ORIGINAL

UNITED STATES
NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF:

LONG ISLAND LIGHTING COMPANY

(Shoreham Nuclear Power Station)

DOCKET NO: 50-322-OL

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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In the matter of:

LONG ISLAND LIGHTING COMPANY : Docket No. 50-322-OL

(Shoreham Nuclear Power Station)

- -

Court of Claims,
State Office Building,
Hauppauge, Long Island,
New York.

Wednesday, March 6, 1985.

The hearing in the above-entitled matter was reconvened, pursuant to adjournment, at 9:00 a.m.

BEFORE:

JUDGE LAWRENCE BRENNER, Chairman,
Atomic Safety and Licensing Board.

JUDGE PETER A. MORRIS, Member.

JUDGE GEORGE A. FERGUSON, Member.

APPEARANCES:

On behalf of Long Island Lighting Company:

TIM ELLIS, Esq.,
Hunton and Williams,
Richmond, Virginia.

ODES L. STROUPE, JR., Esq.
Hunton and Williams,
Raleigh, North Carolina.

On behalf of Suffolk County:

ALAN DYNNER, Esq. and DOUGLAS SCHEIDT, Esq.,
Kirkpatrick and Lockhart,
Washington, D. C

On behalf of the Commission Staff:

RICHARD GODDARD, Esq., and BERNARD M. BORDENICK, Esq.,
Nuclear Regulatory Commission,
Washington, D. C.

C O N T E N T S

P R O C E E D I N G S

JUDGE BRENNER: Good morning.

We did have some preliminary matters that should be taken up first this morning, as we discussed yesterday, although there are others that we will defer to assist the scheduling of witnesses and also because the parties had to discuss further things with respect to them.

Did you want to give us the report on the SNRC letter first, Mr. Ellis?

MR. ELLIS: Yes, sir, I'll do that, Judge Brenner.

JUDGE BRENNER: All right. Thank you.

MR. ELLIS: The figures in the SNRC letter are correct, that is, SNRC Letter 44, and they do correspond to the figures in our testimony errata.

The difference is the addition of the RHR pump loads.

If you, in 1104, subtract 998, 998 and 1022 from the figures in the 1104, you'll get 2786, 2621 and 2529.

Those figures were corrected by 1144 to be 2743.8, 2577.2, 2708.9.

If you then add back the core sprays, two core sprays and the RHR as set forth in the testimony, you will get 3741.8, 3575.2 and 3709.9 as set forth in the errata to our testimony.

JUDGE BRENNER: It might be 3707, but that's a

detail.

MR. ELLIS: It's 3707, I'm sorry.

Thus, what NRC 1144 did was correct the intermediate figure.

JUDGE BRENNER: All right. That certainly explains it to the Board.

And the reason we asked--as I said, these letters are not evidence--we asked it to make sure that what we had in evidence was accurate as it was described on the record.

I certainly hope -- I assume, since there are people from the Staff present, that with that explanation they now understand this SNRC 1144 if they did not previously understand it.

Okay. The Board would like to ask its follow-up questions with respect to the subject of possible non-reporting by TDI.

We have received and appreciate a letter from Staff Counsel, Mr. Bordenick, dated February 28, 1985 attaching a memorandum from Mr. Berlinger to Mr. Reis and that certainly answered part of our question and we appreciate that information.

As I said yesterday, we are still awaiting the courtesy of a reply from OI; however, we have the following question to the Staff, and our question is:

Is any NRC Staff office -- and we treat the NRC Staff as one entity before us, so Staff counsel will have to coordinate, be it I&E or NRR or both of them or any other Staff entity -- is any NRC Staff office investigating whether TDI has failed to meet requirements for reporting defects in the past and whether any such non-disclosure problem has continued as recently as the latter part of 1984?

We have in mind most recently the subject of the fact that the cam gallery cracks or indications were welded, and this was not learned until very recently as Staff Counsel knows, and also the subject of the fact that the original 103 block had degraded Widmanstaetten graphite structure whereas the B bar test results reported by TDI did not reflect this and, moreover, according to the testimony of LILCO's witnesses the B bars for that block -- the B bar for that block or, for that matter, the other blocks, are not available from TDI.

In addition, as part of the same question that we asked at the outset, I have a recollection but I'm not sure and I'm asking that the Staff check it that after the Staff began to pursue the subject of possible non-reporting of defects by TDI -- and at times it might have been called product improvements euphemistically by TDI probably -- there was an identification or a listing of

such so-called product improvements which the Staff had obtained and yet my recollection is even after that fact the Staff reported -- and it may have been an I&E report, it may have been a Board notification, it might have been some other medium, but the Staff nevertheless identified yet other so-called product improvements or defects which came to light thereafter and noted that, notwithstanding the focus earlier, these had not been included in the original list.

So part of our question would involve whether that recollection is correct and it will require going through the I&E and other possible documents and, if so, whether anything is being done with respect to that; as part of the question of whether the Staff is pursuing any such investigation of non-reporting.

Our follow-up question is if the Staff is not pursuing any such inquiry, can we ask the Staff to consider initiating and pursuing such an inquiry and to report back to us as to what the Staff decision is in that regard and the reasons supporting the Staff's decision.

In terms of the date for the Board receiving this report, we would like to receive it promptly, yet we certainly want to give the Staff adequate time to give us a good answer, and in our mind we thought that the date of March 22 would be a reasonable date to accomplish the

potential competing goals.

If that becomes a major problem the Staff can let us know quickly that more time is needed, but we request that the Staff not request more time unless it is truly essential.

We think the job can be accomplished in that amount of time, there should be people familiar with the documents -- again, we emphasize coordination, we do not want to hear from one entity of the Staff and then find out that they don't know what the other entity is doing. We know there have been I&E documents as well as NRR documents that bear on the subject.

The long and the short of it is we think the time has come for some entity of the NRC, an investigating-type entity -- which the Board is not and not capable of being -- to finally put all this together and pursue it.

That completes our questions in that regard.

MR. GODDARD: Thank you, Judge.

JUDGE BRENNER: If you need any clarification, we'll try to provide that also, but I hope it is clear at this point as to what we are looking for.

MR. GODDARD: Unfortunately I think it is clear.

JUDGE BRENNER: I don't know why you say "unfortunately."

MR. GODDARD: I will bring this to management's

attention. I question whether we will be able to meet that March 22 date, I immediately foresee problems there but I will report back to you as soon as possible.

JUDGE BRENNER: We want a reason if the date can't be met, just not a statement that it can't be met.

MR. GODDARD: I understand that.

JUDGE BRENNER: I think it can be met. I think I could do it in that amount of time if I wanted to sit back and look through the documents that I have on file in my office however I have other things to do.

All right. The only further preliminary matter that we thought it would be necessary to take up before taking the testimony of the next panel would be the subject of LILCO's motion to file rebuttal testimony.

Were there any other matters that the parties thought needed to be taken up now?

MR. ELLIS: No, sir. I thought we could delay everything until the next break or until perhaps the lunch break, and get this panel off. Mr. Dynner indicated he only had an hour or two with this panel.

JUDGE BRENNER: You mean including deferring the motion to file rebuttal testimony?

MR. STROUPE: Judge Brenner, I think there is some possibility that that motion could be withdrawn, depending upon some discussions that are taking place between the Staff experts and LILCO experts. I think if we could reserve perhaps until after the lunch break to talk about that, we may have a resolution of that particular situation.

JUDGE BRENNER: All right.

LILCO, will you introduce the witnesses and proceed?

MR. STROUPE: Judge Miller, I believe all these witnesses have been previously sworn in this proceeding.

JUDGE BRENNER: That's right.

Whereupon,

FRANZ F. PISCHINGER,

DUANE P. JOHNSON,

and

MILFORD H. SCHUSTER

resumed and stand and, having been previously duly sworn, were examined and testified further as follows:

JUDGE BRENNER: While you are passing documents to the Reporter, I welcome the witnesses back and remind them that they are under oath or affirmation as previously sworn.

Welcome back, all of you.

MR. STROUPE: Gentlemen, will you introduce yourself, starting with the witness on my immediate left.

WITNESS SCHUSTER: Milford Schuster. I work for Long Island Long Island Lighting Company at Shoreham Nuclear Power Plant.

WITNESS JOHNSON: Duane Johnson, managing engineer at Failure Analysis Associates.

WITNESS PISCHINGER: Franz Pischinger, president of FEV and professor at the University of Aachen, Germany.

DIRECT EXAMINATION

BY MR. STROUPE:

Q Gentlemen, do all of you have in front of you testimony entitled "Additional Crankshaft Testimony of Franz F. Pischinger, Duane P. Johnson and Milford H. Schuster on behalf of Long Island Lighting Company," dated January 15, 1985?

A (Chorus of "Yes.")

Q And do you have in front of you two letters, one dated February 7, 1985, and one dated February 18, 1985, reflecting crankshaft testimony errata?

A (Witness Pischinger) Yes, but we have some corrections.

Q Let me hand you this.

(Handing documents to the panel.)

Do you now have that in front of you?

A (Witness Pischinger) I have it now, yes.

A (Witness Johnson) Yes.

Q Other than these corrections to the testimony, are there any additional changes or corrections that need to be made to the best of your knowledge?

A (Witness Pischinger) No.

A (Witness Johnson) No.

A (Witness Schuster) No.

Q Is this testimony accurate to the best of your knowledge and belief?

A (Witness Schuster) Yes.

A (Witness Pischinger) Yes.

A (Witness Johnson) Yes.

Q And do you adopt it as your own?

A (Witness Pischinger) Yes, I do.

MR. STROUPE: Judge Brenner, I would now move the

admission into evidence of this testimony. And I tender the witnesses for cross-examination.

JUDGE BRENNER: All right.

I assume that the corrections that were made are marked up on the Reporter's copy?

MR. STROUPE: I just handed four copies to the Reporter with the changes marked in black ink.

JUDGE BRENNER: We will admit the testimony of these witnesses into evidence, and bind it into the transcript at this point as if read.

(The documents follow:)

LILCO, January 15, 1985

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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

TABLE OF CONTENTS

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

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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~~ crankshaft was inspected by liquid penetrant and eddy current. These inspections show no relevant indications and therefore no fatigue damage.

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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.

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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.

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11. ~~Were the crankshafts~~ Was the Crankshaft 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

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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 accessable for eddy current inspection. The areas were carefully cleaned by using a Scotchbrite 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?

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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?~~ crankshaft

A. (Johnson and Schuster) The inspections establish that the ~~crankshafts have~~ crankshaft has 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

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10^7 loading cycles for the purpose of demonstrating the reliability of the replacement crankshafts at the qualified load of 3300 KW?

A. Yes. 10^7 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 10^7 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?

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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 nour 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:

	LOOP/LOCA	LOOP	
EDG 101	3459.4 KW	~~3839.2 KW~~	3741.8 KW
EDG 102	3414.8 KW	~~3627.6 KW~~	3575.2 KW
EDG 103	3583.5 KW	~~3867.3 KW~~	3707.9 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

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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.

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FILE NO.

DIRECT DIAL NO. 202 955-

February 18, 1985

Alan R. Dynner, Esq.
Kirkpatrick & Lockhart
1900 M Street, N.W.
Washington, D.C. 20036

Robert G. Perlis, Esq.
U.S. Nuclear Regulatory
Commission
Washington, D.C. 2055

Dear Alan and Bob:

You will recall that Tim Ellis' letter of February 7, 1985 informed you of errata regarding Additional Crankshaft, Additional Block and Diesel Generator Qualified Load Testimony. We failed to note that errata concerning the loads during a LOOP necessitated a change in the table contained in Question 26, lines 20-22 at page 13 of the Additional Crankshaft Testimony. The loads for a LOOP are as follows:

EDG 101	3741.8 KW instead of 3839.2 KW
EDG 102	3575.2 KW instead of 3627.6 KW
EDG 103	3707.9 KW instead of 3867.3 KW

Best wishes.

Sincerely,

Odes

Odes L. Stroupe, Jr.

241/812
cc: Service List

CERTIFICATE OF SERVICE

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

I hereby certify that copies of the attached letter dated February 19, 1985, regarding errata to LILCO's Additional Crankshaft Testimony was served this date upon the following by first-class mail, postage prepaid, or by hand as indicated by asterisk.

Judge Lawrence Brenner, Esq. *
Chairman
Atomic Safety and Licensing
Board, United States
Nuclear Regulatory Commission
Washington, DC 20555

Dr. Peter A. Morris *
Administrative Judge
Atomic Safety and Licensing
Board, United States
Nuclear Regulatory Commission
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Dr. George A. Ferguson *
Administrative Judge
Atomic Safety and Licensing
Board Panel
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February 7, 1985

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Dear Alan and Bob:

This letter lists errata for LILCO's qualified load, additional block and crankshaft testimony.

I. Errata Regarding Additional Crankshaft Testimony

A. Page 2, line 22, the words "crankshafts were" should read "crankshaft was."

B. Page 6, line 1, the words "Were the crankshafts" should read "Was the crankshaft."

C. Page 8, line 15, the word "crankshafts" should read "crankshaft."

D. Page 8, line 17, the words "crankshafts have" should read "crankshaft has."

II. Errata Regarding Additional Block Testimony

A. Page 4, answer 3, paragraph 3c, first sentence, delete the word "replacement" which appears at the end of the first and beginning of the second lines.

B. Page 6, last line of answer 6, insert the word "during" in lieu of "before."

C. Page 9, delete the term "replacement" the first time it appears in the first sentence of the second paragraph.

III. Errata Regarding Diesel Generator Qualified Load Testimony

A. The portion of answer 2 on pages 1 and 2 is set forth fully below with the revisions underscored.

(Dawe) My current position, to which I was appointed in February, 1985, is Supervisor of Projects within the Nuclear Technologies and Licensing Division of Stone & Webster (SWEC). I am responsible for technical and administrative supervision of personnel assigned to SWEC headquarters projects, including field assignments.

I joined Stone & Webster in 1973 as an Engineer in the Licensing Group. In January 1974, I was assigned as Licensing Engineer for the Shoreham Nuclear Power Station (SNPS) under construction, and was Lead Licensing Engineer from 1976 to 1980. In this capacity, I was responsible for all licensing related activities for SNPS, including preparation of the Final Safety Analysis Report. From 1980 through 1984, I held the position of Supervisor of Project Licensing within the Licensing Division. My duties included assuring project awareness of regulatory requirements and developments, assuring proper and consistent application of SWEC licensing policies, and consulting with projects and clients on licensing issues. I have had additional assignments at Stone & Webster including development of company positions for NRC Regulatory Guides and Lead Licensing Engineer for the Special Projects Group of the Operations Services

Division. I am also the Stone & Webster representative to, and participating member of, two subcommittees of the AIF Committee on Reactor Licensing and Safety.

B. Page 5, eighth line from the bottom, insert "generators" in lieu of "operators."

C. Page 16, third and fourth lines from the bottom, should be changed to read as follows: "approximately 22 minutes every 48 minutes during the operation of the diesel (at 3300 KW) . . . ."

D. Page 25, line 2, change "Revision 7" to "Revision 9."

E. Page 25, lines 3-4, delete "(iii) SP 29.015.04, Revision 0, 'Loss of Coolant Accident Coincident With a Loss of Off-Site Power,'" and change "(iv)" to "(iii)."

F. Page 25, line 5, change "Revision 4" to "Revision 5."

G. Page 25, second line of second full paragraph, change "LOOP/LOCA" to "LOOP" and change "SP 29.015.04" to "SP 29.015.01."

H. Page 26, fourth line from bottom, insert "such as" for "for."

I. Page 27, answer 22, third line, change "February 1, 1985" to "February 1985."

J. Page 32, delete the last sentence on the page which reads "The CRD pumps cannot be restarted as long as a LOCA signal is present."

K. Page 33, line 3 of answer 29, delete term "automatic."

L. Page 33, answer 29, fourth line, insert "3741.8 KW" in lieu of "3839.2 KW" and "3575.2 KW" in lieu of "3627.6 KW."

M. Page 34, second and fifth lines, substitute "runout" for "design."

N. Page 34, first line of last paragraph, insert the figure "999 KW" in lieu of "1022 KW."

O. Page 34, last paragraph, line 3, insert "3707.9 KW" in lieu of "3867.3 KW" and delete the parenthetical sentence which follows.

P. Page 36, third line from bottom of first full paragraph, delete "to."

If the County and Staff plan to submit testimony errata at the time of the hearing, it would be helpful if you would send it to us in advance of the hearing.

Best wishes.

Sincerely,

J. S. Ellis, III

T. S. Ellis, III

75/403

cc: Service List

JUDGE BRENNER: They are available for cross-examination, starting with Suffolk County.

CROSS-EXAMINATION

BY MR. DYNNER:

Q Dr. Pischinger, will you please turn to page 5 of your testimony?

A (Witness Pischinger) Yes.

Q I direct your attention to answer 9, the last sentence--

JUDGE BRENNER: Mr. Dynner, excuse me.

I think it would be useful to note for the record the stipulation of facts that the parties have reached with respect to the crankshaft at 3300 kw. To my recollection, we have never noted that on the record. I am looking for it now. Perhaps the County or LILCO could just briefly state for the record what that involved.

MR. DYNNER: Yes, Judge.

The statement you are referring to was set forth in the Joint Report of the Parties which was filed with this Board on February 8, 1985 with respect to crankshafts. It is the position of Suffolk County, as reflected in that Joint Report, that Suffolk County does not challenge the adequacy of the replacement crankshafts to the extent that they do not operate in EDGs loaded above 3300 kw.

The effect on the crankshafts of loads above 3300 kw

remains at issue.

MR. STROUPE: Judge Brenner, I believe it was slightly more than that. I believe that it indicated -- at least the letter from the County indicated that their consultants had determined for themselves that the crankshafts complied with DEMA, ABS and Lloyd's Rules at 3300 kw also.

JUDGE BRENNER: I have the letter but I don't have it in front of me right now.

Is that also accurate?

MR. DYNNER: I think that is what the letter said. I think that is irrelevant, given the fact we are not challenging the crankshafts at loads at 3300. Those in fact are the reasons why, but they were stated in the letter.

JUDGE BRENNER: All right. Thank you.

MR. DYNNER: Those are the reasons rather than the conclusion; in other words, I'm giving you the conclusion.

JUDGE BRENNER: All right. Okay. Thank you. I'm sorry I interrupted your question. I was a little slow in getting to that.

BY MR. DYNNER:

Q Dr. Pischinger, you see the last sentence of answer 9? You say:

"This safety factor coupled with the 10 to the 7th loading cycle confirmatory test gives me confidence that the replacement crankshafts can

safely and reliably accommodate loads substantially above 3300 kw."

Is the 10 to the 7th loading cycle confirmatory test that you're referring to there the testing that LILCO carried out on the EDG 103 at a purported load of 3300 kilowatts?

A (Witness Pischinger) Yes. I refer to this testing by LILCO, of course including the cyclics of the crankshaft which has been in advance of the 500-and-some-odd hours at 3300 kilowatts.

Q Now does that so-called confirmatory test alone -- taken alone -- does that test alone at 3300 establish that the crankshafts are safe and reliable to carry loads substantially above 3300 kw?

A (Witness Pischinger) Yes.

May I explain?

Q Yes.

A (Witness Pischinger) This 10 to the 7th loading cycles have been taken at different loads, and there are several loads, a substantial part of the loads above 3300 kilowatts, even seven hours at 3900, and 101 hours at the magnitude of 3800, 119 hours at 3500, and so on, as you can see from data logs of all these test runs which are reported by LILCO.

If you do an accumulated-damage estimation or

calculation based on those facts you can do a conservative calculation which shows that this test run, including also these overloads, is equivalent to about 3505 kilowatts which is I think substantially above 3300 kilowatts.

Q Did you yourself perform a-- Did you say a cumulative-damage analysis?

A (Witness Pischinger) Yes.

Q You performed one yourself?

A (Witness Pischinger) Yes, in order to be able to make the statement.

Q What was the basis for that cumulative damage analysis that you performed?

A (Witness Pischinger) Well, the data base of the test run was the basis, and the hours run at the different loads.

Q Which type of cumulative damage analysis did you perform?

