coupling not suitable for engine gear case.	Y 07/30/82	Closed out on 04/05/84.
109	Commercial grade wire used in certain engine & panel circuits has failed IEEE 383 Flame Test.	Y 11/23/82	Closed out on 05/18/84.
117	Skid mounted pipe supports not built to ASME Sec. III, NF.	Y 02/23/83	Closed out on 05/18/84.
136	GAI design for DG exhaust piping (Part 21 report by GAI). [Non-TDI-related].	Y 08/05/83	Open. Work is complete (Unit 1 only). NRC has reviewed and found acceptable. Awaiting NRC staff documentation to close out.

DAR#	CONDITION	REPORTABLE (Y/N) DATE	STATUS
138	Use of fuses to isolate a non-Class IE strip chart recorder from IE tachometer transmitter.	N	Closed out on 8/19/83. Recorder is only used when in the test configuration.
139	Use of non-Class IE control power & control components in DG bldg. ventilation system.	Y 08/16/83	Closed out on 08/20/84.
145	Inadequate support for fuel oil line from engine driven fuel transfer pump to engine fuel header.	Y 10/11/83	Open. Work is complete - NRC has reviewed and found acceptable. Awaiting NRC staff documentation to close out.
156	Flexible coupling drive hubs on the overspeed governor and fuel transfer pump drive shafts.	Y 01/20/84	Open. Work is complete - NRC has reviewed and found acceptable. Awaiting NRC staff documentation to close out.
160	Design for DG logic inconsistent with FSAR Fig. 8.3.5. [Non-TDI-related].	Y 02/16/84	Closed out on 05/18/84.
161	Synchronization between DG and alternate preferred power source. [Non-TDI-related].	Y 02/16/84	Closed out on 05/18/84.
174	DG IE voltage interfaces to non-IE engine recorder via a voltage transducer.	Y 04/04/84	Closed out on 07/18/84.

DAR#	CONDITION	REPORTABLE (Y/N) DATE	STATUS
175	Piston skirt castings heat treating of 2 TDI spare parts pistons.	Y	Open. These will be scrapped. No longer intended for use. NRC has reviewed and found acceptable. Awaiting NRC staff documentation to close out.
192	Springs supplied by Belts Spring Co.	Y	Closed out on 7/25/84. Springs identified by the Part 21 report were inspected and found to be acceptable.
193	Bendix delivery valve holder	N	Closed out on 7/25/84. Pumps identified by the Part 21 report were inspected and found to be acceptable.
203	Basler Electric Co. voltage regulators installed by RTE Delta.	Y 09/24/84	Open. Unit 1 modification complete--awaiting testing.
207	Fuel control shaft levers.	Y 10/16/84	DAR was determined not to be reportable on 11/14/84 after being called in to NRC on 10/16/84. An inspection of the levers found them to be acceptable.
214	Intake & exhaust rocker arm assemblies.	N	Closed out on 11/2/84. Rocker arm assemblies with indications

DAR#	CONDITION	REPORTABLE (Y/N) DATE	STATUS
			would not have prevented the engines from running at capacity.
225	Control panel air filter-wrong air pressure rating.	Y 01/31/85	Called in to NRC on 1/31/85. Final report submitted to NRC on 2/27/85. Work is complete -- awaiting NRC staff review.

VI. TDI DIESEL GENERATOR TESTING AND INSPECTION AT PNPP

28. A major element of the TDI Diesel Generator Owners Group Program involves an enhanced engine testing program, coupled with specific component inspections. The Owners Group technical staff, in evaluating specific engine components, provided recommendations to the owners regarding special or expanded engine tests and component inspections which would provide additional assurance of the adequacy of both the engines and the components to perform their safety-related functions. This testing is being conducted in addition to that described in the PNPP FSAR.

A. Testing Program Development

29. The testing program for the standby diesel generators at PNPP is based on IEEE Std. 387-1977 and Regulatory Guide

1.108 (as described in Chapter 14 of the PNPP FSAR). IEEE Std. 387-1977 was developed by the Nuclear Power Engineering Committee of IEEE to provide design criteria, design features, qualification considerations and testing criteria for diesel engine generator units applied as standby power supplies for nuclear power plants. The testing categories and criteria are established in Section 6 of the Standard. Regulatory Guide 1.108, Revision 1, August 1977, provides additional specific guidance on criteria for periodic and pre-operational testing of diesel generator units. The PNPP testing program also includes the recommendations developed by the TDI Diesel Generator Owners Group Program. The Owners Group preparation of testing and inspection recommendations for the PNPP test program was based on the results of the analytical studies performed by the Owners Group and a recognition that tests conducted on the "lead" DSRV-16-4 engines were successfully performed prior to the PNPP tests.

