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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

Before the Atomic Safety and Licensing Board

In the Matter of)	
)	
LONG ISLAND LIGHTING COMPANY)	Docket No. 50-322 (OL)
)	
(Shoreham Nuclear Power)	
Station, Unit 1))	

ADDITIONAL CRANKSHAFT TESTIMONY OF FRANZ F. PISCHINGER,
DUANE P. JOHNSON AND MILFORD H. SCHUSTER ON BEHALF
OF LONG ISLAND LIGHTING COMPANY

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I. Introduction

1. Please state your names, business affiliations and addresses.

A. (Pischinger) My name is Dr. Franz F. Pischinger. I am president of FEV (Research Society for Energy, Technology and Internal Combustion Engines) and a professor at the University of Aachen, Institute of Applied Thermodynamics. My business address is Erkfeld 4, Aachen, West Germany.

(Johnson) My name is Dr. Duane P. Johnson. I am employed by Failure Analysis Associates, 2225 East Bayshore Road, Palo Alto, California 94303.

(Schuster) My name is Milford H. Schuster. I am employed by Long Island Lighting Company (LILCO), Shoreham Nuclear Power Station, Wading River, New York 11792.

2. Have you previously testified in this proceeding?

A. (All) Yes. Our resumes and professional qualifications have been previously submitted in this proceeding.

3. What have you been asked to address in your testimony?

A. (Pischinger) I have been asked to analyze the adequacy of the replacement crankshafts in the emergency diesel generators (EDGs) at Shoreham for operation at 3300 KW and to

give certain other opinions as to the effect of certain postulated loads upon the replacement crankshafts.

(Johnson and Schuster) We have been asked to discuss the results of the inspections of the crankshaft following the 745 hour confirmatory test concluded in November of 1984.

4. Please summarize the results of your work and your conclusions.

A. (Pischinger) I have analyzed the 10^7 loading cycle confirmatory test and the subsequent nondestructive examination reports and I have determined that they confirm that the replacement crankshafts have unlimited life at the qualified load of 3300 KW. I have also analyzed the replacement crankshafts under the Kritzer-Stahl criteria. My previous analysis at 3500 KW and 3900 KW allowed me to conclude that the crankshafts had unlimited life with a safety margin of 1.248 at 3500 KW, and many hours of life at 3900 KW. My analysis at 3300 KW also shows that the crankshafts have unlimited life with a safety margin of 1.318. Additionally I have concluded that certain postulated loads above 3300 KW will have no effect upon the safety and reliability of the replacement crankshafts.

(Johnson and Schuster) Subsequent to the 10^7 loading cycle confirmatory test, the crankshafts were inspected by liquid penetrant and eddy current. These inspections show no relevant indications and therefore no fatigue damage.

II. Kritzer-Stahl Analysis

5. Please describe your calculations under the Kritzer-Stahl criteria.

A. (Pischinger) I calculated a factor of safety for the replacement crankshafts at 3300 KW under the Kritzer-Stahl criteria. The calculated endurance limit for the replacement crankshafts is 25.4 ksi. This endurance limit was calculated using an ultimate tensile strength (UTS) of 700 Newtons per square millimeter. The predicted maximum stresses are 23.66 ksi. The calculated factor of safety is 1.074. However, when the inherent safety factor in the Kritzer-Stahl criteria of 22% is taken into account, the replacement crankshafts have a safety margin of 1.318 for operation at 3300 KW.

6. Please describe how the Tn values you used in your calculations were derived.

A. (Pischinger) The Tn values for 3300 KW were derived by comparing pressure readings at 3300 KW taken by Kiene gauges during the 525 hour endurance run of EDG 103 in October and November, 1984, with the pressure curves measured on EDG 103 in January, 1984, at 3500 KW and 2800 KW. This information was compared to German codes and was used to calculate the appropriate Tn values.

7. What would be the endurance limit of the replacement crankshafts under the Kritzer-Stahl criteria if you used a UTS of 695 Newtons per square millimeter instead of 700 Newtons per square millimeter?