A (Witness Pischinger) It is today a generally accepted method of Miner-Pilgrim-Haiback, which is for instance referred to in the textbook of Collins.

Q Did you take into consideration in performing that cumulative damage calculation the sequences, actual sequences of load that the crankshaft experienced during testing?

A (Witness Pischinger) No, this is not taken into account in this method.

Q And in fact the actual sequence of load--

A (Witness Pischinger) You mean the time sequence?

Q The actual sequences in which the load is run can have a significant effect on the cumulative damage analysis, can't it?

A (Witness Pischinger) There is certainly knowledge that the sequence can have an effect. To take into account some conservatism the addition which Haibach made was to take even into account those cycles below any estimated endurance limit, conservatively estimated endurance limit, and by this you get a rather conservative calculation which is generally thought to compensate for such influences of time schedule.

Q Are you aware that in the textbook of Professor Collins that you mentioned that he specifically states, and I quote:

> "It must be recognized, however, that in its simplicity, certain significant influences are unaccounted for and failure prediction errors may therefore be expected. Perhaps the most significant shortcomings of the linear theory are that no influence of the order of application of various stress levels is recognized and damage is assumed to accumulate at the same rate at a given stress level without regard to past history."

Are you familiar with that statement by

Professor Collins?

MR. STROUPE: Judge Brenner, I am going to object to that question on the basis that he is using an exhibit or apparently something from a textbook that we certainly have no knowledge of. And I think at the very least Dr. Pischinger should be given an opportunity to read that section for himself before having to comment upon it.

JUDGE BRENNER: Overruled. At best your objection is premature, depending on further answers of the witnesses. He referred to the work and I think he started to answer the question, yes, he was familiar with the statement, but we'll go back and find out.

BY MR. DYNNER:

Q Are you familiar with that statement, Dr. Pischinger, that Professor Collins made in the book?

A (Witness Pischinger) Well, if you read a statement out of a certain text, I always hesitate to say yes because you cannot take a sentence out without having the whole chapter or the whole page into your mind. So I can only repeat it is certainly also my knowledge that there can be a certain influence of the time sequence of loading but, at the same time, the Miner-Pilgrim-Haibach rule, which does not take into account the time order, is an accepted method for estimating -- I say "estimating" -- loads given by a certain sequence of loading in time.

Q Accepted by whom?

A (Witness Pischinger) In the literature and by experts. It is used in practice.

Q I see.

Is it used specifically in practice with respect to crankshafts?

A (Witness Pischinger) It is also used for that purpose.

Q Large crankshafts such as the ones in the EDGs at Shoreham?

A (Witness Pischinger) There is no reason why not use it.

Q Well, has it been used other than by yourself, to your knowledge?

A (Witness Pischinger) For estimates, yes.

Q Which cases has it been used in other than the one you used it in at Shoreham?

A (Witness Pischinger) Well, during testing of engines you do such estimates very often. You have a couple of loadings and you want to know what is the equivalent mean load and you use such a method. It is the only method you can rather simply apply.

Q But you cannot specifically tell me any particular cases in which that method was used for large crankshafts, can you?

A (Witness Pischinger) What do you mean by "particular"?

Q Particular situations in which that calculation was used for large crankshafts. Other than your use at Shoreham, you don't know of any specific such cases, do you?

A (Witness Pischinger) Well, we ourself use it if we are estimating. It is not the first time we used it.

Q You mean FEV?

A (Witness Pischinger) Yes.

Q And what other cases have you used it in involving large crankshafts on the order of the size of those at Shoreham?

A (Witness Pischinger) I am not in a position to tell you.

End 2

Q. You say that that testing means that the replacement crankshafts can safely and reliably accomodate loads substantially above 3300 Kw.

What did you mean by "substantially above," how much higher?

A. (Witness Pischinger) I gave you a figure -- well, to refer to this sentence, this sentence also takes into account an analysis according to the Kritzer-Stahl criterion. criterion, though it is, of course, a combined statement.

Q. My question, to clarify, just goes to how much higher the 10 to the 7 testing at 3300 means that you can go to. Did you say 3505 or something like that? I'm not sure what you said.

A. (Witness Pischinger) To make it completely clear, the calculation of the Miner -- according to the Miner-Pilgrim-Haibach method using the 10 to the 7 cycle test run by LILCO leads to a figure of 3505, 3-5-0-5.

Q. All right.

In doing that analysis you used the actual hours that LILCO says it ran the engine above 3300, that is, in the 220 hours prior to the 525 hour run at a purported load of 3300, is that right?

A. (Witness Pischinger) No, not completely, because although they are 20 hours below, 3300 have been taken into account.

Q You used all of those hours --

A (Witness Pischinger) -- all of those hours.

Q -- in addition of the 525.

A (Witness Pischinger) But we did not --

Q You used all of the hours in addition to the 525?

A (Witness Pischinger) Not all, we did not use hours which, in addition to the test run and the previous runs, have been seen by the crankshafts at still lower loads.

There is a figure which I have been supplied with about -- a crankshaft has seen about 1300 hours of operation and only.... I have to look for the figure. 741 hours at 10 to the 7. That means exactly 745 hours have been taken into account.

That means that all the bunch of still lower loads during additional operation, we did not take into account.

Of course, the Miner-Pilgrim-Haibach rule provides or would provide also to take into account considerably lower inputs and they would, to a small amount, also contribute and give us a still higher figure but we did want to make a conservative estimate.

Q Did you take into consideration the instrument error that might have occurred with respect to the hours

that the EDG's were run and recorded by LILCO, that this particular EDG 103 was run and recorded?

A. (Witness Pischinger) We did only take into account the recorded and noted figures for power and no instrument error because, as was reported and so from the reports, this instrument error, if there is one, it would be a plus-minus error. That means that with a very high probability during the whole operation it would partly be -- the reading would partly be above and then other times below the actual value.

Q. You don't know that for a fact though, do you?

A. (Witness Pischinger) Out of the calibration procedure, it is a very, very high probability because during calibration you could find as many points below as above roughly, above the nominal value.

So it would be -- the general best way to do it is to take the value as it has been read by the instruments.

Q. Does the new calculated safety margin or safety factor that you reached under the Kritzer-Stahl criteria alone permit the crankshaft, the replacement crankshaft, to be operated at substantially higher than 3300 Kw?

A. (Witness Pischinger) Yes.

Q. And how much higher would that permit the crankshaft to be operated?

A. (Witness Pischinger) Well if I take into account

the inherent conservative feature of the Kritzer-Stahl criteria, then my conclusion is -- as it had been in September -- that the engine can be operated at 3900 kilowatts.

JUDGE BRENNER: Dr. Pischinger, do you mean continuously for unlimited life at 3900?

WITNESS PISCHINGER: Yes, if I take into account the proven conservative feature of the Kritzer-Stahl. If you take the Kritzer-Stahl criteria nominally then there would be a predicted lifetime of above -- certainly more than 1000 hours.

I think the calculation figured it was 1200 hours which, if you take it very strictly, a small part of which has been already consumed, it would be strictly Kritzer-Stahl criteria, not taking into account that it's very conservative.

BY MR. DYNNER:

Q. Why would you rely on Kritzer-Stahl instead of Lloyd's Register rolls, for example?

A. (Witness Pischinger) Because it is more tailored to the real physics. It is telling what is really happening in a crankshaft with the input of a lot of measured experience.

Q. You are aware that Lloyd's, at 3900, the crankshaft would not meet the Lloyd's requirement at 3900, aren't you?

A. (Witness Pischinger) I did not do the Lloyd's

calculation.

(Pause.)

JUDGE BRENNER: Mr. Dynner, if you want to take a short break we will permit you to do that.

MR. DYNNER: It will only take a minute.

BY MR. DYNNER:

Q In making your Kritzer-Stahl calculations, Dr. Pischinger, did you rely on any S-N curves?

A (Witness Pischinger) No, for the Kritzer-Stahl calculation an S-N curve is not needed.

MR. DYNNER: No further questions.

JUDGE BRENNER: The Staff?

MR. GODDARD: Judge Brenner, the Staff wonders if we might take a short break at this time point of the proceeding in view of the fact that we are moving this quickly; the Staff anticipates no more than 20 to 30 minutes' cross-examination for this panel.

JUDGE BRENNER: All right. How much do you want?

MR. GODDARD: 20 minutes?

JUDGE BRENNER: All right. Let's round it to 10:00, which would be almost 20 minutes.

MR. GODDARD: All right, thank you, sir.

(Recess.)

JUDGE BRENNER: Back on the record.

Mr. Goddard.

MR. GODDARD: Thank you, Judge Brenner.

If I might just have a moment.

(Pause.)

CROSS-EXAMINATION

BY MR. GODDARD:

Q. Dr. Pischinger, you testified just now that in your opinion the crankshafts are good for unlimited operating life at 3900 kilowatts, is that correct?

A. (Witness Pischinger) Yes, in my opinion, that's correct.

Q. At what point in time did you reach the conclusion that these crankshafts could be operated at that load level infinitely?

A. (Witness Pischinger) Are you thinking of a time frame or what?

Q. Yes, in terms of time frame.

A. (Witness Pischinger) This was before the hearing in -- I think it was in September -- when I studied in-depth all the data and compared with the results of the Kritzer-Stahl and compared with conservative S-N data for crankshafts of the same size.

Q. That conclusion though, Dr. Pischinger, is not based on any of the additional information which was produced by virtue of the testing at the 3300 level, plus or minus the instrument error and other factors which have

been testified to here, is that correct?

A. (Witness Pischinger) That's correct.

Q. At page three of your testimony you state that the Kritzer-Stahl criteria contains an inherent safety factor of 22 percent.

That's at the bottom of your answer to question five.

Can you please explain for me the basis for that safety factor, if you are aware of it?

A. (Witness Pischinger) Yes.

JUDGE BRENNER: Excuse me one moment.

Mr. Goddard, it's been a long time for me and I'm sure for all of us, isn't that on the record?

WITNESS PISCHINGER: That's on the record.

JUDGE BRENNER: Let's see what Mr. Goddard thinks.

MR. GODDARD: Judge Brenner, I'm sure your memory is better than mine. It may well be on the record but in view of the fact that he refers to the inherent safety factor in his current testimony, I would like to hear an explanation at this time, if it won't unduly burden the record.

JUDGE BRENNER: I think we spent a fair amount of time on it previously.

Go ahead for now but if we get too much on it and it begins to get redundant we are going to cut it off.

MR. GODDARD: I appreciate that, sir.

JUDGE BRENNER: Dr. Pischinger, will you explain?

WITNESS PISCHINGER: Yes. I will try to repeat this as short as possible.

We have three crankshafts, 11 by 13, which failed, one severed into two pieces and the two others, at nearly the same load and cycles, had considerable cracks at loading cycles.

Using this data and using an S-N curve out of a considerable number of data we would say a crankshaft of about the same size one can arrive at an endurance limit or, if you put it the other way around, if you calculate with the Kritzer-Stahl criteria these 11 by 13 inch crankshafts, you can find that they should have failed a lot earlier. And if you provide to bring this into coincidence, then you can by this calculate the safety factor. I explained it in more detail in the previous hearing.

MR. GODDARD: Yes.

BY MR. GODDARD:

Q I guess my question to you at this point is is the 22 percent safety factor or margin of safety to which you refer inherent in the methodology of Kritzer-Stahl itself or is it based upon your application of the Kritzer-Stahl to the 11 by 13 inch crankshafts that failed and extrapolating from those failures?

A. (Witness Pischinger) No. It is obviously inherent in the Kritzer-Stahl. And I think in the September hearing I also explained on Judge Brenner's question that the conservatism is in calculating the endurance limit of the crankshaft.

There is a procedure combined with the Kritzer-Stahl how to calculate an endurance limit which is very conservative. The stresses are calculated very accurate and we could compare in this case with the stresses measured at the crankshaft and there was a very good coincidence, which I expected to be, but the safety is in the endurance limit which is calculated out of the tensile strength of the steel of the crankshaft by a procedure which takes into account a lot of factors which gives a very low tensile strength.

Q. If I understand your answer correctly, Dr. Pischinger -- and I may well not be understanding it correctly -- that the 22 percent is based on a comparison between the calculated -- what's the word I'm looking for -- the calculated endurance limit under Kritzer-Stahl in your experiential result?

A. (Witness Pischinger) I think the best way to explain it, if you apply the Kritzer-Stahl and combine the predictions of Kritzer-Stahl in a lifetime frame with an S-N curve, an S-N curve which is built of experiments

with a crankshaft of about the same size, then you arrive at a very short lifetime for the 11 by 13 inch crankshaft; we also calculated the severed crankshaft.

By comparison of this short lifetime of the prediction of Kritzer-Stahl, which is a lot longer lifetime, about 4 times 10 to the 6 cycles of the 11 by 13 inch crankshaft, one could very, very good calculate this factor of safety or, in other words, one could calculate an endurance limit which would be higher.

And of course this is backed up by experience with other modern crankshafts. You can find in the literature endurance limits of crankshafts -- for instance, Japanese sources which are also mentioned in the FaAA report, which also gives a lot higher endurance limit, all this coincides.

But this safety factor is calculated out of the comparison of the lifetime predicted and experienced on three crankshafts, which is very strong evidence.

Q. Forgive me, Doctor, but, as I stated, your 22 percent is derived from a comparison of the calculated or predicted endurance limit with the experiential limit, is that correct?

A. (Witness Pischinger) Yes. You could put it that way, yes.

Q. Okay. That's the way I did put it.

Now you're referring to the Kritzer-Stahl method as being a very conservative one.

Is the 22 percent inherent safety factor, as you refer to it in your testimony, inherent in all applications of the Kritzer-Stahl method, or does it apply only to the particular crankshafts which you have considered here.

MR. STROUPE: I'm going to object to that question, Judge Brenner, I don't see the relevancy frankly. We are only talking about this situation.

JUDGE BRENNER: I see the relevancy. I thought it was asked and answered. We will permit it one more time in case I'm wrong and, as phrased differently, this really is a different question.

Do you have the question in mind, Dr. Pischinger? If so, you can answer.

WITNESS PISCHINGER: Yes.

The conservatism of the Kritzer-Stahl is, of course, existing also for other cases. In this special case we could put a figure to it -- usually you cannot put a figure to it because there are, of course, differences in different cases. But the conservatism is there also for other cases.

BY MR. GODDARD:

Q Yet by applying this conservative Kritzer-Stahl calculation, as you indicate in your testimony then, the

calculated factor of safety is only 1.074, is that correct?

A. (Witness Pischinger) If you take not into account the inherent safety factor then the calculated factor of safety -- if you only rely on nominal Kritzer-Stahl, the factor of safety is 7.4 percent.

Q. Then is it also not true, Dr. Pischinger, that the inherent -- that there is an inherent assumption in using the Kritzer-Stahl method that crack initiation controls your calculation rather than crack propagation? Or, in other words, that the crankshaft is considered to be free of flaws at the time you apply the calculation? Is that not correct?

MR. STROUPE: I am going to object to that question. I frankly don't understand it.

JUDGE BRENNER: All right.

There could be some confusion because you started to express it one way, Mr. Goddard, and then expressed it differently.

You are entitled to try to ask the same question again at least so far but if you rephrase it it might be a little more simple.

MR. GODDARD: Thank you, Judge Brenner.

BY MR. GODDARD:

Q. Dr. Pischinger, is it inherent in the assumptions of the Kritzer-Stahl criteria that the endurance limit is

that which would apply to a crankshaft where there has been no crack initiation at the point of calculation; that is, we're not dealing with crack propagation, we're dealing with initiation?

Am I making myself clear to you?

A. (Witness Pischinger) Not completely.

Do you mean by this question that if there are flaws by the type of manufacturing of the crankshaft, small flaws say, do you mean this?

Q. That would be one source.

What I'm asking is is the crankshaft considered free of flaws at the point that you are doing your calculations to reach the so-called endurance limit at a given power level?

A. (Witness Pischinger) What is typical for the derivation of a typical feature, what is a typical feature of the Kritzer-Stahl, is that the endurance limit is derived taking into account the typical production procedure of the crankshaft and the status of -- and this may be a source of conservatism -- the status of about 20 years ago.

This was derived from a lot of experiments with crankshafts of about 20 years ago. We know that we today have improved methods and I personally contributed conservatism to this fact: that it still relies on experiments with such old-time crankshafts which certainly have always -- you could put it that way -- a small amount of minimal

flaws.

Q. However that would be production-induced flaws, which are not notable enough to affect the calculations.

A. (Witness Pischinger) Not stress-induced, prestressed, precracked.

Q. Thank you, Dr. Pischinger.

At page two of your testimony you state, and I quote -- this is in the answer to question four:

"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."

It's about eight to ten lines down in your answer to question four.

A. (Witness Pischinger) I have it now.

endC4

Q Why did you not state in your testimony, as you did today, that the crankshafts have unlimited life at 1300 kw, Doctor?

A (Witness Pischinger) Yes. I have to confess there is a little mixture. Of course, it is true what is written here, but the first figure is taking into account the inherent safety margin, and that means 1.248 at 3500. And the second statement, "Many hours of life at 3500" does not take into account the inherent safety figure. This is a little -- I have to admit this is mixed up here.

Q Perhaps I'm a bit confused, Dr. Pischinger, but is it your opinion at this time that those crankshafts have unlimited life potential for operating at 3900 kilowatts?

A (Witness Pischinger) Yes, it is.

Q Have you computed a factor of safety if those crankshafts were to be operated at that level for an infinite period?

A (Witness Pischinger) Yes. I have to look for this figure, but I am not sure if it is in the previous -- if I gave this figure in the hearing in September or if it is written here.

Could you allow me a little time to look into my --

JUDGE BRENNER: Why don't we see if we could come back to it later, if it is necessary?

WITNESS PISCHINGER: Fine.

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JUDGE BRENNER: Do you think it is necessary for your purposes, Mr. Goddard?

MR. GODDARD: Not for purposes of completing the cross-examination. But the Staff would like on the record that factor of safety and the basis for its calculation, Judge Brenner.

JUDGE BRENNER: All right.

Well, you will have the opportunity of a break, Dr. Pischinger, which will allow you to find it. I don't remember if it is in the record earlier or not.

WITNESS PISCHINGER: It's in the record.

BY MR. GODDARD:

Q. The reason for the question, Dr. Pischinger, is that in that answer you provided the safety margin at 3300 and 3500 kw, but your testimony was silent as to the factor of safety at the 3900 level.

JUDGE BRENNER: Well, ask another question, and we'll come back to it.

BY MR. GODDARD:

Q. Dr. Pischinger, you indicated that your calculations, using the Miner-Pilgrim method -- I believe that is -- gave you an equivalent high cycle load of 3505 kw. Now, in answer to a question by Mr. Bynner, you stated that this method did not account for load sequencing. Can you provide us any more information on the details of your calculations, by which you

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arrived at that equivalent high cycle load of 3505 kw?

A. (Witness Pischinger) Yes, I can. You want me to describe this method?

Q. Yes, please.

A. (Witness Pischinger) For each -- well, at first, we assumed the conservative endurance limit, which is a little below the stresses experienced at 3500, because you have to assume an endurance limit for this method, and the endurance limits, the conservative endurance limit predicted by Kritzer-Stahl -- which is a worst-case, in my opinion. And then we used the S-N curve for crankshafts of this size. And then we calculated for each bunch of load levels which the crankshaft experienced, the induction of damage, by taking into account the number of cycles which, at this load, would have led to damage. Of course, there are a lot of cycles below the S-N curve, as it should be. And, therefore, according to Haibach, we prolonged this S-N curve as it is given by Haibach with a certain slope which also is recommended by Haibach, so that even in the range where there is infinite life, there is taken into account a certain degree of damage in the material -- hypothetical, of course.

And then you sum up the ratios of cycles experienced to cycles which have led to damage at each load level, and from this you can arrive at a load level, or at a -- how should I say -- at an overall damage figure.

And if you use this overall damage for calculating a stress ratio, that means stress experienced to stress according to the endurance limit. Then you can calculate a mean stress which was experienced. And, from the relationship between this stress to the engine power, which we know, then you can calculate this mean engine power.

Q. Thank you, Dr. Pischinger.

Dr. Johnson and Mr. Schuster, at page 7 of the testimony, in the first paragraph, which is a carryover from page 6, and again in the second paragraph, there is a reference to linear indications which were found and which were evaluated by any current and found to be acceptable.