B. The "Lead" Engine Concept

30. The "lead" engines for the model DSRV-16-4 engines installed at PNPP were the DSRV-16-4 engines located at the Comanche Peak Steam Electric Station of the Texas Utilities Generating Company. A full pre-operational test program was conducted on the Comanche Peak engines in accordance with the Texas Utilities' program based on NRC Regulatory Guide 1.108,

"Periodic Testing of Diesel Generator Units Used as Onsite Electrical Power Systems at Nuclear Power Plants" (Revision 1, August 1977) and IEEE Std. 387-1977, cited above. In excess of 100 hours of operation were logged on these engines. The Comanche Peak test program included starting and load acceptance tests, auxiliary system tests, load capability tests, and control circuit tests. Specific tests, in addition to those described in Commanche Peak's SAR were required by the Owners Group to be performed on the Comanche Peak engines. Tests required by the Owners Group included a torsiograph test, which confirms the adequacy of the crankshaft, and engine vibration tests. The lead engines at Comanche Peak were successfully tested using a program based on IEEE Std. 387, Regulatory Guide 1.108 and the additional Owners Group recommendations.

31. In addition to the Comanche Peak testing, more than 1600 hours of operation have been accumulated on the DSRV-16-4 engines at Duke Power's Catawba Plant. This has further substantiated the Comanche Peak test results. The results of the Comanche and Catawba engine tests have provided additional assurance regarding the capabilities of the DSRV-16-4 engine design. The results of the testing at Comanche Peak, as well as supplemental information from the Catawba Plant, are referenced in the PNPP DR/QR Report.

32. Information from pre-operational and lead engine testing at other plants was obtained through the Owners Group and from site visits. For example, CEI representatives from the Nuclear Testing Section and Quality Assurance Departments visited the Comanche Peak Plant after the pre-operational testing of their first TDI engine to review their methods and results. The PNPP test program was reviewed in detail with Comanche Peak personnel to assure that the test program completely and consistently incorporated the Owners Group recommendations and operating experiences on the engines to date. The test program also included applicable input from routine reporting and surveillance programs, such as INPO reporting, TDI Service Information Memos, 10 C.F.R. Part 21 and 10 C.F.R. § 50.55(e) reports. Resolution of potential problem areas for particular components on the engines or on auxiliary equipment identified by these programs were included, as required, in the test program.

C. PNPP Pre-Operational Testing and Inspections

33. The purpose of the diesel generator testing program at PNPP is to provide additional assurance that the TDI diesel generators are reliable, prior to plant licensing and operation. The program consists of a comprehensive pre-operational engine test program and includes testing recommended by the TDI Diesel Generator Owners Group.

34. The PNPP test program includes a rigorous group of tests which demonstrate the capability of a diesel generator unit to perform its intended function. These tests are described in Section 6.4 of IEEE Std. 387-1977 and Regulatory Guide 1.108 (as described in Chapter 14 of the PNPP FSAR). The tests include diesel generator auxiliary systems tests for electrical and pneumatic controls, diesel generator control circuit functional and start tests, diesel generator load tests, diesel generator load acceptance tests, and diesel generator reliability tests, as discussed below. At PNPP, an additional measure of the performance of each cylinder on each engine will be obtained by logging cylinder exhaust temperature sensor readings under load. This data will be taken throughout the pre-operational tests.

35. The diesel generator auxiliary systems tests will demonstrate the proper functioning of the electrical and pneumatic controls for the diesel generator auxiliary systems. Auxiliary systems include the starting air, jacket water, lube oil and fuel oil systems.

36. The diesel generator control circuit functional and start tests will demonstrate electrical and pneumatic control circuit operability in the "Manual" mode of operation for both Unit 1 diesel generators. Each diesel generator will be tested to demonstrate that it is capable of starting, achieving rated

voltage and frequency within acceptable limits and time, and accepting load in the various modes of operation.