A. (Pischinger) If a UTS of 695 Newtons per square millimeter were used, the endurance limit for the replacement crankshafts would be 25.25 ksi.

8. Is this significant for your analysis of the adequacy of the crankshafts under the Kritzer-Stahl criteria at either 3500 KW or 3300 KW?

A. (Pischinger) No. The calculated factor of safety using a UTS of 695 Newtons per square millimeter is 1.067, compared to 1.074 if the value of 700 Newtons per square millimeter is used. This is totally insignificant. The actual safety margin at 3500 KW is 1.248, based on a UTS of 700 Newtons per square millimeter, while it is 1.239 based on a UTS of 695 Newtons per square millimeter. The actual safety margin at 3300 KW is 1.318, based upon a UTS of 700 Newtons per square millimeter, while it is 1.302, based upon a UTS of 695 Newtons per square millimeter. Thus, as one can see, the safety factor is essentially the same for each respective load regardless of whether one utilizes 695 or 700 Newtons per square millimeter for the ultimate tensile strength.

9. Do the crankshafts have infinite life for operation at 3300 KW?

A. (Pischinger) Yes. As I testify later herein, infinite life is established by successful testing for 10^7 loading cycles at 3300 KW. In addition, the safety margin of 1.3 (rounded) calculated according to the Kritzer-Stahl criteria gives added assurance of the adequacy of the crankshafts. This safety factor is at the upper end of the range of safety factors (1.15 to 1.3) commonly accepted in the European diesel industry. This safety factor coupled with the 10^7 loading cycle confirmatory test gives me confidence that the replacement crankshafts can safely and reliably accommodate loads substantially above 3300 KW.

III. 10^7 Loading Cycle Confirmatory Test, Inspections and Analysis

10. What does the 10^7 loading cycle confirmatory test consist of?

A. (All) As indicated in the testimony of Messrs. Dawe, Notaro and Youngling, the 10^7 loading cycle confirmatory test consists of 220 hours of operation at or above 3300 KW prior to October 8, 1984 and an endurance run of 525 hours at approximately 3300 KW between October 8, 1984 and November 2, 1984.

11. Were the crankshafts inspected after the completion of the 525 hour endurance run?

A. (Johnson and Schuster) Yes. Liquid penetrant testing was performed on all crankshafts fillet areas and external radii of all oil holes, except the fillets and oil holes at main bearings 1, 2, 10 and 11. In addition, all oil holes were inspected by eddy current to within approximately three inches of the journal surface, except the oil holes at main bearings 1, 2, 10 and 11.

12. Why were inspections not performed on the fillets and oil holes at main bearings 1, 2, 10 and 11?

A. (All) The fillets and oil holes at these locations are virtually inaccessible without removal of the crankshaft from the EDG. However, these fillets and oil holes are not the highest stressed and there is therefore, no need to conduct inspections at these locations.

13. What were the results of the liquid penetrant inspections?

A. (Johnson and Schuster) The liquid penetrant inspection of the fillets and oil hole radii at main bearing journals 3, 4, 5 and 6 and the oil hole radii at main bearing journals 7, 8 and 9 revealed no recordable indications. The liquid

penetrant inspection of the fillets at main bearing journals 7, 8 and 9 revealed recordable linear indications at various locations. All recorded indications were evaluated by eddy current or were reexamined by liquid penetrant and were found to be acceptable.

The liquid penetrant inspection of the fillets and oil hole radii at connecting rod journals 1, 2, 3, 4 and 5 and oil hole radii at connecting rod journals 6, 7 and 8 revealed no recordable indications. The liquid penetrant inspection of the fillets at connecting rod journals 6, 7 and 8 revealed recordable linear indications at various locations on the thrust face for journals 6, 7 and 8, the fillet to thrust face transition areas for journals 7 and 8, and the fillet for journal 7. All of the recorded indications on the thrust face and fillet were evaluated by eddy current and were found to be acceptable.