Can you provide the specific details of the linear indications which were recordable, as indicated in that testimony, and your basis for determining the acceptability of those indications?

A. (Witness Schuster) The acceptance criteria for the penetrant examination would be as provided; and the procedure was MB 5300. MB 5300 provides what the requirements are that the penetrant examiner has to follow during the examination. And, basically, what it does is it provides you with the requirement that any linear indication would be considered to be recordable.

These are the recordable indications that were provided for in the testimony and in the previous penetrant

reports that were submitted for your review, for the Staff review.

The evaluation of these indications was done with any current, and Dr. Johnson can expound in this area, and also by additional cleaning in some of these areas, because the indications were mechanical in nature, caused by machining discontinuities and service discontinuities. And additional penetrants were done in accordance with this code section and procedure, and found to be nonrelevant.

We found that some of the remnants from the previous examinations that were done after the 100-hour run in these mechanical areas -- you know, and geometric areas of the crankshaft -- required us to do additional cleaning. We verified this by using black light in areas where we did not apply any penetrant just prior to this examination.

I think I've answered your question.

Q. Before Dr. Johnson comments, Mr. Schuster, is it your testimony that all of these indications which were examined by you were, in fact, mechanically induced, and none of them were stress induced?

A. (Witness Schuster) That's correct, yes, sir. They are associated with machining, transition areas in geometry -- that sort of thing, sir.

Q. Dr. Johnson, do you have anything you wish to add to that answer?

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A. (Witness Johnson) I would just like to comment that the indications were not in the high stressed areas, and they did not have the orientation that would be expected of a fatigue crack if it would be initiating.

Q. Thank you, gentlemen.

MR. GODDARD: I have no further questions of this panel.

JUDGE BRENNER: The Board has a small amount of questions that it will ask at this time. I want to note, however, that we're holding off on questions related to the potential situation of the effect of the fuel racks being wide open during the immediate rapid loading cycle based, Mr. Stroupe, on the fact that you've told us that further discussions might resolve that. If that is not resolved in some acceptable fashion -- a fashion acceptable to all parties and the Board -- we will still require the presence of these witnesses, primarily Dr. Pischinger, because we want to ask some questions about it. And I'll have to find out more fully what LILCO meant by its motion to file rebuttal testimony, but we're holding off on that whole subject. So, if we finish with these witnesses before lunch, and I expect we will, they may still have to be here, depending on what transpires on that subject.

MR. STROUPE: Judge Brenner, I have talked to both Mr. Dynner and Mr. Goddard about this matter of the rebuttal

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testimony. And, frankly, what we would like to do is, after this panel -- the cross-examination of this panel is completed, we would like to have, perhaps, an hour to meet -- the County, the Staff, and LILCO's consultants -- to see if, indeed, we need a ruling on the rebuttal motion this afternoon.

Mr. Dynner, who can obviously speak for himself, has indicated to me he would oppose this because his consultant is not here.

JUDGE BRENNER: All right. Well, let's finish the testimony here and then see what happens. I don't expect to take an hour, other than the lunch break time, anyway -- which we might extend slightly, if necessary. And then I will hear from you, also, Mr. Dynner.

Let's get done. All right.

EXAMINATION BY THE BOARD

BY JUDGE MORRIS:

Q. Dr. Pischinger, I would just like to follow up a little bit on that question of Mr. Dynner with respect to sequencing. I believe I understood your answer to be that it is either taken into account or it didn't matter; and I wonder if you could explain why that need not be pursued.

A. (Witness Pischinger) You speak of --

Q. Sequencing of the loads.

A. (Witness Pischinger) Well, the methods to take into account the sequencing are not so well established and so

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generally accepted, although there is certainly agreement that there can be an influence of sequencing. So this is the reason why, because we generally use for estimates the rule, the improved Miner rule, which takes not into account the sequences of the load.

Q. Well, as you applied this methodology to the 103 crankshaft, how did you conclude that your result was conservative?

A. (Witness Pischinger) Well, on the one hand, there is the conservative assumption regarding the endurance limits.

Q. No. I mean strictly with respect to the load sequencing. Will it make a difference, for example, if you operate at 3300 for some period of time and then went to 3900, as opposed to operating initially at 3900 and then later on dropping back to 3300 or 3500?

A. (Witness Pischinger) Well, in my opinion, if you put the higher loads on first, and you really have a crankshaft which is weak or, let's say, overstressed, then they can initiate damage, and at lower loads can easier promote or let this crack progress. If you do it the other way around, then there are some scientists who even think, based on evidence, on experimental tests, that you can train a crankshaft by operating a little below the endurance limit, and then it can stand a little better the higher stresses.

So we think that by sequencing first high and then

WRBbrb9

low we are rather on the safe side.

Q. Was that in fact the case with the 103 crankshaft?

A. (Witness Pischinger) The 103 crankshaft was, in the beginning -- these higher levels were in the beginning. I think this could be stated also by Mr. Schuster.

A. (Witness Schuster) The higher loads were experienced during the 100-hour endurance, the 100-hour test earlier in the year. 3500 kilowatts and up was part of the criterial for the 100-hour test run.

end 5

Q And your analysis took this into account, or the Miner analysis as applied, would that take it into account?

A (Witness Pischinger) Well, the Miner analysis is a result of a lot of experience with accumulated damage and could be taken as an average. It can give you sometimes a little too high value, sometimes a little too low, and in this case I should expect it is rather on the -- that the result is rather on the low side because you have a sequence which should be if there would be -- if the crankshaft would be in danger, would have more promoted the appearance of crank than had it been done the other way around.

Q Thank you. I think I understand now.

BY JUDGE BRENNER:

Q Dr. Pischinger, I am looking at page 12 of your testimony, and the answer at the top of that page which is the answer to question 24, page 12, the answer at the top, which is a carryover answer to question 24.

The sentence I am interested in is the third sentence which states:

"Indeed--"

Do you have it?

A (Witness Pischinger) Yes.

Q All right.

Looking at that sentence, you talk about the exponential effect of the hours above 3300. Now I take it by

definition you mean non-linear effect on the results of the higher loads. Is that right?

A (Witness Pischinger) That's right. That is what the application of the Miner rule leads to.

Q Can you give me a rough quantification of the exponential effect? How non-linear is it? Is it close to linear or markedly above linear?

A (Witness Pischinger) It is markedly above linear because usually you use this relationship in a logarithmic scale and then it is linear or near to linear, so it is exponential.

Q All right.

Can you remind me roughly how many hours of the 745 were above 3300 kw?

A (Witness Pischinger) Yes, sir. There were approximately 525 hours at 3300, and approximately 119 hours at 3500, and 101 hours above 3500, some of them considerably, and seven hours at 3900.

Q All right.

If we assume that there was a load meter error solely in the non-conservative direction of, oh, say about 70 kw or, if it is easier for you to work with a round number, 100 kw, and that's okay also for purposes of my question, that is, that the meter always read high so the load being run was actually 70 to 100 kw below the perceived meter reading, what

would be the effect of your conclusion, based on the 10 to the 7th cycles endurance run for the acceptability of the crankshaft at 3300 kw? Did you examine that question at all?

A. (Witness Pischinger) Yes, I understand the question but we did not explicitly calculate out of the reasons I mentioned earlier on. But, of course, one could calculate this, and one would derive a lower corresponding value. But it certainly would be above 3300.

Q. You would still have a safety margin, using your method, at 3300 Kw?

A. (Witness Pischinger) That's what I believe.

Q. I don't know how far to push the sensitivity on something you haven't calculated. Are you in a position as answer that same question as to 3400 and then 3500 Kw? Would there still be a safety margin for continuous operation at those load levels using the method you used but assuming the endurance run was 100 Kw lower approximately?

A. (Witness Pischinger) Well, if it goes to very accurate figures, then we should have to apply this rule; we should calculate it.

Q. All right. Thank you.

JUDGE BRENNER: The Board has no further questions. Is there redirect by LILCO?

MR. STROUPE: Yes, Judge Brenner, just a few.

JUDGE BRENNER: Very well.

REDIRECT EXAMINATION

BY MR. STROUPE:

Q Dr. Pischinger, with reference to your testimony on page 5, specifically the answer to question 9, the last sentence of that answer, Mr. Dynner asked you certain questions about your cumulative damage analysis and reliance thereon.

Is it correct that you were able to make this statement in this sentence based not just on cumulative damage analysis alone?

A (Witness Pischinger) Well, this is correct in a double sense. On the one hand the Kritzer-Stahl calculations which are very conservative give infinite life for 3300, so I feel completely safe.

In addition, the endurance run with 10 to the 7th loading cycles showed no indication, no relevant indication on the crankshaft, and there are only 20 hours below that meter reading of 3300 and a lot of cycles above, so you don't even need any calculation to state that it will be safe for loads substantially above 3300.

But the Miner rule-- With the Miner rule I tried to give a figure to it.

Q Dr. Pischinger, you stated I believe in response to questioning this morning that you did not indeed take into account the sequencing of loading in your Miner's-Haibach analysis. Is that correct?

A (Witness Pischinger) Yes.

Q Is it correct that the effect of any sequencing of load upon that calculation would be more than offset by the inherent conservatism in the calculations themselves?

MR. DYNNER: Objection. It's a leading question, quite leading.

MR. STROUPE: I will withdraw the question and rephrase it.

JUDGE BRENNER: All right. Of course some of the damage has been done. On the other hand it is balanced out by the fact that we have expert witnesses as opposed to fact witnesses.

MR. STROUPE: I will rephrase the question.

BY MR. STROUPE:

Q Dr. Pischinger, do you have any concern by virtue of your statement that the Miner-Haibach methodology does not take into account load sequencing?

A (Witness Pischinger) No, not in this case. And I may also refer to what Judge Morris asked and I responded to that, which explains it a little bit.

Q Dr. Pischinger, you stated earlier that you did not take into account in your cumulative damage analysis the effect of any hours below and operation below 3300 kw other than the 20 hours that you referred to. Is that correct?

A (Witness Pischinger) This is correct.

Q If you had taken into account those hours that you are aware of operated on EDG 103 below 3300 kw, what effect would that have had on your calculation?

A (Witness Pischinger) Well, the figure would have been higher to a certain extent.

Q Are you able at this time, Dr. Pischinger, to quantify that figure?

A (Witness Pischinger) No. I have not the detailed sequence of loads of these engines which I should have.

JUDGE BRENNER: Mr. Stroupe, it is not perfectly clear to me what Dr. Pischinger means by "the figure would be higher." Maybe I can ask you to explain that.

BY MR. STROUPE:

Q Dr. Pischinger, the figure would be higher than what?

A (Witness Pischinger) The figure 3505 would be higher by taking into account additional loads on this engine.

Q Dr. Pischinger, in response to Mr. Dynner's question concerning your use of this cumulative damage methodology, I believe you indicated, did you not, that you could not give him a specific example of this use upon a large crankshaft such as the Shoreham replacement crankshafts. Is that correct?

A (Witness Pischinger) That's correct.

Q Was that because you are not able to do that, or because that information would be proprietary?

A (Witness Pischinger) I wanted to indicate by that that this information should not be disclosed to the public, and I think what is here is the public.

JUDGE BRENNER: It is up to you, Mr. Stroupe. I think there is a lot he could have said without disclosing particular names and companies and so on. I misunderstood what he meant when he said he wasn't able before.

BY MR. STROUPE:

Q Dr. Pischinger, have you indeed had occasion to utilize this methodology in analyzing crankshafts similar to the Shoreham replacement crankshafts in the past?

A (Witness Pischinger) Well, not completely similar to the crankshaft, but certainly to crankshafts.

Q In response to some questions from Judge Morris you indicated I believe that in your opinion the sequencing of higher loads on the crankshaft in the initial period with lower loads thereafter would provide some conservatism. Is that correct?

A (Witness Pischinger) Yes.

Q And did you indicate that to the best of your knowledge, the higher loads with regard to the Shoreham crankshafts were the first loads placed upon the crankshaft?

A (Witness Pischinger) Yes.

Q Do you know, Dr. Pischinger, whether the stresses upon -- the actual stresses upon the crankshaft -- the

predicted stresses upon the crankshaft at 3300 kw as opposed to the predicted stresses upon the crankshaft at 3500 kw are close in number?

A (Witness Pischinger) Yes, the stresses are close in number by about 4 to 5 percent, out of my recollection.

Q Is that 4 to 5 percent you're saying?

A (Witness Pischinger) You mean between 3500 --

Q -- and 3300.

A (Witness Pischinger) -- and 3300. Give me a little time.

(Pause.)

Q I'm just asking you approximately, Dr. Pischinger.

A (Witness Pischinger) Yes.

MR. DYNNER: I object. I'm a little tardy. I am going to object to the relevancy of that question. I don't think there is any relevancy to his testimony at all as to what those stress levels are. If I could just finish explaining my objection, the only testimony has been on the sequencing, and on the fact that in the testimony with respect to his saying that lower stresses -- that the lower loads followed by higher loads is a better situation, there is no relevancy as to what the difference might be because it is not in controversy.

JUDGE BRENNER: Well, no. We've asked him questions going to the sensitivity of the different stress levels and

we have emphasized from the very moment we ruled on the reopening of this proceeding that we were interested in that and in fact, frankly I thought we would see somewhere calculations at intermediate levels, based on what I said at the reopening at the time we granted the reopening than I have seen, so we think it is relevant, so we overruled the objection.

So we don't waste time, I want to make sure that the questioner and the witness are on the same wavelength, that you asked him about the difference in stress levels. Is that what you wanted to ask him, Mr.Stroupe?

MR. STROUPE: That's correct, between the stresses at 3500 kw and at 3300 kw.

WITNESS PISCHINGER: The difference, as I said, is about 5 percent.

BY MR. STROUPE:

Q Does that enable you, Dr. Pischinger, to conclude that if a crack propagates during operation at 3500 kw -- initiates at 3500 kw --

MR. DYNNER: I am objecting because it is another leading question.

MR. STROUPE: May I finish the question, Mr. Dynner?

JUDGE BRENNER: Wait a minute. I didn't even hear the beginning of the question.

Back up and ask it again, but consider whether it

is leading. I'm not saying whether Mr.Dynner is right or wrong, but if there is a problem there....

On the other hand, if it is leading by including information that the witness has already testified to, then there is no harm, and we have an expert witness, and the alternative is for the questioner to have to back up and ask redundant questions to solve that problem, so just leading in form is not necessarily objectionable unless it is really supplying new information. It is permissible for a questioner to build on the same witness' previous answers.

All right. With all that in mind, ask it again, Mr. Stroupe.

BY MR. STROUPE:

Q Dr. Pischinger, based on your knowledge of the stresses which you just gave to me, can you determine whether if a crack initiates at 3500 kw, the stress levels at 3300 kw would be sufficient to cause it to propagate?

A (Witness Pischinger) After the experience with the endurance run of this crankshaft and neglecting all other information, just being aware of this endurance run, one can predict that it would -- if one assumes that the crack would initiate now for any overloading whatsoever, followed by continuous loading at 3300, one can compute out of experience that it certainly would take up to 10 to the 8th cycles -- that means 10 times what has been seen now -- to have a

cracked crankshaft, which means at the same time if you do inspections of the crankshaft at certain time intervals, you are completely safe.

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Q. Dr. Pischinger, with regard to the meter error situation that has been talked about this morning, does meter error have any effect upon your calculations under Kritzer-Stahl?

A. (Witness Pischinger) No, Kritzer-Stahl is a method which does not rely on any meter readings.

MR. STROUPE: I have no further questions, Judge Brenner.

JUDGE BRENNER: Does the County have any follow-up?

MR. DYNNER: Short follow-up, Judge.

RECROSS-EXAMINATION

BY MR. DYNNER:

Q. Dr. Pischinger, going back for a minute to the questions that were asked of you again by Mr. Stroupe on page five of your testimony, speaking now just about the 10 to the 7 cycle testing and not about the Kritzer-Stahl formula, if the 10 to the 7 testing had been accomplished only at 3300 Kw -- in other words, there were no hours at all above 3300 Kw -- would you, by that testing at 3300 Kw, only have been able to conclude that the testing showed that the crankshafts could accomodate loads substantially above 3300 or would it just show that the crankshaft was, in your view, safe and reliable at 3300 Kw?

MR. STROUPE: I am going to object to that

question, Judge Brenner, on the basis that that's a completely hypothetical situation that in fact assumes -- fails to assume facts that are in the record and would not be relevant, I don't believe, to this inquiry.

JUDGE BRENNER: I think it is relevant to better understand the difference sources leading to Dr. Pischinger's conclusion and he has identified already that it includes several sources and this will help us understand in isolation at least one of those potential sources.

So I think it is relevant for that purpose and the objection is overruled.

WITNESS PISCHINGER: Well given the fact that there had been an endurance run exactly with 3300 kilowatts up to 10 to the 7 cycles and no crack been found, then this in my opinion is a confirmation that at this very load there is infinite life.

Of course, one can conclude out of the knowledge of behavior of that crankshaft that if you have a little higher load and you assume that you just by chance have been under the endurance limit with this run, then you can assume that crack initiation with a higher load would take quite a long time before leading to serious damage, that being cracking. Because the time between crack initiation and severing of the crankshaft increases tremendously when you come near to the endurance limit.

So in this case I would conclude that if this hypothetical case would be given, I would conclude that this endurance test run still would have been of a high value to the purpose in the Shoreham power station because you could make, even at higher loads, the plant rather safe by frequent inspections of the crankshaft. But this you would have to provide.

BY MR. DYNNER:

Q. All right. Let me try to state the question a little bit differently.

Am I correct that what allowed you to say that in your opinion the crankshaft would be safe and reliable up to 3505 kilowatts under your cumulative damage analysis was the 227 hours that the crankshaft ran at or above 3500 kilowatts and the total 10 to the 7 cycle test run?

Do you understand the question?

A. (Witness Pischinger) Yes.

If you refer only to the experimental part of my statement--my statement had several backgrounds, the experimental part.

Q. Yes, that's correct. So the answer to the question is yes, assuming we're not talking about the Kritzer-Stahl criteria analysis but only talking about the 10 to the 7 cycle testing, is that right?

A. (Witness Pischinger) Yes.

Q All right.

Are you aware of the number of hours that the crankshaft on EDG 102 ran at or above 3500 hours before it broke in half?

MR. STROUPE: I'm going to object to this. I think we are going into an area that, to my knowledge, really was not raised after the cross-examination initially by the County.

JUDGE BRENNER: Can I get the question again?

(Whereupon, the Reporter read from the record as requested.)

JUDGE BRENNER: Mr. Dynner, can you tell us where you are going with the line of questioning and why it's relevant?

MR. DYNNER: I don't think the objection was on relevancy grounds but I will answer your question.

JUDGE BRENNER: I want to know where you are going.

MR. DYNNER: I think it's fairly simple where I'm going. The witness has testified now that the basis--solely on the 10 to the 7 cycle testing, that the basis for his testimony that on the 10 to the 7 cycle test that the crankshaft is safe and reliable at 3505 is the extra 227 hours that the crankshaft ran at or above 3500.

The obvious contrast then which I am about to

make is to contrast that with the fact of the number of hours that the crankshaft that broke ran at or above 3500 hours.

He is drawing conclusions, in other words, about the safety and reliability of the crankshaft at certain levels based upon some 227 hours of testing at certain load levels and therefore is directly relevant on the issue of the testimony he gave about the 227 hours to show what the experience has been on crankshafts, which his own testimony says he relied on and looked at for other purposes.

JUDGE BRENNER: Give me a moment. I want to confer with my colleagues on the Board.

(The Board conferring.)

JUDGE BRENNER: We have an extensive previous record on the use of experience with the older crankshafts, for the calculations for the larger crankshafts, and we had a whole litigation focussed on 3500 earlier. And we don't have that record firmly in mind, but we have all of that. Nevertheless, we will let you pursue this point. But don't ask it the way you have asked it, because we'll spend time with every little detail, much of which might already be in the record -- although I'm not claiming it is -- as to how many hours the crankshafts operated at certain loads. So don't ask -- instead of asking him that question and seeing if he can pull a number out or not, why don't you go more

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directly to the point, consistent with what you argued before us as to the relevance and, in essence, ask the witness why does not the particular experience at particular load levels with the older crankshaft affect his view that that experience validates the conservatism of the Kritzer-Stahl criteria?