37. The diesel generator load tests will demonstrate the capability of both Unit 1 diesel generators to start, load to 100 percent of full rated load and achieve steady-state temperature equilibrium. Each diesel generator will demonstrate operation at 100 percent load for 24 hours within the manufacturer's design and operational parameters. Each diesel generator's capability to reject 100 percent rated load without tripping due to overspeed will be tested.

38. The diesel generator load acceptance tests will demonstrate the capability of the diesel generator to start upon receipt of a start signal, and to independently accept design loads without exceeding manufacturer specifications and design criteria.

39. The diesel generator reliability tests will confirm the starting performance of the Unit 1 diesel generators by the performance of a minimum of 69 total valid tests with no failures, in accordance with the criteria specified in Reg. Guide 1.108, Rev. 1, Sections C.2.a(9) and C.2.e. PNPP is also currently committed to performing 20 additional tests, 10 on each Unit 1 diesel generator. The 20 additional start-and-load tests will be conducted in accordance with Reg. Guide 1.108 and

IEEE-387-1977, Section 6.3.2, with one exception. Since a single step load of 50 percent of the generator nameplate continuous KW rating is not available, the generator will be loaded with the available bus loads once it has attained the necessary speed and voltage. The bus will then be synchronized with offsite power and loaded to 50 percent of rating. This exception is necessary due to differences between the actual field configuration and the factory testing capability.3/

40. One test per diesel will be performed with the engine initially at "normal operating temperature equilibrium", as defined by IEEE Std. 387-1977. The remaining start-and-loads will be done with the diesel generators initially at warm standby, their normal condition when PNPP is operating. Including the 69 tests required by Reg. Guide 1.108, this accounts for a total of a minimum of 89 start-and-load tests. Each start will be documented in accordance with Section 3.0 of Regulatory Guide 1.108 on a chronological test log.

41. As of March 23, 1985, the Division I engine had run for approximately thirteen-and-one-half hours, with no hardware-related incidents on the engine, as follows:

3/ PNL has recommended that fast-starts during PNPP's preoperational testing be limited to current NRC requirements. See "Technical Evaluation Report - A Review of the Operability and Reliability of Transamerica Delaval, Inc., Diesel Generators at Perry Nuclear Power Plant Unit 1," February, 1985. In light of this recommendation, PNPP will discuss the elimination of the 20 additional fast starts with the NRC staff.

† Approximately 3-1/2 hours at no load

† Approximately 2 hours at 20% load

† Approximately 1 hour at 35% load

† Approximately 1 hour at 50% load

† Approximately 1 hour at 75% load

† Approximately 5 hours at 82% load

As of March 23, 1985, the Division II engine had run for approximately seven hours, with no hardware-related incidents on the engine, as follows:

† Approximately 1-3/4 hours at no load

† Approximately 2 hours at 20% load

† Approximately 1 hour at 35% load

† Approximately 1 hour at 50% load

† Approximately 1 hour at 75% load

† Approximately 15 minutes at 82% load

42. Additional engine tests beyond the industry standards and Regulatory Guides have been recommended by the Owners Group. As noted above, an example of such an additional test is a torsiograph test, which confirms the adequacy of the crankshaft to withstand operating torsional stresses. This

test will consist of variable speed measurements performed at no load conditions and variable loads (25%, 50%, 75% and 100%) at engine generator nameplate full-load rating prior to regulatory pre-operational testing. This test will provide additional assurance that the PNPP engine crankshaft design is adequate. Hot and cold crankshaft deflection measurements, as recommended by TDI, are also being performed prior to pre-operational testing to verify the adequacy of the crankshaft.[4/] An engine baseline vibration survey will also be taken to determine the initial vibration characteristics. A visual survey will be performed while the engines are running at full load to identify any individual component with unusually high vibration levels.

43. In addition, the Owners Group has recommended inspection of selected engine components following approximately 100 hours of engine operation. These component inspections will be conducted at PNPP following established site procedures.

4/ A hot deflection check of the Division I engine following twelve hours of operation and after a run at 82% of load has already been conducted with favorable results.