The recorded indications on the fillet to thrust face transition areas of connecting rod journals 7 and 8 were not accessible for eddy current inspection. The areas were carefully cleaned by using a Scotch brite pad, reinspected with liquid penetrant and were found to be acceptable.

14. What were the results of the eddy current inspections of the oil holes?

A. (Johnson and Schuster) The eddy current inspection of all the oil holes showed no recordable indications.

15. Who conducted the inspections?

A. (Johnson and Schuster) The liquid penetrant inspections were conducted by LILCO and FaAA personnel. The eddy current inspections were carried out by FaAA personnel. All the inspectors are qualified level II NDE inspectors.

16. Who supervised the inspections?

A. (Johnson and Schuster) The inspections were supervised by Milford H. Schuster from LILCO and Dr. Duane Johnson from FaAA. Dr. Johnson is a qualified level III NDE inspector and Mr. Schuster has many years of experience in nondestructive examination.

17. What conclusions can you draw from the post-test inspections of the crankshafts?

A. (Johnson and Schuster) The inspections establish that the crankshafts have suffered no fatigue damage after operating for 10^7 loading cycles at or about the qualified load of 3300 KW.

18. Dr. Pischinger, are you aware that EDG 103 with the replacement crankshaft has been operated to accumulate at least

10⁷ loading cycles for the purpose of demonstrating the reliability of the replacement crankshafts at the qualified load of 3300 KW?

A. Yes. 10⁷ loading cycles in the Shoreham EDGs equates to slightly less than 741 hours. EDG 103 accumulated approximately 745 hours at or about the qualified load of 3300 KW, as a result of the confirmatory test.

19. Are you familiar with the load levels at which these loading cycles were accumulated on EDG 103 with the replacement crankshaft?

A. (Pischinger) Yes. LILCO has, since my previous testimony in this proceeding, continued to keep me informed as to the status of the EDG's and I have continued to act as a consultant to them. I have also reviewed LILCO letter SNRC 1094 dated October 19, 1984 with its attachments which set out the testing protocol, and I have discussed the 10⁷ loading cycle confirmatory test with personnel from LILCO, FaAA and Stone & Webster. Thus, I am thoroughly familiar with those load levels. I have also reviewed the testimony of Messrs. Dawe, Notaro and Youngling as to the 525 hour endurance run.

20. Did you have an opportunity to inspect the replacement crankshaft of EDG 103 and to review the reports of

inspections pertaining to the replacement crankshaft of EDG 103 made following the accumulation of 10^7 loading cycles?

A. (Pischinger) Yes. After completion of 10^7 loading cycles and during the teardown and inspection of EDG 103, I visually inspected those portions of the crankshaft which were the most highly stressed and which were observable. In addition, I have been furnished with a copy of all reports of inspections of the crankshaft performed after teardown and I have reviewed those reports.

21. What did your visual inspection of the replacement crankshaft following the completion of the 10^7 loading cycle confirmatory test disclose?

A. (Pischinger) It disclosed no visible problem with any of the areas of the crankshaft which were observable, indicating that the 10^7 loading cycle confirmatory test had no adverse effect upon the crankshaft and it confirmed my previously expressed opinion that the replacement crankshafts are suitable for unlimited operation at 3300 KW.

22. What did your review of the post- 10^7 loading cycle confirmatory test inspection reports of the replacement crankshaft disclose?

A. (Pischinger) It indicated that no relevant indications were found in any of the areas inspected, including the most highly stressed fillet areas of the crankshaft. This confirmed my visual inspection and confirmed my independent analysis and opinion that the replacement crankshafts have unlimited life at 3300 KW.

23. Dr. Pischinger, based solely on the performance of this 10^7 loading cycle confirmatory test and the results of the inspections following the test, including your own visual inspection and your own review of the nondestructive examination reports, what conclusions, if any, are warranted with respect to the reliability of the replacement crankshafts?

A. (Pischinger) It can be concluded that the Shoreham replacement crankshafts have demonstrated unlimited life at the qualified load of 3300 KW as indicated on the control room kilowatt meter. This also confirms my independent analysis under the Kritzer-Stahl criteria.