We don't want to sit here while we find out, probably reduntantly to what is already in the record, that the earlier crankshaft operated for so many hours at such and such a load.

MR. DYNNER: I don't understand why my question is not relevant. I think it's relevant. And he might know the answer. If he doesn't know the answer, I'm not going to pursue it.

JUDGE BRENNER: No. Your question is too collateral to be helpful. It's an intermediate point. You won't get there from here without getting to the question that I suggested you have to ask anyway.

MR. DYNNER: You are upholding the objection, or what?

JUDGE BRENNER: Yes, for the reasons I've given. It's not going to be productive to ask it that way.

I'll tell you: let's come up for a bench conference, off the record, right now.

(Whereupon, a bench conference was had.)

MR. DYNNER: No further questions.

JUDGE BRENNER: Staff, did you have any remaining questions?

MR. GODDARD: The Staff has no further questions.

JUDGE BRENNER: All right.

Give us a moment. I want to check something.

(Pause.)

(The Board conferring.)

JUDGE BRENNER: Dr. Pischinger, I had asked you earlier about the possible results at 3400, using the Kritzer-Stahl criteria -- or, at least, I'm asking you that now -- and we have earlier testimony in this proceeding where you did some calculations at that level; but I don't have those numbers in front of me.

I do have in front of me your testimony that your methodology would result, at 3300 kw, in a safety margin of 1.074, without taking into account what you believe to be the inherent safety factor, and 1.318, taking into account that safety factor.

You also, with respect to 3500, repeat what you say is your previous testimony that the safety factor at 3500 is 1.248. And I inferred, from the answer you gave Mr. Goddard, that that takes the safety factor into account. Correct?

WITNESS PISCHINGER: Yes.

JUDGE BRENNER: That's the sentence on page 2,

where you said you had mixed together taking it into account and not taking it into account at 3900.

WITNESS PISCHINGER: Yes.

JUDGE BRENNER: Okay.

WITNESS PISCHINGER: 1.248 for 3500.

JUDGE BRENNER: I take it if we were to calculate --

WITNESS PISCHINGER: 34?

JUDGE BRENNER: Yes. Would it be approximately in between the numbers we have?

WITNESS PISCHINGER: Yes. One could, with very good accuracy, interpolate -- linear.

JUDGE BRENNER: Just for the record, in case we have erred somewhere: for 3500, using your 1.248, taking into account the safety factor, we've calculated that without the safety factor the safety margin would be 1.023. Do you know if that's correct? I don't know if you have that figure handy or not.

WITNESS PISCHINGER: Certainly in between.

JUDGE BRENNER: No. I'm talking about 3500 now. In other words, I'm taking away the 22 percent safety factor that you believe exists.

WITNESS PISCHINGER: Yes. At 3500 it is 1.017. It's now a question of accuracy. The safety factor, how it comes out of the calculation, is 1.227. That means you have to divide by 1.227.

WRB7/brb4

JUDGE BRENNER: All right; Judge Morris understands that. He'll explain it to me later where my calculations went wrong.

endWRB7

JUDGE BRENNER: So instead of dividing 1.248 by 1.22 I should have divided 1.248 by 2.227?

WITNESS PISCHINGER: That's it.

JUDGE BRENNER: Okay, thank you.

Did LILCO have any follow-up?

MR. STROUPE: We have none, Judge Brenner.

JUDGE BRENNER: All right.

We may have completed with your testimony. In any event, I think you certainly don't have to sit here at the witness table if you don't want to while we discuss what to do with the motion to file rebuttal testimony, and the coincident Board desire to have asked questions of you on that same subject. So we will see where all this leads to.

I will thank you again for your presence and your testimony in the event you do not have to come back and take the stand, but you are not absolutely dismissed at this point, but you don't have to stay there. You can take a break or whatever.

MR. GODDARD: Judge Brenner, the Staff would only remind you that we are awaiting an answer on the record to the safety factor for 3900. That may generate further questions.

JUDGE BRENNER: Yes, I had not forgotten that.

WITNESS PISCHINGER: Could you give me time to find this out so that I can give you the exact figure?

JUDGE BRENNER: You might want to do that now if it is convenient for you during this break.

Let me see if I understand the procedural situation. I don't know how complex it is.

LILCO and the Staff want to discuss whether or not some agreement leading to some sort of a stipulation as to the question of possible effect of the fuel rod being wide open could be resolved, and Mr. Dynner, for reasons, you have some problems with that.

Do you want to tell us what they are?

Let me tell you at the outset if nobody filed any motions we were just going to ask questions of these witnesses on that subject, and we would have been over and done with.

Go ahead.

MR. DYNNER: Yes, Judge.

It all goes to basically the timing of all this. We unfortunately don't have our consultants with us. Mr. Bridenbaugh is coming in tonight. We received the motion yesterday, and last night I got the rebuttal testimony which is the subject of the motion.

JUDGE BRENNER: I'm sorry, you got the rebuttal testimony?

MR. STROUPE: A draft, Judge Brenner.

MR. DYNNER: Yes.

But last night I got the rebuttal testimony and

obviously we have not had an opportunity to have our consultant look at the testimony and see what LILCO is talking about.

With respect to the motion itself, I would point out that this issue and the issues we're talking about about the additional BMEP effect and the fuel rack is in fact discussed by the Staff in the December 3 SER at page 4, and that much of the-- I have been at a loss to understand much of what has been going on in terms of motions to strike and not to strike, and people saying that this is a new issue that they couldn't have responded to because it is discussed at some length on page 4 of the SER of December 3.

It is my feeling that if there is a basis to settle that issue and have it disappear, and right now there is no specific testimony going to it, given the motion to strike Mr. Knox's testimony, that this ought to be something to which the County's consultant can participate and can look at it so we can figure out whether or not we agree to any new facts and information that LILCO might be bringing to bear on it.

I cannot make those judgments in terms of what the County's position is. That doesn't mean-- And I also would not be in a position, given the tardiness of all this, to be able to prepare and effectively carry out a cross-examination of the LILCO rebuttal testimony at this

point.

It seems to me at least that the more advantageous and efficient way to handle this would be to do it in a timeframe that would allow the County's consultant to hear what the consultants of LILCO and the Staff have to say about the issue so we know whether it is real or whether it can be explained away.

JUDGE BRENNER: Let me remind myself and the parties of some background as I see it, and then we will let LILCO respond to what you said, Mr. Dynner.

If there had been no motion filed by LILCO, the situation from the Board's perspective would have been as follows:

We had testimony in the Staff's testimony -- I don't recall the precise date it was filed, on or about February 1, I think.

Mr. Goddard, do you recall?

MR. GODDARD: February 5, Judge Brenner.

JUDGE BRENNER: All right.

From that time forward at least, everybody knew that the Staff had raised that point in testimony on the record as distinguished from the possibility that it was in pre-existing documents; in any event, from February forward.

At the time we first addressed the motion to strike that portion of the Staff's testimony, we said we would hold

off to decide whether to strike in the event anybody asked the Staff's witnesses questions which adduced the fact that some witness on that panel could support the testimony, although right at that time Mr. Knox did not appear -- it did not appear from the paper credentials at least that Mr. Knox could support it.

We also had in mind as a Board, and I hope we said on the record but I cannot assert from my memory now that we did, that nevertheless, even if as a technical procedural matter that portion of the testimony was struck, we still -- that is, the Board -- intended to ask witnesses with credentials with respect to diesel engines questions about that subject. And I think we said that with reference to the upcoming Staff panel.

We also had in mind the fact that Da. Pischinger for one had credentials with respect to diesel engines and we would have asked him also so we could get his view, and then the Staff witnesses' view, and that is what we intended to do and we still intend to do if the matter is not settled.

The motion to file rebuttal testimony could have been filed earlier than yesterday. Nevertheless as I say, all of the parties from the February 5th time of the Staff's testimony and, with a refreshed recollection, at the time we addressed striking that portion, knew that we were interested in the subject.

So we struck the testimony and we could stop right there as a technical matter but the Board on its own doesn't want to do that with the possibility that there might be something of significance. In order to know that one way or the other, we want to simply ask, and we didn't think it was that complex a matter and we thought we could ask.

If there is written testimony that assists us in that regard, so much the better. But I don't see anything brand-new in the area; that is, the subject doesn't stem from yesterday's motion to file rebuttal testimony. So the County knew about the subject from the time of the Staff's testimony. The Board was keyed in from that point.

MR. DYNNER: If I can respond, we of course knew about the subject matter. What we didn't know was what LILCO's position was about that subject matter.

And what I said and repeat is that we are not in a position-- Now that we have been given a draft of the rebuttal testimony which sets forth LILCO's position, I am not in a position to know whether LILCO's position, as set forth for the first time last night to us, is correct or incorrect, and whether it is something that I can cross-examine on. I can't.

Now that doesn't mean that the Board -- in any way that I'm saying that the Board shouldn't ask questions, all the questions it wants, or that I can't ask questions of

people. It is just that on the rebuttal testimony we are not prepared because we didn't know what LILCO's position was until last night.

And secondly, in terms of my other statement, it just seemed to me that if in fact this is a non-issue, which I won't know until Mr. Bridenbaugh gets here,--

JUDGE BRENNER: Well, I'm trying to accommodate everyone's schedule, including Mr.Bridenbaugh's, and they want to let their witnesses go.

But you knew or you should have known-- Well, maybe that's unfair. I would have thought that you should have known that the Board would have asked Dr. Pischinger questions on that subject, based on our previous statements. We said we wanted to-- I think we said we wanted to ask the witnesses with expertise in that subject area questions in that regard. I can't really assert that as a matter of fact but I think we said that.

I don't want to preclude the Board or anybody else from going forward with that subject with Dr. Pischinger just because Mr.Bridenbaugh isn't here when he certainly could have been here, unless you can give me a reason why it would be a surprise to the County that this subject would come up when Dr. Pischinger is on the stand, given our previous statements when we addressed that subject in the context of the fact that Mr. Knox didn't have the

expertise to support it, or might not have the expertise to support it.

Wasn't the County aware that the Board intended to permit questions, if not to ask our own questions on that subject, of witnesses with diesel expertise?

MR. DYNNER: Yes, I think that-- Well, I have a couple of answers.

The question is: Did I anticipate it, and the answer is No.

The question: Should I have anticipated? Maybe.

There's been-- Our understanding was that what was going to happen, what we thought was going to happen was that once the motion to strike was granted that there was going to be testimony by the Staff as to whether or not what Mr. Knox had said that the PNL people had said was or was not the fact.

If the Staff witnesses got up and said "No, Mr. Knox misunderstood us, this isn't right. What we said in the SER we found out isn't true. We have new evidence, et cetera," one way or the other, that's what I thought was going to happen. In other words, I thought the Staff witnesses were going to be questioned about this first, and then there would be follow-up questions from other diesel witnesses.

But I just didn't focus on the fact that-- You know, once we changed the testimony so that the crankshaft

was going to come before the block, I never focused on the issue that Dr. Pischinger would be here. I just didn't-- Maybe I should have but I didn't, and for those reasons.

JUDGE BRENNER: Let's hear from LILCO now, including what you propose to do if we granted the motion and what alternative approaches do you have? The motion is silent on timing, the extent of the testimony, et cetera. I'm referring to the motion to file rebuttal testimony.

MR. STROUPE: Judge Brenner, let me give you perhaps a couple of alternatives that LILCO at least has thought about, and then Mr. Ellis can address the other matters that you raised.

We have-- Obviously our panel that would be addressing that very subject is the very panel we just completed cross-examination of with the exception of the two inspection witnesses. The panel that we have proposed would be principally Dr. Pischinger with Mr. Youngling of LILCO, and Dr. Johnston of FaAA.

We have indeed prepared testimony and we delivered to Mr. Dynner last night, as he indicated, a copy of that testimony which will not change if indeed it is allowed to be filed or if it is needed to be filed.

We again would suggest the possibility of some continuing discussions between the County, LILCO and the Staff today to see if indeed we can resolve this issue and

perhaps have it go away by having our consultants talk.

I understand Mr. Dynner's problem but--

JUDGE BRENNER: What about the telephone? Mr. Bridenbaugh is en route? Is that the problem?

MR. DYNNER: Yes, sir.

MR. STROUPE: The only other alternative that we believe is reasonable would be to go forward with our motion, allow us to file rebuttal testimony and put our people on the stand, and then hope that that gets to the root of the problem. That may convince the Staff to do something at that point in time, but I think that is the only other alternative that we can reasonably rely upon.

If we wait until tonight--

JUDGE BRENNER: Well, when did you intend to put the rebuttal testimony on if we had granted the motion?

MR. STROUPE: Today.

JUDGE BRENNER: But you haven't even served it.

MR. STROUPE: Yes, it has been served on the parties. It has not been filed with the Board because, obviously, the motion hasn't been granted at this point.

Again as we said yesterday, the problem we have is the time problem with Dr. Pischinger in that he has a return to Germany tomorrow.

JUDGE BRENNER: I know, but the motion could have been filed earlier if you wanted to put in written rebuttal

testimony.

Mr. Ellis, did you want to add something?

MR. ELLIS: Yes, sir.

I just would point out that the testimony is not extensive. The reason that we did not serve it upon the Board I think is it would have been inappropriate for us to do so in light of the Board's previous indications that motions of this sort should not be accompanied by the testimony until they're granted. But we did want to give it to the County and the Staff as soon as we had prepared it.

It is also important I think to point out that this is not an issue raised by the County in its testimony, nor was it originally by LILCO. We were under the impression erroneously, as it turned out, and that was part of our motion to strike the testimony, that the intermittent and cyclic loads that were part of the contention were the intermittent and cyclic loads that we identified in our testimony.

The testimony, by the way, the rebuttal testimony, Judge Brenner, is six pages.

End 8

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JUDGE BRENNER: What's the schedule for Dr. Pischinger's plane tomorrow?

MR. STROUPE: He has a flight leaving, I believe, at approximately four-thirty or 5:00 p.m. from Kennedy.

JUDGE BRENNER: Tomorrow?

MR. STROUPE: Tomorrow.

JUDGE BRENNER: All right.

Give us a moment, and see if we can solve everybody's problem. That's what we'll try to do.

(The Board conferring.)

JUDGE BRENNER: Mr. Bridenbaugh is coming in tonight?

MR. DYNNER: Yes, sir.

JUDGE BRENNER: Reasonably early tonight, so that you can all discuss it this evening if we allow that?

MR. DYNNER: I'm expecting him between seven and eight tonight.

MR. GODDARD: Judge Brenner, that timing is acceptable to the Staff. And our witness will be available to discuss the matter with Dr. Pischinger and with Mr. Bridenbaugh, if that is the decision of the Board.

JUDGE BRENNER: Did you want to add something, Mr. Ellis?

MR. ELLIS: Yes, sir.

I think there has been some reference to resolving

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or settling the matter among the three parties. I don't think that is necessarily what is the only resolution. Another resolution is that the Staff may--

JUDGE BRENNER: I understand.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: I had planned to address that, but I want to discuss this.

(The Board conferring.)

JUDGE BRENNER: We are going to try to reach a balance and permit the parties to have discussions tonight, and then they can let us know first thing in the morning as to whether it has been resolved as to just two parties or no parties or all three parties.

If it has not been resolved as to -- let us say as to the County, we will permit witnesses to be asked about it. That's the bottom line that I wanted to give you first.

Our reasoning for trying to reach this accommodation for all parties is as follows:

As I said, we could have simply stated the fact that we struck the testimony and that would have been the end of it, because the Staff, indeed, was the only party that raised it, although the Staff argued that it was relevant to the contention, and we agreed with the Staff on the question of relevance. So the County did not even raise it as one of the

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supporting parts of that subpart of the contention.

The next procedural proposition will be that, since it was only the Staff that raised it, if the Staff and LILCO agreed that there was nothing to it, and the Staff said they were withdrawing the point, we could have rested right there. And, again, that would have been correct procedurally, considering the fact that the County never even raised the matter.

However, in this public interest proceeding, now that the matter has been raised, we want to give the County a better opportunity than that. However, the extent of the opportunity we will give the County is that tomorrow will be the time to find out what the witnesses with expertise in diesel matters have to say about the subject if it is not resolved.

In the circumstances now, we would like to get the testimony for the Board to look at also when we break, which will be momentarily. And then we'll leave it at that. We'll go to the Staff's crankshaft witnesses right after lunch, and proceed with that. And if we finish with those witnesses we will go to the next witnesses in line. We're not going to stop artificially, we will break the sequence to go back to this subject after.

If there is some particular remaining problem when we resume at nine o'clock tomorrow morning the parties can

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address it. But be advised that our decision is probably that we want to proceed with the subject in that early, very early tomorrow timeframe if it's not otherwise resolved.

Now, if the parties, for example, need another half hour tomorrow morning, and people are available to take up that subject outside the courtroom while we continue with other people with the other subject, we will certainly be amenable to some minor adjustment of that nature.

It's our hope that-- Well, it's not our hope; we believe it will have the effect of giving the parties more than the appropriate opportunity to pursue the subject either by settlement or by getting facts on the record, if that proves to be necessary.

Dr. Pischinger, do you have the answer?

WITNESS PISCHINGER: I have the answer.

JUDGE BRENNER: All right.

WITNESS PISCHINGER: To make sure, the question was the factor of safety when applying the inherent -- when taking into account the conservatism of the Kritzer-Stahl criterium which is given by 2.7 percent.

If you take this into account you will arrive, for a power of 3900 kilowatts, at a factor of safety of 1. 6 percent. That means 1.136.

JUDGE BRENNER: All right, Mr. Goddard? Is that your question?

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MR. GODDARD: The Staff has no further questions. Thank you.

JUDGE BRENNER: Thank you, Dr. Pischinger.

The panel we have just heard from is excused as a panel. Now, we might have selected people back, depending on who LILCO believes can best address the question.

Thank you, Dr. Pischinger.

(Panel excused.)

JUDGE BRENNER: All right; let's recess until one-thirty. Remember, there were miscellaneous matters that I raised yesterday for the parties to think about. It's up to the parties in a timely fashion this week to come back to us on those subjects whenever the parties think it's appropriate.

MR. ELLIS: We'll be prepared after lunch, Judge Brenner.

JUDGE BRENNER: All right. Let's proceed and see if we can finish the Staff witnesses on the subject, too.

Which subject did you want to--

MR. ELLIS: Cam gallery monitoring. I think we can dispose of that. And I will also discuss with Mr. Dynner and with Mr. Goddard the other matter.

JUDGE BRENNER: All right. Well, you'll have a few extra moments. We'll come back at one-thirty.

(Whereupon, at 11:50 a.m., the hearing in the above-entitled matter was recessed to reconvene at 1:30 p.m.)

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AGB/wbl

AFTERNOON SESSION

(1:30 p.m.)

JUDGE BRENNER: Good afternoon.

Did I understand correctly that the parties are prepared to take up the matter of settlement of the monitoring of the cam shaft gallery next?

MR. ELLIS: Judge Brenner, of course the matter has been settled. What is remaining open is the Board's concern that the Board raised.

I had indicated that we could take that up. I have talked to Mr. Goddard. He would prefer to have Mr. Berlinger here at the time we do it.

I am prepared to indicate to the Board what LILCO's current thinking is with respect--

JUDGE BRENNER: I'm sorry; let me interrupt you.

Rather than status reports, I wanted to know if the parties had reached full agreement on the matter. Let me ask that question.

MR. DYNNER: Maybe I should address that.

We have agreed to settle the matter on the terms that were stated the last time on the record. And subsequent to that, of course, the Board raised the issue of whether or not the parties had considered further monitoring after emergency operation of the diesels.

Frankly, we haven't

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JUDGE BRENNER: Right; I saw all that in a letter from Mr. Ellis. And my comment in response to that letter was that I didn't want to approve it with that matter unsettled and just left hanging and unstated in a settlement.

MR. DYNNER: Yes. And all I was trying to express to you is that that letter also states the fact that we were not going back on the fact that we would settle on the grounds that we had. And I think the letter reflects that.