VII. OVERALL CONCLUSION

44. The PNPP TDI diesel generators have been thoroughly reviewed from both a design and quality standpoint by the TDI Diesel Generator Owners Group and PNPP's engineering and quality assurance personnel. Based on recommendations generated in Phase I of the Owners Group Program, the components with potentially generic problems were reviewed, inspected, replaced, and/or modified. All of the Owners Group recommendations are being implemented and will be completed prior to fuel load. Those offered by SwRI are being logged onto PNPP's preventative maintenance program and will also be implemented.

45. The Phase II DR/QR effort, and the third element of the Owners Group effort, which includes implementation of a maintenance program and additional engine testing and inspection of components, provides additional assurance that the PNPP TDI diesel generators will reliably perform their intended safety-related functions for the life of the plant. PNPP is committed to implementing each of the applicable Owners Group recommendations and testing to verify the reliability of the TDI diesel generators.

46. As described above, the PNPP test program meets or exceeds both the testing described in IEEE Std. 387-1977 and the testing described in PNPP FSAR Chapter 14 pertaining to

Regulatory Guide 1.108, and implements the Owners Group recommendations. Fulfillment of the testing program provides assurance that the TDI diesel generator units meet their design requirements and will perform with a high degree of reliability. This comprehensive testing program, other DSRV-16-4 successful test programs, the PNPP DR/QR effort, and the Owners Group results, all provide an unprecedented level of assurance regarding the reliability of the TDI diesel generator units in nuclear plant applications.

Edward C. Christiansen

Education: Cleveland State University, BSET, 1975, CumLaude
Generator Power Control and Protection course, 1981, Basler Electric.

Coordination of Protective Devices, 1980, University of Toledo.

Protective Relay School, 1977, Westinghouse
Seismic Seminar, 1976, Wyle Laboratories.

Boiling Water Reactor Fundamentals, 1975, CEI
USAF Missile Guidance and Control School, 1964, USAF.

Professional: Registered Professional Engineer in the State of Ohio, registration number E-041307.

Business Experience

1982-Present Cleveland Electric Illuminating (CEI) Co.
Perry Nuclear Power Plant
Nuclear Construction Department
Senior Design Engineer

Lead engineer responsible for the procurement and installation of all electrical equipment at the Perry Nuclear Power Plant. Among the responsibilities is the coordination of all project standby diesel-generator activities.

1981-1982 Davy McKee Corporation
Independence, Ohio
Electrical Engineering Department
Senior Engineer

In charge of the design of a 115/4.16kV electrical substation for TEMEX, S.A., located in Casoleacaque, Mexico. Wrote specifications and performed bid evaluations for oil circuit breakers, transformers, standby diesel generators, and battery packages.

1979-1981 Cleveland Electric Illuminating (CEI) Co.
Perry Nuclear Power Plant
Nuclear Engineering Department
Lead Electrical Equipment Engineer

Responsible engineer for the procurement and installation of electrical equipment at the Perry Nuclear Power Plant. This included the development of one lines, schematics, ahd the coordination of protective devices within the plant. Also responsible for the qualification

of electrical equipment used in nuclear safety related circuits.

1974-1979 Cleveland Electric Illuminating Co.
Cleveland and Perry, Ohio
Associate Electrical Engineer

As a member of the Perry Nuclear Power Plant design team, I was the engineer responsible for the procurement of the 13,800 and 4160 volt switchgear, 480 volt load centers, large motors, and cathodic protection equipment. Responsibilities included reviewing the specifications and design of the equipment, as well as evaluating vendor's quotations. Also, reviewed the design of the electrical systems in which the aforementioned equipment was applied.

1968-1973 Cleveland Electric Illuminating Co.
Senior Electrical Engineering Technician

Worked on the automation of the CEI transmission system. My responsibilities included specifying and evaluating the vendor's design of a dynamic computer driven display board showing transmission station equipment status. Assignment included reviewing assembly language programing of a minicomputer and application of power electronic circuits. This project also included the application of a data acquisition system to CEI's Lakeshore power plant. Included was the design of plant circuit breaker control circuits and monitoring of plant processes.

1963-1967 United States Air Force
Sergeant

Worked as a guidance and control technician on the Bomarc Interceptor Missile. Responsibilities included performing trouble-shooting and routine electrical and electronic maintenance on the aircraft and ground equipment.

PROFESSIONAL AFFILIATION

Member of the Institute of Electrical and Electronics Engineers (IEEE) Society