24. Is your conclusion that the 10^7 loading cycle confirmatory test demonstrates unlimited life for the crankshaft at the indicated qualified load of 3300 affected in any way by the fact that approximately 20 hours of the 745 hours accumulated during the test involved operation between 3250 KW and 3300 KW?

A. (Pischinger) No. Twenty hours of operation at between 3250 KW and 3300 KW out of 745 hours is insignificant in terms of the 10^7 loading cycles. Indeed, given the number of hours the EDG operated at loads above 3300 KW, the exponential effect of these hours above 3300 KW more than compensates for these 20 hours below 3300 KW and therefore this has no effect upon my conclusion as to unlimited life at the indicated qualified load of 3300 KW.

25. Dr. Pischinger, the testimony of Messrs. Dawe, Notaro and Youngling indicates that certain intermittent or cyclic loads were excluded from the determination of the maximum emergency service load and qualified load for certain reasons. That testimony also established that even if these intermittent or cyclic loads were experienced incident with the maximum emergency service load (a very unlikely possibility), the qualified load would be exceeded for one EDG only (EDG 101) and then only by 31.4 KW for no more than a few minutes. Putting to one side the unlikelihood of this occurring as explained by those witnesses, does the possibility that the qualified load will be exceeded by 31.4 KW for no more than a few minutes change or affect your opinion concerning the reliability of the replacement crankshaft?

A. (Pischinger) No. In my previous testimony I indicated that the replacement crankshafts were shown to have unlimited life at 3500 KW under the Kritzer-Stahl criteria. This is still my opinion. This of course, would be true for any loads between 3300 KW and 3500 KW. Thus, it is obvious that loads of 3331.4 KW for a few minutes, or indeed for an unlimited period of time, are of no concern with regard to the replacement crankshafts. Additionally, a significant portion of the hours accumulated during the 745 hour confirmatory test were run at loads above 3331.4 KW. This gives added confidence to my opinion.

26. Dr. Pischinger, the testimony of Messrs. Dawe, Notaro and Youngling also discusses the effects of possible operator error on diesel generator loads during a LOOP or a LOOP/LOCA. That testimony indicates that such operator error is unlikely, but that if it should occur the maximum short duration loads that might result for the LOOP/LOCA are as follows:

	<u>LOOP/LOCA</u>	<u>LOOP</u>
EDG 101	3459.4 KW	3839.2 KW
EDG 102	3414.8 KW	3627.6 KW
EDG 103	3583.5 KW	3867.3 KW

Putting to one side the fact that these operator errors are not likely to occur, and/or result in loads of this magnitude, does

the possibility that the diesel generators will see any of these loads affect or change your opinion that the replacement crankshafts are reliable and suitable for operation in the Shoreham EDG's?

A. (Pischinger) No. As I previously stated in my original testimony in this proceeding, my analysis under Kritzer-Stahl indicated that the replacement crankshafts are suitable for many hours of operation at a load of 3900 KW. None of the above postulated loads equals or exceeds 3900 KW and as Messrs. Dawe, Notaro and Youngling have indicated, these loads would exist for only a short period of minutes. Thus, these loads have no effect upon my opinion that the replacement crankshafts are reliable and suitable for operation in the Shoreham EDG's.

IV. Conclusions

27. Please summarize your conclusions.

A. (All) The replacement crankshaft on EDG 103 has been tested for 10^7 loading cycles at or about the qualified load of 3300 KW. Post-test inspections revealed that the crankshaft suffered no fatigue damage during the confirmatory test. This establishes that the crankshafts have unlimited life at 3300 KW. The safety factor at 3300 KW under the Kritzer-Stahl criteria is 1.3. All these factors allow us to

conclude without reservation that the crankshafts are adequate for unlimited operation in the Shoreham EDGs at a load of 3300 KW. Also, any postulated loads as discussed previously herein would have no effect upon the reliability of the crankshafts.