The issue of further monitoring after emergency operation of the diesels, which the Board raised, is one which we hadn't considered, which we said, subsequent to the settlement, that we thought would be advantageous and ought to be perhaps considered. LILCO and the Staff didn't feel it was necessary. And the only purpose of that letter with the statement that we thought it would be beneficial, was that we didn't know how strongly the Board felt that that matter ought to be encompassed within the settlement.

That's the reason it's stated the way it's stated.

We're not suggesting-- We're not prepared to suggest, having made the statement on the record that we've settled the matter on the terms that were then stated, that we're going back on our word. The settlement stands subject to our own feeling that if the Board feels that there ought to be, that it would be desirable to have monitoring after emergency operation. The County feels that way, and LILCO and

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the Staff might want to consider it further.

But it won't affect our commitment to the settlement.

JUDGE BRENNER: That's where the matter stood when I raised it again the beginning of this week: I understood all that. And I wanted the parties to meet again to decide whether the settlement could encompass such a matter or whether the parties could reach a decision that such a matter need not be encompassed. Because my concern was not necessarily as a matter of substance that it should be covered or not covered, but that it shouldn't be left silent, so that a problem cropped up later on and it was found that the settlement did not address the situation, and was silent on it even after we had raised it.

So I wanted the parties to meet and discuss that and see if they could reach agreement on it. That was my request. Maybe it wasn't understood.

MR. DYNNER: Well, we reiterated our position, our concern, and said it wouldn't affect the settlement. I think at this point we were waiting to see whether LILCO nevertheless wanted to include some additional monitoring after emergency operation.

My point is that I can't -- I have no bargaining ability, if you want to call it that, to suggest that there be this kind of monitoring, because I already committed to the

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settlement I committed to.

So it's only a question of whether LILCO and the Staff want to do it as a matter of their own further reflection. I don't have any way of negotiating it.

JUDGE BRENNER: Well, I don't know that that's accurate.

Why don't you tell me what LILCO proposes?

MR. ELLIS: I don't think it's a matter of further negotiations. LILCO certainly has considered it. And I think Mr. Goddard's concern to have Mr. Berlinger here is valid: I'd be delighted to wait until he comes back.

We have considered it. It's LILCO's position that the testing and the testimony before the additional testing that was ordered by the Board, has confirmed that these are process cracks that in several hundred hours of operation, up to I think 1300 now, have not propagated.

The addition monitoring is really a matter of negotiation. And the three months interval was not selected, in LILCO's view, as a result of any concern over three hours of operation; that is, there is no correlation between three months and three hours necessarily.

I might point out, incidentally, that it might not be three hours. There will always be some time in getting the load, the engine up to load and some time in getting it back down.

But the point is that the technical case is one that shows that there are process cracks that do not propagate and therefore the extent to which further monitoring is required was a matter of negotiation, there was a meeting of the minds.

I have discussed with the company whether the company would be willing to perform additional monitoring in the event of operation and there is no technical basis for it but the company is willing to do it if we put in something like 30, 40, 50 hours, something like that, that would certainly I think be acceptable to LILCO.

I think it's important for the Board to realize that we're talking about operation and the engine has to be secured for this to be done and the side covers removed and it takes 24 hours of straight-through work to do it.

So that should be balanced against what has already been done to demonstrate what the nature of these cracks are and what can reasonably be expected. So that --

JUDGE BRENNER: All right. I understand your position.

We knew that the engine would be unavailable for operation. I was going to ask you what the approximate time period was and you have answered that.

We haven't reached any conclusion, you understand, we merely asked the question because, as I said, we didn't

want silence to cause a problem to occur later on.

All right. We've got LILCO's position. I would like to get the Staff's position later on this week, and you let us know when that is convenient, Mr. Goddard.

MR. GODDARD: Yes, Judge Brenner, if I may respond briefly at this time, the proposal was submitted to the Staff by LILCO's Counsel that the monitoring be done on the basis of every three months or 30 hours of operation, whichever comes first. Technically the Staff has no objection to that position and we'll accept it.

The reason I asked that Mr. Ellis defer this until Dr. Berlinger was present was because Mr. Ellis was making reference to a number of conversations which he or his people apparently had with Dr. Berlinger, which I was not party to, to the extent that this proposal for monitoring every 30 hours -- not 30, 40 or 50 hours -- be done in conjunction with a --

JUDGE BRENNER: Well let me cut you off since we are going to have to come back to the subject anyway. Tell us whether it's the Staff position that any hours are necessary as part of the agreement in the Staff's view or whether we could just approve the settlement as is without any further requirement for measuring the cam gallery cracks.

MR. GODDARD: On a technical basis the Staff does not feel that an hours requirement is necessary and the Board

could approve the settlement as standing.

JUDGE BRENNER: What was the Staff's basis for agreeing to the interval in the settlement, was it related to time or to contemplated operation during that time or to none of that?

MR. GODDARD: It was a position adopted in order to facilitate a settlement, that's all.

JUDGE BRENNER: Yes, but it was the Staff's recommendation in the testimony that the cam gallery crack be monitored or measured in some fashion, that's what -- you see, that's the basis, this didn't just come out of the blue. That's why I want to know what the Staff's view is.

If you want to discuss it and let us know tomorrow, that's okay.

MR. GODDARD: I think I should have that question answered by a technical member of the Staff.

JUDGE BRENNER: You understand from our point of view one of the stimuli to this agreement is the fact that the Staff -- one of the conclusions in the Staff's testimony is that some monitoring occur, either this or another type. And given that, I want to know what the Staff's view is as to what the technical basis is for the intervals, whether it's related to some contemplation of hours at all or whether it is just a time interval and so on.

We're only asking questions at this point.

MR. DYNNER: I don't know if this will help you or not but on page 30 of the Staff's testimony, Dr. Bush's testimony was in fact -- in fact went to the issue of crack monitoring and in fact suggested a three-month period for the TSI depth gauge monitoring.

JUDGE BRENNER: All right. But my question remains whether there was inherent in that some contemplation of the operation that the engines would see during that period of whether it was solely a time function or something else.

MR. GODDARD: Perhaps Dr. Bush might answer that question.

JUDGE BRENNER: Well why don't you get together with him instead of our having to hear it on the record. You may have questions yourself. He's your witness, talk to him about it and come back and let us know.

It wasn't our purpose to insist that some added condition be there, as I have tried to explain, we were simply asking the question.

All right. Is there anything further that need be taken up now or should be taken up now?

MR. ELLIS: No, sir.

JUDGE BRENNER: All right.

Mr. Goddard.

MR. GODDARD: At this time the Staff is ready to

present Dr. Spencer Bush and Mr. Adam Henriksen with regard to the subject of cylinder blocks -- I'm sorry, crankshafts.

Whereupon,

SPENCER H. BUSH

and

ADAM J. HENRIKSEN

were called as witnesses and, having been previously duly sworn, were examined and testified further as follows.

JUDGE BRENNER: All right.

Let's note for the record -- I thought you were going to tell us but I'll say it, that the Staff informed us that unfortunately Professor Sarsten has passed away since the testimony was prefiled and we were certainly sorry to learn of that.

You are going to have to explain what adjustments the Staff is going to make in its testimony in light of that and also what adjustments Staff is going to make in terms of what part of the testimony you are moving into evidence now on the subject of crankshafts since the testimony also includes the subject of cylinder blocks which we are not now admitting into evidence.

MR. GODDARD: That is correct.

First, at this point the Staff would propose to move into testimony the entire package at this time, consisting of both blocks and crankshafts and

make any corrections to it at this time and reserve the cross-examination on the blocks, of course, until we present this panel at a later date.

JUDGE BRENNER: Is that acceptable to the other parties?

MR. STROUPE: Judge Brenner, I just raised the question as to whether we preserve cross-examination as to that portion of the testimony dealing with these step changes in loads that we talked about earlier today.

JUDGE BRENNER: Yes, we are going to hold off on that.

MR. STROUPE: Yes, that's acceptable to us on that basis.

JUDGE BRENNER: County, is that okay?

MR. DYNNER: Yes.

JUDGE BRENNER: All right.

MR. GODDARD: Insofar as the late Professor Sarsten was a sponsor of some of this testimony, the Staff proposes that he simply be deleted as a sponsor of all of the testimony forwhich there are other witnesses on this panel who are themselves sponsoring this testimony.

There were two questions which were sponsored by Professor Sarsten alone: one of these dealing with the Det Norske Veritas calculations was struck by the Board in its early order before this hearing resumed.

The other --

JUDGE BRENNER: Why don't you refer to the particular part; and my next question is has that been lined through with respect to the copies given to the Reporter?

MR. GODDARD: It has been lined through on the copies given to the Reporter. That was, I believe, question and answer 12 on page 21 of the testimony.

The remaining answer, which was provided by Professor Sarsten alone, is the answer to question 5 at page 10 of the testimony. Dr. Bush will assume the sponsorship of that portion of the testimony.

Dr. Bush and Mr. Henricksen are previously sworn, having appeared as witnesses earlier in this proceeding.

DIRECT EXAMINATION

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BY MR. GODDARD:

Q. Dr. Bush and Mr. Henricksen, I ask you at this time if the document entitled "Joint Testimony of Spencer H. Bush, Adam J. Henricksen, and," -- of course -- "Professor Arthur Sarsten on Load Contentions Concerning TDI Emergency Diesel Generators at the Shoreham Nuclear Power Station," consisting of 32 pages and dated February 5th, 1985, is the testimony prepared by you and which you intend to sponsor as your testimony in this proceeding?

A. (Witness Bush) Yes.

A. (Witness Henricksen) Yes.

Q. Is it true and correct, to the best of your knowledge, with the exception of the matter which is presently the subject of discussions between LILCO, yourselves, and a Suffolk County witness to appear later? Is it true and correct --

JUDGE BRENNER: I didn't hear you.

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MR. GODDARD: I said, is it true and correct, to the best of their knowledge, with the exception of that portion of the testimony on which we are reserving cross-examination.

JUDGE BRENNER: I thought you said something else I didn't hear.

WITNESS BUSH: Yes.

WITNESS HENRICKSEN: Yes.

BY MR. GODDARD:

Q. Are there any corrections of any nature which you wish to make to the testimony at this time?

A. (Witness Bush) There is an item with regard to Question 9 that could be struck; or it could, alternately, be discussed. It would be Item No. 1 under the answer to Question 9 on page 13.

JUDGE BRENNER: That's within the subject that you had talked about --

MR. GODDARD: That is within the subject which we are going to discuss, and I ask you to preserve that.

WITNESS BUSH: Other than that, that's the only one I am aware of.

BY MR. GODDARD:

Q. Mr. Henricksen?

A. (Witness Henricksen) I don't know anything else.

MR. GODDARD: Very well. Copies of the testimony

with the deletions made will be furnished to the Reporter at this point for insertion in the record at this point; and the Staff moves that the testimony be accepted into the record as though read.

JUDGE BRENNER: I'd like to identify more definitively the parts that we are reserving. Dr. Bush just gave us one, which is Item 1 on Answer 9; so we are not presently putting that into evidence.

MR. STROUPE: I believe there are at least one other.

MR. GODDARD: The answer to Question 10 appearing on page 14 also deals with that issue.

There may be a note in the conclusion which I haven't noted at this point. I was unable to find it. There may be a note that refers to that portion of the testimony. But there was nothing additional or of new information.

JUDGE BRENNER: I guess I don't agree with you on Question and Answer 10. That's broader than just that subject.

Does LILCO have a different view?

I don't see why this always seems to take so long when we move the Staff's testimony in. Is there any other part of their testimony that particularly relates to the question of the fuel racks being wide open or the loading during step-ups being higher?

MR. GODDARD: Not as to the fuel racks or the particular means of reaching that higher load.

JUDGE BRENNER: Other than that Item 1 of Answer 9, correct?

MR. GODDARD: That is correct.

JUDGE BRENNER: Do you agree with me that Question and Answer 10 --

MR. GODDARD: -- in Question and Answer 10, which deals with the short-term loads and the effects of those loads.

JUDGE BRENNER: My question is: do you agree with me that that is not solely related to that subject?

MR. GODDARD: That is not solely related, no, that's correct. It would be within the scope of potential cross-examination later.

JUDGE BRENNER: I mean, even if that question was resolved, Question and Answer 10 is still potentially pertinent to other matters in controversy?

MR. GODDARD: Yes. That is correct.

JUDGE BRENNER: All right. I think I've got it now. It would just be that Item 1, then, on Answer 9 that is not being moved into evidence at this time, and -- I haven't reviewed it closely with that point in mind, because I know the parties wanted to reserve on it until this morning. So, if a party sees something else in there that

they want to tell us about, they can later.

MR. STROUPE: Judge Brenner, could I ask one clarifying question of Mr. Goddard?

Did I understand him to say that the answer to Question 5 is now being sponsored by Dr. Bush?

JUDGE BRENNER: That's what I understood him to say.

MR. GODDARD: That is correct.

JUDGE BRENNER: And I was going to ask --

MR. STROUPE: I think we may have a little problem with that because, frankly, I'm not convinced that Dr. Bush's expertise is in that area.

JUDGE BRENNER: Fine. You are only about five seconds ahead of me; and we'll get to that point right now. I was going to say that the witnesses have previously been sworn, as we stated, and I wanted to know if there were any new objections to admission of the testimony based on the adjustment we just heard, which -- in fact, the only one of any materiality is the one you've just raised, Mr. Stroupe. Do you have an objection to it that you want to raise at this time, or do want to note the fact that you might have an objection, subject to cross-examination; or how do you want to proceed? I don't know that he has the expertise, either.

MR. STROUPE: I would object on the basis that I

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do not believe it is within Dr. Bush's expertise. I must say that I did not examine Dr. Bush on anything like this last fall. I believe Mr. Ellis did; and we can't, frankly, remember what the record reflected on that. But, at the very least, it seems to me that we should have some sort of voir dire to see if this is his area of expertise.

JUDGE BRENNER: County?

MR. DYNNER: I just have a question: that Answer 5 has a number of sentences in it --

JUDGE BRENNER: Is this the first time that the parties have heard that Dr. Bush was going to take over sponsorship of this answer?

MR. DYNNER: Yes. This is the first I have heard of it.

JUDGE BRENNER: LILCO?

MR. STROUPE: We were told that there would be others on the panel that would take over the sponsorship of this answer.

JUDGE BRENNER: You thought there would be an additional witness?

MR. STROUPE: I, frankly, assumed that if anyone took over this sponsorship it would be Mr. Henricksen.

JUDGE BRENNER: I think I interrupted you, Mr. Dynner. I'm sorry.

MR. DYNNER: I was only going to point out that I

was going to agree with Mr. Stroupe that, at least, portions of Answer 5 appear on their face to be outside of Dr. Bush's area of expertise, based upon his qualifications, as examined in the past and as submitted in the past. Other portions of Answer 5 appear to me to be consistent with testimony that was given by Dr. Bush and others at the prior hearing.

JUDGE BRENNER: All right.

I haven't focussed on it. I don't like being put in the position of learning these things for the first time. We have talked ad nauseum about the point of our being informed of these things in advance. Of course, in this case, this unfortunate case, it couldn't be well in advance; but it certainly could have been before today -- Monday, for example. And now everybody has to, just for the first time. This isn't the first time we've wasted time on things for which hearing time should not be devoted, and it's at the expense of Staff witnesses as well as everybody else, while we're here wasting time.

Given the situation -- and take that comment for the future, if there is a future in this hearing; and I hope that future is rapidly coming to an end, at least as far as this Board is concerned -- how would you like to proceed? Would you like me to order that the Staff to establish by direct examination what they believe the expertise is, or

would you prefer to proceed first by cross-examination, first LILCO and then the County, in the course of your other cross-examination? And then we could come back to the subject of whether it should be struck. I'm willing to do what the parties want to do, given the fact of lack of advance notice.

MR. STROUPE: I think, frankly, I would like to proceed in the manner of having the Staff show us why this is within his expertise, and then to have an opportunity to raise my own questions. My recollection from the previous hearing this past fall is that Dr. Bush testified to the shot peening aspects and the metallurgical aspects of the crankshaft, and I think we can probably find that out pretty quickly.

JUDGE BRENNER: That's not the sole question. The question is what he knows about this answer now.

All right. I'm inclined to proceed that way, given Mr. Stroupe's desire. Do you have any problem with that, Mr. Dynner?

MR. DYNNER: No, we don't. And we also may have questions dealing with voir dire on the same issue.

JUDGE BRENNER: All right. You incorporate it at any point in your cross-examination, if the testimony is still on the record by that time, if that's acceptable, rather than a separate round.

MR. DYNNER: Yes, of course.

JUDGE BRENNER: This is an easier case to isolate, but for all I know you might have voir dire-type questions where Professor Sarsten was one of the witnesses in a group, and you have some question as to whether certain sentences within those answers that remain could be sponsored by these two witnesses, for all I know. I haven't gone through that process for myself, I must confess, because we weren't told until now what the adjustments would be.

All right. Let's do this: we'll admit the testimony into evidence at this time, and bind it into the record as if read, with the adjustments we've already noted as to the parts struck and the part, that Item 1 in Answer 9, being held in abeyance and subject to the rights of the parties to make further motions to strike based on the lack of expertise of these witnesses to sponsor parts that we are at this time admitting into evidence.

So, with that, we can mechanically bind all of this testimony into the transcript at this point as if read.

(The documents follow.)

February 5, 1985

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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)	)	

JOINT TESTIMONY
of
SPENCER H. BUSH, ADAM J. HENRIKSEN, AND PROFESSOR ARTHUR SARSTEN
on
LOAD CONTENTIONS CONCERNING TDI EMERGENCY DIESEL GENERATORS
at the
SHOREHAM NUCLEAR POWER STATION

CONTENTS

INTRODUCTION OF WITNESSES

Q. Please state your names, your business addresses, and your professional qualifications.

A. (Bush) My name is Spencer H. Bush. I am self-employed, under the firm name of Review and Synthesis Associates, Richland, Washington. A summary of my professional qualifications and experience was submitted as Attachment 2 to Volume 1 of the joint testimony filed by the NRC staff in August 1984.

A. (Henriksen) My name is Adam J. Henriksen. I am self-employed, under the firm name of Adam J. Henriksen, Inc., Fox Point, Wisconsin. A summary of my professional qualifications and experience was submitted as Attachment 3 of the joint testimony referenced above.

A. (Sarsten) My name is Arthur Sarsten. I am a Professor of Internal Combustion Engines at the Norwegian Institute of Technology, Trondheim, Norway. A summary of my professional qualifications and experience was submitted as Attachment 5 of the joint testimony referenced above.

SCOPE OF TESTIMONY

Q. What is the scope of your testimony?

A. (All) Our testimony addresses the following parts of Suffolk County's load contention as admitted by the Atomic Safety and Licensing Board:

> Contrary to the requirements of 10 C.F.R. Part 50, Appendix A, General Design Criterion 17 -- Electric Power Systems, the emergency diesel generators at Shoreham ("EDGs") with a maximum "qualified" load of 3300 kW do not provide sufficient capacity and capability to assure that the requirements of clauses (1) and (2) of the first paragraph of GDC 17 will be met, in that
>
> (a) LILCO's proposed "qualified load" of 3300 kW is the maximum load at which the EDGs may be operated, but is inadequate to handle the maximum load that may be imposed on the EDGs because:
>
> (i) intermittent and cyclic loads are excluded;
>
> (ii) diesel load meter instrument error was not considered;
>
> (iii) operators are permitted to maintain diesel load at 3300 kW ±100 kW; and
>
> (iv) operators may erroneously start additional equipment.
>
> (c) The EDG qualification test run performed by LILCO was inadequate to assure that EDGs are capable of reliable operation at 3300 kW because:
>
> (i) DG 103 block was not subjected to the entire 740 hours of testing;
>
> (ii) the test results on the DG 103 block are not transferable to the DG 101 and 102 blocks;
>
> (iii) operators were permitted to control the diesel generators at 3300 kW ±100 kW during the test; and
>
> (iv) instrument accuracy was not considered.

SUMMARY OF TESTIMONY

Q. Please summarize your testimony on these contentions.

A. (All) Our summary testimony is provided under the two subheadings that follow.

FATIGUE LIFE OF CRANKSHAFTS IN THE SHOREHAM EDGs

From our review of LILCO's testimony and data logs, we believe that EDG 103 was, in fact, operated at a nominal, instrument-indicated load of 3300 kW during that portion of the 1 x 10^7-cycle confirmatory test claimed by LILCO to have been conducted at the 3300-kW load level. We understand that the wattmeter may oscillate approximately ±100 kW around the value at which the load is set, presumably because this is as close as the load can be controlled without blocking the governor. Based on wattmeter calibration data, the actual load could have differed from the indicated load by about ±70 kW. In the context of the overall test loads included in the 10^7 cycles and the order in which they occurred, however, we view these deviations from 3300 kW as of no consequence.

In our opinion, EDGs 101, 102, and 103 are suitable for nuclear standby service at the "qualified" load of 3300 kW. This opinion is subject to the surveillance and maintenance recommendations documented in the following technical evaluation report, which we assisted in preparing: Review and Evaluation of Transamerica Delaval, Inc., Diesel Engine Reliability and Operability - Shoreham Nuclear Power Station Unit 1, PNL-5342, dated December 1984. As noted on pages 4.24 through 4.25 of that report, "...the replacement crankshafts for

EDG 101, EDG 102, and EDG 103 are acceptable for their intended service, provided that they are not operated during engine tests at loads in excess of the qualified load of 3300 kW." We believe that this restriction is necessary to avoid routine operation of the crankshafts at loads in excess of the load at which one crankshaft has been successfully tested.

Accordingly, we recommend that the permissible load for engine tests, including surveillance tests at the qualified load, be no higher than 3300 kW as read on control room instrumentation. We understand that the wattmeter may oscillate approximately ±100 kilowatts around the value at which the load is set, as discussed above. In our opinion these oscillations during routine tests will not be detrimental to engine reliability, provided that the indicated mean load is no higher than 3300 kW.

Loads at which EDG 103 was operated as part of the confirmatory test to 1×10^7 cycles, and the post-test examination that revealed no evidence of damage to the crankshaft or other key engine components, provide a basis for drawing conclusions about the capability of the EDGs for emergency operation at loads above the qualified load. EDG 103 sustained over 220 hours (approximately 3×10^6 cycles) at instrument-indicated loads of 3500 kW and above. With a conservative application of instrument error from calibrations performed by LILCO preceding and following the time the higher-load testing was performed, we estimate that the actual load during this period was at least 3430 kW. If cracks had initiated during this testing, it is likely that they would have propagated during subsequent operation at approximately 3300 kW for the time necessary to bring the total cycles to 1×10^7. But no cracks were found in the post-test inspection of the crankshaft.

In light of these results, and taking into consideration the small but inevitable differences in the properties of the three crankshafts, it is our opinion that it would be within the demonstrated capability of the engines to operate at loads to 3430 kW for an hour or so if the engines were needed to carry such loads under emergency conditions. This comment does not apply for routine operation of the engines, including engine testing, for which we recommend a load limit of 3300 kW as discussed earlier in this summary.

The testing performed on EDG 103 does not provide an adequate basis for drawing conclusions about the effects on the EDGs of loads higher than 3430 kW. However, an additional observation may be made based on other considerations. It is generally accepted in the technical literature on fatigue and cumulative damage in metals that momentary overloads, even those approaching the ultimate tensile strength of the metal, can be sustained without failure. This literature provides a basis for confidence that brief excursions (less than 1 minute) of the Shoreham engines to loads as high as 3900 kW under emergency conditions would not compromise engine operability.

If an engine were operated at high overload for a longer period during an emergency, its capability to meet the load profile throughout the emergency would depend on whether or not a crack would initiate in the crankshaft during the overload and propagate to failure before the engine was no longer needed. The available information does not provide a basis for us to comment with confidence on this scenario. However, overloads to 3900 kW for up to 1 hour under emergency conditions followed by much lower loads in accordance with LILCO's predicted LOOP/LOCA profile are believed to be sustainable. Any crankshaft

that is subjected to more than a momentary overload approaching this level should receive a thorough nondestructive examination before it is returned to service.

CYLINDER BLOCKS

The replacement EDG 103 block was not subjected to the entire qualification test performed on the EDG 103 engine. Nevertheless, the absence of any reportable indications in the block top after more than 500 hours of operation at or above 3300 kW provides significant evidence that the replacement block is suitable for service at the qualified load. If further operation beyond the most recent inspection does not exceed the FaAA-recommended inspection interval before the end of the first fuel cycle, the top of the replacement block need not be reinspected until the first shutdown for refueling. It is also unnecessary, in our opinion, to monitor cam gallery cracks in the replacement block. The known cam gallery cracks in this block have not been repair-welded, and, therefore, residual stress fields that may be associated with repair welds have not been introduced into the block material.

The replacement EDG 103 block was more suitable than either the EDG 101 block or the EDG 102 block for the tests that LILCO conducted to obtain data on compressive and alternating stresses in the camshaft gallery. Use of either of the latter two blocks for the cam gallery tests would have involved the installation of strain gages over repair welds rather than over base metal. However, the test of EDG 103 at qualified load did not contribute to resolution of questions concerning the ligament cracks in the top surfaces of the EDG 101 and 102

blocks, the potential for developing stud-to-stud or stud-to-end cracks in those blocks, or the circumferential cracks reported in the original EDG 103 block.

Our conclusions expressed previously in written testimony regarding the EDG 101 and 102 blocks remain unchanged. In our opinion, the 101 and 102 blocks are adequate for service subject to certain caveats on surveillance of known cracks. Following any period of operation of EDG 101 or EDG 102 at or above 50% of qualified load, visual (with the naked eye) and eddy-current inspections should be performed on those portions of the block top that are accessible between cylinder heads. The purpose of these inspections is to verify the continued absence of detectable cracks between studs of adjacent cylinders. In addition, the behavior of several representative cracks in the camshaft galleries of the EDG 101 and 102 blocks should be monitored. If no changes indicative of crack growth are observed over the first fuel cycle, the need for continued monitoring of the cam gallery cracks should be reconsidered by the NRC staff.

Our opinion expressed in previous testimony is also unchanged regarding circumferential cracks of the type found in a cylinder liner counterbore of the original EDG 103 block. If such cracks were to develop in any of the three blocks currently in service, it is highly unlikely that they would represent a hazard to EDG reliability. They would be expected to propagate only a short distance into a region of compressive stress and stop. At any time a liner is removed from any of the three engines, however, it would be prudent to perform an appropriate nondestructive examination of the landing of the block. If a circumferential indication is found, an attempt should be made to characterize

the depth and length of the indication through appropriate nondestructive tests. However, we do not advocate removal of cylinder liners for the sole purpose of this inspection.

TESTIMONY ON CONTENTIONS

Q1. How is your testimony organized?

A1. (All) The testimony is presented in two general parts concerning 1) the crankshaft and 2) the cylinder block.

I - CRANKSHAFT

Q2. What issues are addressed in this part of your testimony?

A2. (All) This part of the testimony deals with 1) conclusions that may be drawn from the qualification tests, and 2) the fatigue life of the crankshafts currently installed in the Shoreham TDI diesel engines, designated as EDGs 101, 102, and 103. Item 1 is relevant to the contentions (c)(i) through (iv) and Item 2 is relevant to contentions (a)(i) through (iv).

Conclusions that May be Drawn From Confirmatory Testing

Q3. Can you comment on the purpose of the confirmatory tests done by LILCO to accumulate 10^7 operating cycles on EDG 103?

A3. (All) It is our understanding that these tests were conducted by LILCO primarily to provide unequivocal evidence that the high-cycle fatigue endurance limit of the crankshaft used in EDGs 101, 102, and 103 is at or above 3300 kW. The tests also included strain gage measurements to determine if the stress field in the cam gallery region of the block is compressive. These cam gallery tests are discussed in a later section of this testimony.

Q4. Have you reviewed the procedures and results pertaining to the confirmatory tests done by LILCO to accumulate 10^7 operating cycles on EDG 103?

A4. (All) Yes. Our review of the test results has been provided to the Board in two reports, namely Post-Test Examination of Transamerica Delaval, Inc. Emergency Diesel Generator 103 at Shoreham Nuclear Power Station for U.S. Nuclear Regulatory Commission Staff, by A. J. Henriksen, B. J. Kirkwood, W. W. Laity, P. J. Louzecky, J. F. Nesbitt, and L. G. Van Fleet, dated December 3, 1984, and Post-Test Examination of the Transamerica Delaval, Inc. Emergency Diesel Generator 103 Piston Skirts and Related Components at Shoreham Nuclear Power Station for U.S. Nuclear Regulatory Commission Staff, by A. J. Henriksen, B. J. Kirkwood, W. W. Laity, P. J. Louzecky, J. F. Nesbitt, and L. G. Van Fleet, dated December 14, 1984. Our review of the procedures is based on LILCO's letter to NRC (Harold Denton) dated October 18, 1984, concerning the confirmatory test, and information provided in test data sheets and supporting procedures regarding the calibration of electrical switchboard instruments.

Q5. Why was it not possible to draw conclusions regarding the acceptability of the crankshafts from calculations alone?

A5. (Sarsten) Crankshaft calculations involve uncertainties arising from the complex geometry of crankshafts and the variations in torque, bending loads, and other relevant input data. A large factor of safety must be employed to accommodate these uncertainties. It appears to me that the analytical evidence alone does not provide a sufficient basis for concluding that the crankshafts are adequate for the qualified load of 3300 kW. An unequivocal answer can be supplied only by an engine test for a sufficient time to accumulate 10^7 operating cycles.

Q6. Regarding the tests conducted by LILCO at a nominal 3300 kW, do you believe that they can be proven to have been at that value?

A6. (All) No. We noted several points that could affect the certainty of the tested value:

1. There was uncertainty with respect to whether operators had the flexibility during the confirmatory tests to operate at 3300 ± 100 kW.

2. Instrument uncertainties could have introduced an error of up to 2.5% of full-scale power readings.

3. LILCO reported that 20 hours were run at loads in the range of 3250 to 3300 kW and that 81 hours were run at loads between 3300 and 3400 kW.

Q7. Have you resolved these questions?

A7. (Henriksen) I believe so. The points just identified have been addressed. First, based on a review of the testimony and the data logs provided, I believe LILCO operators did operate most of the time with the wattmeter indicating a load of 3300 kW. This is based on my belief that the flexibility provided by NRC in conducting surveillance tests at 3300 kW ±100 kW does not really mean that the load will be set at 100 kW above or below 3300 kW during that test. Rather, as I understand it, when set at 3300 kW, due to the mode of operation described in LILCO's testimony, the wattmeter oscillates between 3200 and 3400 kW. This is probably as close as the load can be controlled unless the governor load limit is blocked.

I have also reviewed the level of possible errors involved in the load measuring system. According to LILCO's testimony, the wattmeter instrument error could be as much as ±2% of full-scale or ±112 kW. An additional error of ±0.5% or ±28 kW in the remainder of the instrument loop could result in a total of ±2.5% or ±140 kW error in measuring the load. However, the calibration data furnished for the wattmeter, dated November 10, 1983, October 1, 1984, and January 4, 1985, indicated that the error in the meter never exceeded 40 kW in the 3000 to 4000 kW load range. Thus, including the possible 28 kW error in the remainder of the loop, the total instrument error appears to not have exceeded ±1.25% or ±70 kW during any period of operation of this particular engine since November 10, 1983.

The 20 hours of operation reported to be below 3300 kW is considered to be sufficiently few that they are of little or no significance to the question of the tested load, especially since there were 81 hours of operation above 3300 kW.

Q8. Does the possibility that due to instrument errors the confirmation test may have been conducted at a load as low as 3230 kW mean that the endurance limits for the crankshafts cannot be confirmed to meet or exceed 3300 kW?

A8. (Bush) No. I believe the crankshaft is qualified for its intended service even though some of the confirmatory test data may have been accumulated at loads slightly below 3300 kW. As I will testify in a later section, I am convinced from my analysis of engine load data that EDG 103 has operated at or above an instrumented-indicated load of 3500 kW for about 3×10^6 cycles with no evidence of damage to the crankshaft. This strongly suggests that the endurance limit is at or above 3430 kW, accounting for instrument error.

Additional testing of 7×10^6 cycles at engine loads near 3300 kW would have been sufficient to propagate any cracks that may have been present because the crankshaft stresses at 3300 kW are quite close to those at 3500 kW. Therefore, I do not consider it significant that some of the confirmatory testing may have occurred at loads somewhat below 3300 kW.

Fatigue Life of Crankshafts in the Shoreham EDGs

Q9. Have you reviewed the testimony of the County and LILCO regarding the load profiles that the Shoreham EDGs will be required to provide?

A9. (Bush, Sarsten, Henriksen) Yes. Generally we understand the engines may be subjected to loads in the following categories:

1. Load spikes equivalent to 3900 kW due to sequenced starting of large cooling pumps for the first 30 to 60 seconds of a LOOP/LOCA event.

2. Short time intermittent and cyclic loads for a few minutes that may exceed by a few percent the "qualified load", taken here as 3300 kW.

3. LOOP/LOCA loads, assumed to be at or below 3300 kW after the first few minutes.

4. Loads that may result from operator error during the first hour of a LOOP/LOCA event, taken as 3800 to 3900 kW for times of 40 to 60 minutes.

5. Periodic testing loads of 3300 kW to meet NRC Regulations.

Q10. Do you believe the engines (EDGs 101, 102, and 103) can sustain loads of Category 1 as described above?

A10. (Bush) Short-term loads as high as 3900 kW for less than a minute under emergency conditions are not considered to be a problem. Almost all texts related to fatigue and to cumulative damage in metals cite the effects of momentary overloads. An example is Collins Failure of Materials in Mechanical Design (1981). Figure 1, taken from Collins (1981, p. 293, Figure 8.27), illustrates the prestressing effect of momentary overloads on existing cracks and their subsequent delay in propagation.

Short-term high loads, even those approaching the ultimate tensile strength, do not generally produce cracks and may, in fact, provide a plastic zone around any existing crack that retards its growth. The preceding condition markedly exceeds the short-term achievable overloads of these EDGs. It is my conclusion, therefore, that loads such as those identified in Category 1 are not of concern.

Q11. Do you believe the Shoreham TDI EDG crankshafts can sustain loads identified in Category 2 as described above?

A11. (Bush) I would like to offer some background information prior to answering this question. I have carefully reviewed the operating history of the Shoreham EDGs, particularly noting the operating time at engine loads at and above 3500 kW. In the case of EDG 103, which has undergone extensive post-test examination showing no damage to the engine (particularly the crankshaft), I note that the engine has sustained over 3×10^6 cycles at loads at or exceeding 3430 kW when conservative assumptions regarding instrument error are included as discussed earlier.

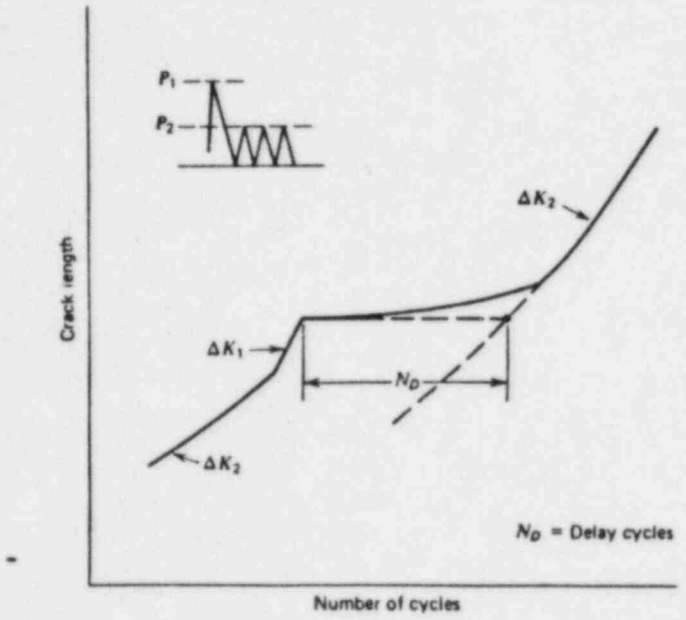

FIGURE 1. Delay in Crack Growth Following the Application of Single Overload

Source: J. A. Collins, Failure of Materials in Mechanical Design - Analysis, Prediction, Prevention, 1981, p. 293, Figure 8.27.

The loads and corresponding hours at which EDG 103 is reported to have operated are as follows:[a]

Load	Hours
Approximate hours at 3500 kW	119
Approximate hours at loads greater than 3500 kW	101
Approximate hours at 3900 kW	7

Any of several approaches may be used to predict cumulative fatigue damage from these loads. Miner's rule, more correctly termed the Palmgren-Miner cyclic-ratio summation theory, has been used for many years to predict the fatigue (endurance) limit of materials. An alternative method that provides better correlation with experimental data is the Manson approach, which takes into account the loading sequence. The predicted fatigue limit using the latter approach for the EDG 103 crankshaft would vary markedly depending on the sequence of application of the loads noted in the preceding summary. We are unaware from available information what the actual sequence was.

A conservative view is to assume that the beginning of the high-cycle fatigue limit is less than 3×10^6 cycles, and to define the lower bound of the fatigue limit as that associated with the lowest load at which EDG 103 was operated during the first 3×10^6 cycles. This would set the lower-bound value from the EDG 103 test at 3430 kW, based on an assumed instrument error of ±70 kW applied to the indicated load of 3500 kW.

(a) Pacific Northwest Laboratory, Review and Evaluation of Transamerica Delaval, Inc., Diesel Engine Reliability and Operability - Shoreham Nuclear Power Station Unit 1, PNL-5342, December 1984 (p 4.22).

Table 1 is a summary of data from six references on the high-cycle fatigue limit for several ferrite steels. A significant message from this data is that the onset of the fatigue limit is close to 1×10^6 cycles, regardless of the ferritic alloy, heat treatment, or surface hardening treatment. Note that several of the values are for aircraft or automobile crankshafts.

As illustrated in Figure 2, the fatigue limit of ferrite steels is essentially constant as a function of the number of cycles above the onset of high-cycle fatigue. This is unlike nonferrous metals, which have no clearly defined fatigue limit with time.

The steel used in the EDG 103 crankshaft is ABS Grade 4S, which corresponds roughly to an AISI-5050 steel in composition. The tensile strength is about 100 ksi and the yield strength about 60 ksi. The mechanical properties would correspond to some of the 4000 series steels cited in Table 1, and, therefore, one would anticipate similar initiation of the fatigue limit near 1×10^6 cycles.

LILCO's nondestructive examinations of the EDG 103 crankshaft following the 10^7-cycle test provide evidence that cracks had not initiated in the crankshaft during the initial 3×10^6 cycles at loads at or above 3500 kW as read on the wattmeter. Because crankshaft stresses at 3500 kW are not substantially different from stresses at 3300 kW (as discussed in response to Question 12), subsequent operation at the latter load to bring the total cycles to 10^7 would have been sufficient to cause propagation of cracks formed at the higher load. This is further confirmation that the high-cycle fatigue limit is at or above the value corresponding to 3500 kW minus known instrument error, or 3430 kW.

TABLE 1. Location of the Initiation of High-Cycle Fatigue (Endurance) Limit for Several Ferrite Steels

Reference	Beginning of Fatigue Limit x 10^6 Cycles	Material	Comments
(1)	1.0	1047 Steel	
(2)	~3.0	4340	Vacuum melted - longitudinal specimens
	~3.0	4340	Vacuum melted - transverse specimens
	~0.9	4340	Air melted - longitudinal specimens
(3)	~1.5	4340	Completely reverse S-N curve
(4)	~0.3	3130	Temper embrittled
	~0.8	3130	Non-temper embrittled
(5)	2.0	0.78% C	Spheroidized
	2.5	0.78% C	Pearlitic
(5)	1.5	4140	Quenched and tempered
	2.0	4140	Shotpeened
	2.5	4140	Nitrided
(5)	0.7	(4140,x4340, VCM)[a]	Quenched and tempered
	1.0	(4140,x4340, VCM)[a]	Shot-peened
	1.5	(4140,x4340, VCM)[a]	Nitrided, polished nitrided
	~3.0	(4140,x4340, VCM)[a]	Nitrided
(5)	0.8	4340	Automobile crankshaft - normal heat treatment
	0.7	4340	Automobile crankshaft - shot-peened
	~2.0	4340	Automobile crankshaft - nitrided
(5)	1.5	4340	Transverse specimens from crankshaft
	0.2	1.20% C	Quenched and tempered

(a) Above are torsional fatigue results on aircraft engine crankshafts including 4140 series.

TABLE 1. (contd)

Reference	Beginning of Fatigue Limit x 10^6 Cycles	Material	Comments
(6)	0.9	3420	Quenched and tempered
	1.0	1050	Quenched and tempered
	1.0	4130	Normalized
	1.5	Structural steel	-
	1.5	Alloy struc. steel	-
	~2.0	Cast iron	-

(1) Hayden, H. W., et al. 1965. "Mechanical Behavior". Volume III in The Structure and Properties of Materials. John Wiley & Sons, New York, New York.

(2) Reed-Hill, R. F. 1964. Physical Metallurgy Principles. Van Nostrand, New York, New York.

(3) Collins, J. A. 1981. Failure of Materials in Mechanical Design - Analysis Prediction, Prevention. John Wiley & Sons, New York, New York.

(4) Hollomon, J. H., and L. D. Jaffee. 1974. Ferrous Metallurgical Design. John Wiley & Sons, New York, New York.

(5) American Society of Metals. 1961. "Properties and Selection of Metals". Volume 1 in ASM Metals Handbook. Novelty, Ohio.

(6) Marks, L. S. 1941. Mechanical Engineers' Handbook. 4th ed. McGraw-Hill, New York, New York.

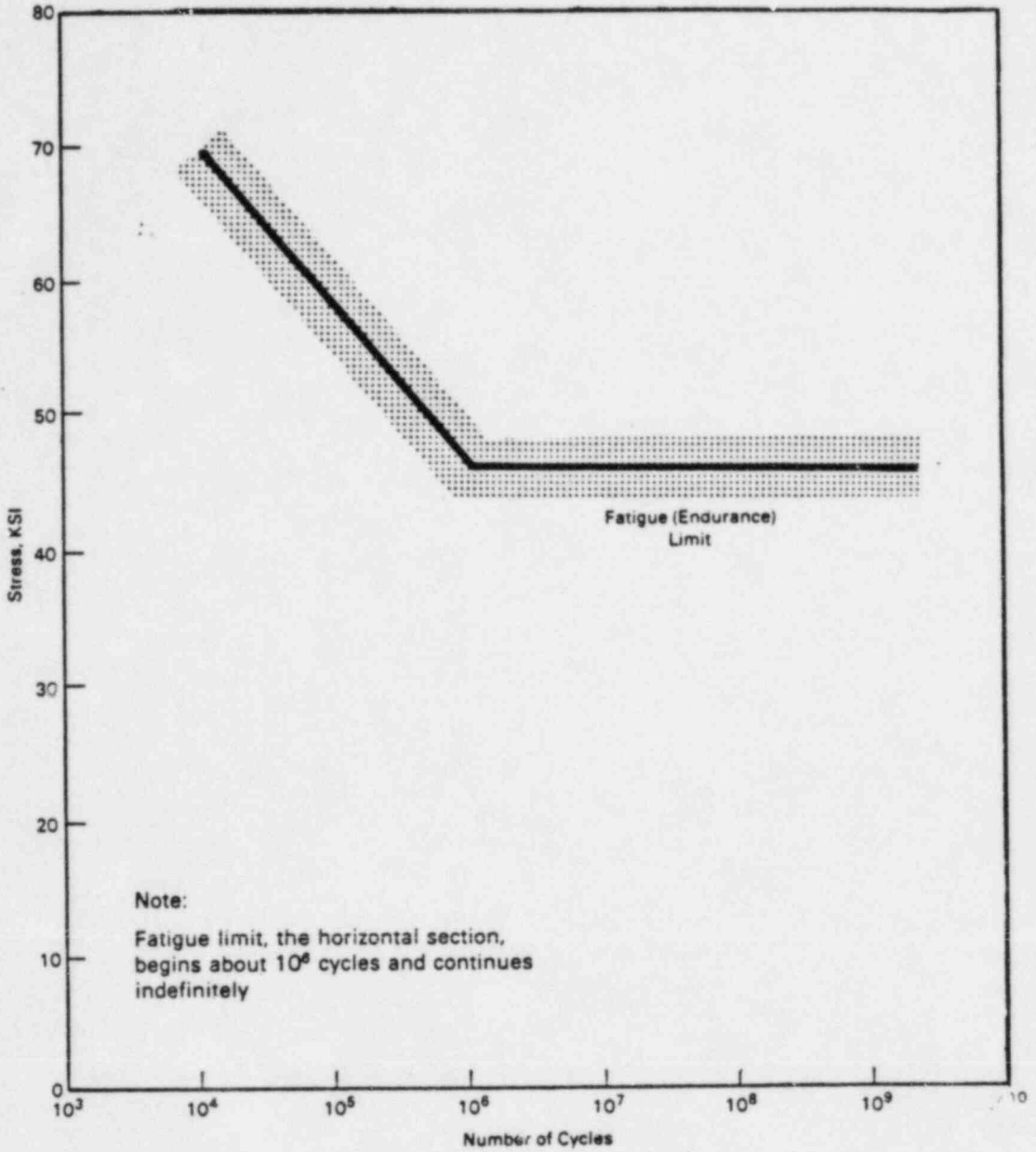

FIGURE 2. Typical High-Cycle Fatigue Curve for a Ferritic Steel (1050 AISI)

The point of the background discussion is now clear. In my opinion, the Category 2 engine loads that may result from intermittent and cyclic demands in the vicinity of 3350 to 3400 kW for times up to one hour or so are below the probable high-cycle fatigue limit. Therefore, loads in Category 2 are not of concern.

Q12. Can you quantify the relative stresses at 3300 kW and 3500 kW?

A12. (Sarsten) If one takes the bending stresses as employed and interpreted by Det Norske Veritas for the Shoreham crankshafts in their report 84-0099A of September 17, 1984, and the maximum firing pressures as read from TDI test curves dated March 19, 1976, for a Shoreham engine, then the relative calculated bending stresses are 20,450 psi and 21,120 psi for 3300 kW and 3500 kW, respectively. DELETED

Q13. Do you believe the EDGs can sustain the loads identified in Category 3 above?

A13. (Bush) As defined in the response to Question 9, all loads in Category 3 are at or below 3300 kW. I believe the endurance limit for these crankshafts is above this value. Hence, the Category 3 loads are not of concern.

Q14. The engine loads that may result from operator error (e.g., Category 4) could exceed the high-cycle fatigue limit. Do you believe the crankshafts will sustain these loads for periods up to an hour and still have the ability to meet the succeeding load challenge of a LOOP/LOCA?

A14. (Bush) I believe the crankshaft can survive up to an hour of overload to about 3900 kW without crack initiation, but the probability of

crack initiation cannot be quantified. It is a function of parameters such as previous load history and metallurgical properties. The question then is, if a crack initiates during a LOOP/LOCA, will it propagate to the point of engine shutdown before the engine is no longer needed? My engineering judgment is that the combination of a Category 4 transient operation followed by time at lower load/time profiles such as the LOOP/LOCA demand profile should not lead to crankshaft failure. The only way to quantify this judgment would be to conduct a three-dimensional finite element analysis combining the LOOP or LOOP/LOCA load histories that were imposed on a crankshaft having an initial crack and determine the final crack size.

I feel that any crankshaft that is subjected to a sustained overload approaching Category 4 should be given careful surface and volumetric non-destructive examination prior to returning it to service.

Q15. What LOOP/LOCA load profile did you consider in evaluating the ability of the crankshaft to sustain the assumed operator error load?

A15. (Bush) I assumed the following LOOP/LOCA load profile based on data provided in LILCO's testimony dated January 15, 1985, and the Shoreham Final Safety Analysis Report (FSAR), Tables 8.3.1-1A and 8.3.1-2:

Time	Load (kW)
Less than 1 minute	3900
1 minute to 3 minutes	3331
3 minute to 12 minutes	3266
12 minutes to 30 minutes	3265
30 minutes to 60 minutes	3253
Longer than 60 minutes	2617

Q16. Do you believe the Shoreham EDGs can sustain the NRC required monthly and refueling-outage testing at the qualified load of 3300 kW, identified in the response to Question 3 as Category 5 loads?

A16. (Bush, Sarsten, Henriksen) Yes. These Category 5 testing loads are considered to be below the endurance fatigue limit for these crankshafts. As stated earlier, this limit is believed to be at or above 3430 kW, based on the results of the testing up through the first 3×10^6 cycles, and is certainly confirmed to be at or above 3300 kW, based on the confirmatory tests that brought the total testing cycles to over 1×10^7. Detailed comments regarding these confirmatory tests, including our views on the uncertainties with watt-meter readings, are provided earlier in this testimony.

In view of the fact that the endurance limit can be established with certainty as being only at or above 3300 kW, we feel that it would be prudent to limit surveillance testing to this value. The reason for this is that surveillance tests can add over 3×10^7 cycles during the assumed 40-year life of the Shoreham Nuclear Power Station.

II - CYLINDER BLOCKS

Q17. What is the purpose of this testimony?

A17. (Bush) This testimony addresses parts c(i) and c(ii) of the contention concerning testing of the EDG 103 block, and also addresses metallurgical considerations related to my conclusion that existing cracks in the cam gallery region of the EDG 101 and 102 blocks should be monitored.

Q18. Have you reviewed the testimonies filed by the County and by LILCO concerning the test involving the EDG 103 block, the suitability of the cylinder blocks in EDGs 101 and 102 for service at 3300 kW, and whether there is a need to monitor the cam gallery cracks in the EDG 101 and 102 blocks?

A18. (Bush) Yes.

Q19. Please summarize your conclusions on these issues.

A19. (Bush) My conclusions are as follows:

First, as I have stated previously in written testimony (filed on October 12, 1984), the replacement EDG 103 block was more suitable than either the EDG 101 block or the EDG 102 block for the tests that LILCO conducted to obtain data on compressive and alternating stresses in the camshaft gallery. Use of either of the latter two blocks for the cam gallery tests would have involved the installation of strain gages over repair welds rather than over base metal. However, the selection of EDG 103 for the test at qualified load did not contribute to resolution of questions concerning the ligament cracks in the top surfaces of the EDG 101 and 102 blocks, the potential for developing stud-to-stud or stud-to-end cracks in those blocks, or the circumferential cracks reported in the original EDG 103 block.

Second, operation of the replacement EDG 103 block for more than 500 hours at or above 3300 kW based on the meter reading, followed by LILCO's nondestructive examinations that revealed no reportable indications in the block top, provides significant evidence that the replacement block is suitable for service at the qualified load of 3300 kW. Based on the known performance of the block through the qualification test, I concur with the conclusion of

Dr. Rau and Dr. Wachob[a] that it would be appropriate to reinspect the replacement block top at intervals determined through FaAA's cumulative damage analysis.[b] This means that if further operation beyond the most recent inspection does not exceed the FaAA-recommended interval before the end of the first fuel cycle, the top of the replacement block will not have to be reinspected until the first shutdown for refueling.

Third, the conclusions I expressed in previous written testimony regarding the EDG 101 and 102 blocks are not affected by the qualification test performed with EDG 103. As I previously testified, I believe that the 101 and 102 blocks are adequate for service subject to certain caveats on surveillance of known cracks. Following any period of operation of EDG 101 or EDG 102 at or above 50% of qualified load, visual and eddy current inspections should be performed on those portions of the block top that are accessible between cylinder heads. The purpose of these inspections is to verify the continued absence of detectable cracks between studs of adjacent cylinders. In addition, the behavior of several representative cracks in the camshaft galleries of the EDG 101 and 102 blocks should be monitored. If no changes indicative of crack growth are observed over the first fuel cycle, the need for continued monitoring of the cam gallery cracks could be reconsidered by the NRC.

Fourth, I have previously expressed the opinion based on engineering judgment that circumferential cracks of the type found in a cylinder liner

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(a) Additional Cylinder Block Testimony of Dr. Duane P. Johnson, Dr. Charles A. Rau, Jr., Milford H. Schuster, Dr. Harry F. Wachob and Edward J. Youngling on Behalf of Long Island Lighting Company, January 15, 1985, at 10.

(b) This analysis is presented in the FaAA report Design Review of TDI R-4 and RV-4 Series Emergency Diesel Generator Cylinder Blocks, the most recent revision of which is FaAA-84-9-11.1 dated December 1984.

counterbore of the original EDG 103 block do not represent a hazard to EDG reliability. My opinion on that issue remains unchanged. Similar cracks may also occur in the EDG 101 and 102 blocks because of the high stress concentration associated with the geometry of the cylinder liner landing. They may occur even in the replacement EDG 103 block, although the stress concentration in the replacement block appears to be less severe. At any time a liner is removed from any of the three engines, it would be prudent to perform an appropriate nondestructive examination of the landing in the block. If a circumferential indication is found, an attempt should be made to characterize the depth and length through appropriate nondestructive tests. However, I do not advocate removal of cylinder liners for the sole purpose of this inspection.

Monitoring of Cam Gallery Cracks in EDGs 101 and 102

Q20. How is your testimony organized on this topic?

A20. (Bush) I first will comment on the examination[a] performed by Walter C. McCrone Associates, Inc. of a cam gallery crack specimen removed from the original EDG 103 block. I will next briefly summarize my assumptions and conclusions regarding the origin and characteristics of the cam gallery cracks. Finally, I will present my conclusions regarding the need for monitoring cam gallery cracks in the blocks of EDGs 101 and 102, and my reasons for those conclusions.

(a) Walter C. McCrone Associates, Inc., Cast Iron Analysis re LILCO vs Suffolk Company (sic), MA number 13747, dated January 11, 1985.

Comments on Testing Performed by Walter C. McCrone Associates, Inc.

The test results reported by McCrone provide unequivocal evidence that the predominant oxide in the samples removed from the crack surface was magnetite. The x-ray diffraction patterns are unambiguous and can be readily interpreted by an analyst who is trained in the field of x-ray diffraction. The McCrone laboratories are well known at the Pacific Northwest Laboratory as having competence in conducting quantitative iron-oxide measurements of the type requested by the County.

Assumptions and Conclusions Regarding Origin and Characteristics of Cam Gallery Cracks

Based on the above-mentioned test results, I have concluded that the crack examined in the sample removed from the original EDG 103 cylinder block was formed during cooling of the casting. There was no evidence of an oxide film formed at low temperatures, which could have been indicative of crack propagation after the block was placed in service. The absence of the latter oxide film tends to confirm that the crack is in a compressive stress field as determined analytically and experimentally by FaAA.

Because the original EDG 103 block exhibited degraded metallurgical properties as confirmed by the morphology of the Widmanstaetten structure, it is reasonable to assume the following:

1. The tensile properties of the typical Grade-40 cast iron in the EDG 101 and 102 blocks are superior to those of the degraded Grade-40 cast iron in the original EDG 103 block. The Grade-45 cast iron in

the replacement EDG 103 block compares even more favorably in this regard. If one reasonably assumes that the hot tensile properties of the EDG 101, 102, and replacement 103 blocks would also be better than those of the original EDG 103 block, the depth of cam gallery cracks in the former would be expected to be shallower than those in the latter.

2. With the evidence that cam gallery cracks in the original EDG 103 block are hot tears that did not propagate, and recognizing the superior materials properties of the EDG 101, 102, and replacement 103 blocks, it is reasonable to assume that the cracks in the latter blocks are also hot tears and that these cracks have not grown in service.

Conclusions Regarding the Need for Monitoring Cam Gallery Cracks

Based on the information summarized above, I conclude that the existing cam gallery cracks in the EDG 101, 102, and 103 cylinder blocks would not be expected to grow under normal operating conditions. Nevertheless, I believe that monitoring of the cam gallery cracks in EDGs 101 and 102 is necessary for the reasons listed below. I do not believe it is necessary to monitor cam gallery cracks in EDG 103, because the known cracks in the replacement block have not been repair-welded.

1. The inferences and conclusions regarding crack behavior are based on detailed examination of one crack in the original EDG 103 block. This is insufficient data on which to draw conclusions with certainty regarding the other EDG blocks.

2. Associated with the known repair welds in the cam galleries of the EDG 101 and 102 blocks are residual stress fields of an undetermined nature. These stress fields could influence crack propagation.

3. Cracks in the cam gallery represent a degraded condition. In my opinion the known data on these cracks where weld repairs have been made is insufficient to establish what will or will not happen to these cracks over time. My concern is related to the possibility of an initial lengthening of the cracks into stress fields of decreasing compression or, possibly, tension.

4. Certain postulated crack growth patterns ultimately could lead to a loss of function of a diesel generator. I recognize this is improbable, particularly when coupled to the low probability of a LOOP/LOCA. However, crack monitoring will provide confirmation as to whether or not the cracks continue to be benign. The action needed to perform the monitoring is straightforward, and I believe that it would be consistent with good practice for safety-related equipment in nuclear service.

In my opinion, the preferred approach for monitoring the cracks would be to install crack-opening displacement gages at the weld overlays on the second camshaft bearing saddle inboard of each end of the engine. These saddles are representative, and they are much more accessible than saddles toward the middle of the engine for any servicing of gages that may be required. The gages should be monitored during monthly engine tests.

Other methods of monitoring may also be acceptable. One alternative approach would be to monitor the depth of representative cracks (e.g., at locations described above) with an appropriate surface probe (e.g., a TSI depth gage), and also monitor crack length (parallel to the longitudinal axis of the engine) using magnetic particle or liquid penetrant examinations. Depth measurements taken in this manner may lack accuracy, but the combination of depth measurements and length measurements would probably be sufficient to show any significant changes in crack size. To obtain the desired information in this manner with minimal disruption of engine availability (due to the need to remove access covers), it would be sufficient to take these measurements every 3 months.

Regardless of the method chosen, it is my opinion that the monitoring should continue through the first fuel cycle. A decision should be made by the NRC staff at the first refueling outage regarding the need to continue with the monitoring.

Stud-to-Stud Cracks in the Cylinder Block Top

Q21. Do you consider that the qualification test performed on the EDG 103 engine provides an appropriate basis for predicting the behavior of block top cracks in the EDG 101 and 102 engines?

A21. (Bush) No. Differences in the mechanical properties of the cast iron used in the EDG 101 and 102 blocks from the cast iron used in the replacement EDG 103 block and, perhaps more importantly, design changes incorporated into the top of the replacement EDG 103 block do not permit an extrapolation of test results from the latter block to the blocks of EDGs 101 and 102.

Q22. What are your views on the probability that stud-to-stud cracks could initiate in either EDG 101 or EDG 102 during a LOOP/LOCA and propagate to the extent that either engine would be lost from service?

A22. I consider loss of function of EDGs 101 and 102 under these postulated circumstances to be highly improbable for the following reasons:

1. There is no evidence of stud-to-stud cracking in these blocks from previous operation at and above 3500 kW. Such cracks would be more likely to initiate at these higher loads than at the qualified load of 3300 kW.

2. All future surveillance testing is to be accompanied by monitoring of the block tops of EDGs 101 and 102 to verify the continued absence of detectable stud-to-stud cracks.

3. Based on extrapolations from the original EDG 103 block, I would not expect the fatigue crack growth rates in the stud-to-stud area to be so high that there would be a loss of EDG function during a LOOP/LOCA, assuming crack initiation occurred shortly after the start of the LOOP/LOCA. This is particularly true at the low power levels--less than 3000 kW--characteristic of predicted load profiles through most of a LOOP/LOCA, even if one assumes the improbable situation that the engines would be the only source of emergency power for approximately a week. A quantification of crack initiation and growth to the point of loss of function would require a three-dimensional finite element analysis in which crack initiation is assumed. FaAA has conducted such an analysis (FaAA-84-9-11.1, December 1984). My own semi-quantitative assessment is that the cumulative probability of crack initiation and propagation to the point of loss-of-function is quite low.

MR. DYNNER: Judge, I would add, fully consistent with what you just said, that as you'll note in part of our cross-examination plan and the way we approach this that we did not move to strike portions of Dr. Bush's testimony which we might otherwise have moved to strike at the time, had we known that Professor Sarsten would not be here. We would have looked to see whether Professor Sarsten agreed or disagreed with some of the things that Dr. Bush is saying about crankshafts; and now we won't have that opportunity. So that is consistent with what you said about voir dire as to other portions of Dr. Bush's testimony besides Answer 5.

JUDGE BRENNER: Okay. All right. Why don't you ask questions as to that -- is it Answer 5? Yes. -- Question and Answer 5, page 10, to establish Dr. Bush's expertise and bases to sponsor that answer; and then we'll see what develops there. And we may have to come back to the question of expertise and bases as to other answers, also, during or after the cross-examination by the other parties.

We'll proceed for now --

MR. GODDARD: We may, indeed, Judge Brenner.

With that in mind, the Staff would respectfully request we take a short break at this period in the hopes that by doing so we can expedite this proceeding significantly, rather than proceeding to qualify Dr. Bush on this particular question. I anticipate no more than ten minutes.

JUDGE BRENNER: All right, we'll do that. We'll come back at 2:10.

MR. GODDARD: Thank you.

Ind GB 11 (Recess.)

JUDGE BRENNER: Mr. Goddard.

MR. GODDARD: The Staff would request that Dr. Berlinger be allowed to join the panel at this time. He is the coordinator of the Staff's effort on TDI Owners' Group engines and specifically for the Shoreham proceeding in regard to these diesel engines. Accordingly, having him there at this time may facilitate the examination of these witnesses.

JUDGE BRENNER: Again, he has no prefiled testimony.

MR. GODDARD: He has no prefiled testimony on crankshafts at this point.

Now there is a piece of prefiled testimony which will come in at such time as we get to the question of the cylinder blocks. It is one-page testimony which identifies his role in the preparation of the two Staff SERs.

MR. DYNNER: We object again on the same basis that we objected previously, but perhaps with even more vigor, given the fact that I don't know what Dr. Berlinger knows about crankshafts, about the issues that are testified to with respect to crankshafts at all.

JUDGE BRENNER: Mr. Stroupe?

MR. STROUPE: LILCO has no objection, Judge Brenner.

JUDGE BRENNER: All right.

Give us a moment. It would have been nice if we

knew this when we took the earlier break.

MR. GODDARD: I didn't know Dr. Berlinger was here at that time, Judge Brenner.

JUDGE BRENNER: So you were going to proceed without him if he had not physically arrived when he did after we swore this panel. Right?

MR. GODDARD: Yes, we were.

(The Board conferring.)

JUDGE BRENNER: We are going to sustain the County's objection. There is no prefiled testimony of Dr. Berlinger. We know we ruled differently last time. We think it created some problems in ruling differently last time and, moreover, the Staff had a further opportunity between last time and this time to better explain to the parties and to the Board just what of substance would be added to the prefiled testimony.

We are here with prefiled testimony to conduct cross-examination thereon, and that is the purpose of the proceeding. We know generally what Dr. Berlinger's role was, that he coordinated some matters related to the review, but that is different than being here as a sponsor of prefiled testimony.

Moreover, we had greater concern in the area of other testimony that some of the witnesses were compartmentalized and the fact that there were three separate pieces of testimony

and that maybe there were areas that were not fully coordinated, for which Dr. Berlinger could have been helpful. That concern doesn't apply to this area, so we will go with just Mr. Henriksen and Dr. Bush for the reason that Dr. Berlinger has no testimony on crankshafts.

When we get to blocks we will address separately whether or not there is any testimony of substance in that one page you referred to. I don't have it in front of me now. We don't have to discuss it now.

All right. So I will ask you to step down, Dr. Berlinger, and we will stay with the other two witnesses on the subject of crankshafts.

DR. BERLINGER: Judge Brenner,--

JUDGE BRENNER: I have made the ruling, Dr. Berlinger.

DR. BERLINGER: Can I make a comment?

JUDGE BRENNER: No, only because the proper procedure is for your Counsel to make any arguments.

This isn't the first time we have considered the issue and have been thinking about it all along. And now we have made our ruling in response to the County's objection as I've stated.

(Dr. Berlinger conferring with Counsel.)

JUDGE BRENNER: Mr. Goddard, I want to proceed --

MR. GODDARD: Yes, sir.

JUDGE BRENNER: -- at this time.

BY MR. GODDARD:

Q Dr. Bush, at this time I am going to ask you some preliminary questions with regard to your qualifications to sponsor the answer to question 5 which was previously sponsored solely by Professor Arthur Sarsten.

Did you and Professor Sarsten as well as Mr. Henriksen work together in the preparation of the answers to these questions which are submitted as the Staff testimony, to include the answer to question 5?

A (Witness Besh) Yes, we did.

Q Would you state what, in your opinion, constitutes experience which you have in qualifying large pieces of mechanical equipment based upon calculational methods?

A (Witness Bush) Yes.

I would indicate that I do not have experience of a specific aspect of the calculational modes to establish the torsional stresses. However, I don't really consider this question as related to that. This is in essence an engineering mechanics question and complex geometries and in that particular area, I have some 20 years of experience.

I have chaired a group for the American Society of Mechanical Engineers having to do with this aspect of engineering mechanics and fracture mechanics for the last 13 years.

I have a number of papers in the literature related to the calculations as they relate to pressure vessels which may or may not be considered complex geometries. I have a series of papers having to do specifically with large steam turbines and their failures and failure mechanisms as they relate to it which I believe to be almost directly related because we are now talking of large rotating equipment.

These were done both from the deterministic and probabilistic point of view and are still cited in the international literature as being related to this.

So far as I'm concerned what we have here is we have a geometry, we have stress concentration factors, and we have stresses which are primarily in this instance torsional stresses and bending stresses that relate to the prediction of fatigue life, high-cycle fatigue life. And that is the area in which I have my experience.

Q Inasmuch as your professional qualifications are not before the Board and the parties at this time as they were submitted as part of a proceeding some time ago, would you relate briefly your educational background?

A (Witness Bush) Yes.

I have degrees in metallurgical engineering at the doctorate level -- well, at the bachelor, master's and doctorate level, and in chemical engineering at the bachelor's

level. Much of my work has been in mechanical metallurgy and in moving over in engineering mechanics.

For the last 20 years much of my work has been more mechanical engineering than it has been metallurgical engineering. It is kind of a bridge between the two, with primary emphasis being on the behavior of pressure components of rotating machines.

Q Would you relate briefly your occupational experience since obtaining those degrees?

A (Witness Bush) I have worked at the Hanford project since 1953, first with General Electric and then for Battelle Memorial Institute. Several years were in a managerial capacity, but from 1963 on, I was essentially serving as a consultant in a variety of areas.

In the areas that I think are relevant here, I spent 12 years on the Advisory Committee on Reactor Safeguards with my primary responsibility being in the area of engineering mechanics, fracture mechanics, and metallurgy of materials.

Since then I have consulted for quite a few companies in the area of engineering mechanics behavior and fatigue behavior, particularly in crack components, particularly as either chairman or member of senior review panels for Lowrence Livermore in probabilistic fracture mechanics.

I have done similar things. I am currently doing it for EGNG in the response of pressurized components and also for Oak Ridge at this time in that same area.

Q Did you in fact collaborate with Professor Sarsten in formulating the answer to question 5?

A (Witness Bush) Certainly Arthur and I discussed it. I don't know whether you could call that "collaboration" or not.

Q Can you provide any further detail as to the nature of your interaction with Professor Sarsten in his preparation of the answer to question 5?

A (Witness Bush) Well, we discussed at some length--In fact, Arthur was providing me input data for calculations that appear in other questions, specifically in the tau values, the sigma sub tau values or the torsional values, and also he was beginning to do calculations on determining the bending stresses and the correlation of these as they interrelated so I would have been able to do vector summations of these values at specific locations where the stress concentration factors were highest to determine what we would expect in the way of high-cycle fatigue.

Unfortunately, we were never able to complete all of those calculations. They do relate specifically to some of these variations in torques and bending loads that are cited in here.

Q And is it your testimony that being provided with the various stresses involved and being aware of the geometry of the crankshafts as provided to you by the drawings in this case that the conclusions set forth in answer 5 are the conclusions which you would reach independently today?

A (Witness Bush) To a general degree, yes. I would agree completely that analysis per se, unless accompanied by something that would benchmark it in the sense of an absolute value, is essential, which is one of the reasons for the 10 to the 7th operating cycles.

And I think we have heard other testimony that essentially corroborates this particular opinion that you indeed need to have a bridge between the two. You have to have some experimental evidence to benchmark your analytic technique, whatever it may be.

Q Are there any modifications which you would make to the answer number 5 before electing to sponsor it as your own?

End 12

A. (Witness Bush) I probably wouldn't have written it quite the same but I certainly would have touched on the basic issues namely that you have the problem of geometry and combined stresses which is the first item, you have, for the different approaches when you do calculations you have varying factors of safety which you generally don't know precisely and therefore you are unable to establish unequivocally what your margins are and therefore certainly I would agree that you would fall back then on experimental evidence which mainly would be to test for a sufficient number of cycles to be well beyond the inception of the endurance limit.

Q. Thank you, Dr. Bush.

MR. GODDARD: I have no further questions with respect to qualification of the witness.

JUDGE BRENNER: Mr. Stroupe, do you have a position in light of that?

MR. STROUPE: Yes. I would like the opportunity I believe to cross-examine on qualifications and credentials for that particular answer. What concerns me more than anything I heard was the fact that I believe Dr. Bush indicated that Mr. Sarsten was in the process of trying to furnish him some calculations and in the process of trying to perform some calculations that he would have used and I frankly am a little concerned that that's something that

has not indeed been done and may go into the formulation of this answer.

JUDGE BRENNER: All right. We could let you begin your cross-examination at this point, given your position, and see what else transpires.

MR. STROUPE: That's fine.

JUDGE BRENNER: Thank you, Mr. Goddard, and we will go over to Mr. Stroupe at this point.

MR. GODDARD: Yes.

CROSS-EXAMINATION

BY MR. STROUPE:

Q Dr. Bush, let me say at the outset -- preface my questioning to you with the comment that I certainly have no reason to doubt your analytical abilities and we know of your expertise in other areas.

JUDGE BRENNER: Mr. Stroupe, are we clear that this will be your total cross-examination --

MR. STROUPE: Complete cross-examination, yes.

JUDGE BRENNER: Okay.

BY MR. STROUPE:

Q Dr. Bush, going for a second to the matter of your qualifications with regard to the sponsorship of answer five to question five, could you tell me how you would calculate stress concentration factors in the Shoreham replacement crankshafts?

A. (Witness Bush) I would look at the geometry and I would look particularly at the locations -- in other words, I would look at the size of the radius at a given location, I would look at the intersection with any other geometric changes -- an obvious one being an oil hole -- I would then probably enter the table, such as are provided in some of the Welding Research Council bulletins, and establish from that an acceptable stress concentration factor for that particular location and then use a value such as that for such a calculation.

Q. Would you also perform forced torsional vibratory calculations?

A. (Witness Bush) The answer to that is definitely no, that is a very esoteric area and, as I indicated previously, I do not consider myself to be an expert in the -- actual calculation using multiple modes for such a modal analyses are not something I would be doing.

I would have to take an input in the sense of torsional values and bending stresses that are provided in order to do the engineering mechanics calculation.

Q. Dr. Bush, have you indeed performed any stress concentration calculations for the Shoreham replacement crankshaft?

A. (Witness Bush) No.

Q. And I take it you have not performed any forced

vibratory torsional calculations for the Shoreham replacement crankshafts either?

A. (Witness Bush) That certainly is correct.

Q. Have you performed any critical speed calculations with regard to the Shoreham crankshafts?

A. (Witness Bush) You're not talking about resonant effects, of that nature?

No, again that falls in the other area that I wouldn't be predicting. I would take the stress inputs only under those circumstances.

Q. Have you attempted to do any finite element analysis with regard to the Shoreham replacement crankshafts?

A. (Witness Bush) No, I didn't have enough input to even consider that application. I discussed it as a possibility and certainly reviewed the finite element calculations that had been done--recognizing I didn't have the background information, I simply had the drawings that were in the Failure Analysis approach, and doing a finite element calculation without appropriate input is a waste of time and money and so we didn't even consider it.

Q. Now you indicated in response to Mr. Goddard's questioning that you and Mr. Sarsten had, I believe, collaborated on the answer to question five, is that correct?

A. (Witness Bush) No, I don't think I said that. I said we discussed it. I think if we went back we would

find that I had not said we collaborated.

Q. Did you actually review any of Mr. Sarsten's calculations with regard to the Shoreham replacement crankshafts that are referred to in this answer number five?

A. (Witness Bush) The answer to that is yes. I have specifically -- in fact, I have a set right here that we were working with that covers the torsional stresses as a series of kilowatt levels that I had specifically requested starting as low as 2400 kilowatts and going as high as 3900 kilowatts. I was interested in that particular value and, as I have indicated, I had requested the bending stresses. Unfortunately we never completed those, though I have obtained the bending stress values that are available from other sources for comparison and find that they normally vary by only 2 or 3 percent over the range of concerns so we were able to use bending stresses from sources other than these calculations and make assumptions with regard to the combining of those with the torsional stresses.

Q. Did you actually check Mr. Sarsten's calculations that you referred to?

A. (Witness Bush) The answer to that is no, that is a modal analysis and as I indicated I did not consider myself an expert in modal analysis.

Q. Dr. Bush, could you tell me on page 10 of your testimony, and specifically the answer to question number

five, what is referred to when the statement is made:

"It appears to me that the analytical evidence alone does not provide sufficient basis for concluding that the crankshafts are adequate for the qualified load of 3300 Kw."

A. (Witness Bush) Obviously these are Arthur's words, not mine. We discussed this and my position tended to be more optimistic than Professor Sarsten's. Professor Sarsten was making calculations against which he compared to a predetermined standard such as DEMA or others and he then established whether it met, was below or exceeded these particular values.

And in some instances because of this, you might say, the lack of knowledge about the factors of safety, he had reservations concerning that.

In my case, I approached it differently in that given that the stresses and given that there is a reasonable assurance that the stresses are correct, I believe I could make a calculation.

Now the problem obviously goes to the number of modes that you use and other things, and even though I do not do modal analyses, I recognize the limitations there because they are analogous to what is done in seismic analysis, with which I have some familiarity, and what I

think we are seeing here is an expression that he simply was not able to -- that it was too close to the predetermined value and without defining the factor of safety we don't establish exactly what your margins are with regard to 3300 kilowatts.

Now I would not have answered it this way for obvious reasons because I feel there is adequate margin well above 3300 kilowatts.

Q. So it would be fair to say that you really do not support this portion of the answer to question five?

A. (Witness Bush) Well certainly my testimony elsewhere would not unequivocally support this statement, you are correct.

Q. Dr. Bush, if I may, let me direct you to page four of your testimony.

Specifically let me address you to the last sentence in the paragraph in the middle of that page that reads:

> "In our opinion these oscillations during routine tests will not be detrimental to engine reliability provided that the indicated mean load is no higher than 3300 Kw."

Am I correct that it would be your opinion that oscillations during routine testing within a plus or minus 100 Kw band would not be something that the Staff would be concerned about?

MR. GODDARD: Objection. At this point the Staff has listened to a number of these questions. It appears to have gone far beyond Dr. Bush's qualifications with regard to question and answer five.

JUDGE BRENNER: You missed the boat, Mr. Goddard. We said this would be the entire cross-examination and, just to make sure, I asked again because I thought maybe we weren't clear and Mr. Stroupe and I were on the same wavelength at least.

MR. GODDARD: Okay. Perhaps I did miss the boat and I apologize for the interruption, Mr. Stoupe.

JUDGE BRENNER: And Mr. Stroupe or any other party has the right to oome back and to move to strike portions. Of course, it may become less necessary if the witness himself strikes portions by his testimony, but we will see what transpires.

All right.

WITNESS BUSH: This is really --

JUDGE BRENNER: Hold it, there's no question pending -- at least if there is, I forgot it.

I'm sorry for the misunderstanding and maybe I didn't express it clearly earlier.

MR. GODDARD: I think you did. I think I was being interrupted.

JUDGE BRENNER: All right. We've got it now in any

event.

You're correct, I noticed that you were being interrupted in that approximate time frame and I should have been softer in my comment to you. I saw that and forgot it and undoubtedly that explains it.

Mr. Stroupe, is there a question pending?

MR. STROUPE: I believe there is but I think I can restate it, Judge Brenner.

JUDGE BRENNER: Dr. Bush probably knew what it was but I forgot it.

MR. STROUPE: Dr. Bush probably has the question in mind.

WITNESS BUSH: I know the question --

JUDGE BRENNER: Ask it again for my benefit.

BY MR. STROUPE:

Q. Dr. Bush, am I correct that the Staff would have no concern with regard to oscillations within a plus or minus 100 Kw range during routine testing of the Shoreham EDG's?

A. (Witness Bush) I cannot speak for the Staff.

Q. Let me ask that question of you.

A. (Witness Bush) This is not an area that I pursued particularly. This was an area that Mr. Henriksen pursued extensively on there and I was very peripheral to it; I know what went on and I know the conversations with regard to the what I call instrument behavior or instrument error,

but this is not an area I responded to.

Q. Well Dr. Bush, given the fact that you have indicated in your testimony that in your opinion the reliability of the crankshaft has been established at least for 3430 Kw, does that enable you to say that routine testing within a plus or minus 100 Kw band at 3300 Kw would be of no concern to you?

A. (Witness Bush) I am not concerned from the point of view of the calculations but I am not going to express an expertise with regard to the instrument error type of thing.

Can I make the differentiation there?

Q. Yes, I wish you would.

A. (Witness Bush) The actual calculations that were done that established what I would call the variability, that one doesn't concern me. Then there is an inherent error that is established by calibration. I am aware of that calculation but did not participate in it so I cannot express a first-hand opinion; I know what was done but I wasn't the one who did it.

I accepted on the basis of what was discussed in a round table essentially how that value was there, I understand the basis for it and have no problems with it but I did not generate the information.

Q. Dr. Bush, your opinion as to the reliability of

the crankshaft at 3430 Kw includes accounting for meter error, does it not?

A. (Witness Bush) I think you'll find that my testimony indicates that in my opinion in specific questions it's above 3430.

Q. Mr. Henriksen, let me direct the same question to you and ask you if you are concerned with routine testing within a plus or minus 100 Kw band for the Shoreham EDG's at 3300 Kw.

A. (Witness Henriksen) From an operational point of view I am not worried at all that it is going to be detrimental to the engines; it's not necessarily the way I would test it but it wouldn't worry me.

Q. Mr. Sarsten, would you agree with -- I'm sorry, excuse that.

Mr. Henriksen, would you agree that the safety factor which Dr. Pischinger has calculated pursuant to his Kritzer-Stahl analysis is well within the bounds of safety factors generally recognized in the European diesel industry?

A. (Witness Henriksen) I'm sorry, but that's a little outside of my area of expertise.

Q. Dr. Bush, are you able to answer that question?

A. (Witness Bush) The only information I really have on the Kritzer-Stahl is when I listened today. I can understand the endurance limits aspect but I must confess

that's only one small part of it so I cannot answer that question.

Q. Let me direct your attention, both of you, to testimony on page 11, specifically item number two on page 11 relating to instrument uncertainties.

Are either or both of you aware that there is testimony in the record that a large portion of the hours put upon the engine prior to the 525 hour endurance run were measured on a digital Kw loop that resulted in a meter accuracy of approximately .6 percent?

A. (Witness Henriksen) I was not aware of that.

A. (Witness Bush) The same would apply to me. I had understood the measurements were made as cited here.

Q. If that indeed were to be the case, Dr. Bush, would your calculations contain more conservatism due to your use of the 2.5 percent error factor?

MR. DYNNER: Objection. There is no testimony that he in fact used a 2.5 percent error factor.

JUDGE BRENNER: I guess I have a related problem. I'm willing to sustain that objection and I will. To broaden my own problem, I would like specifically to know what particular calculation of his in his testimony you are pointing to and then I want to ask him about the effect of things on, such as that 2.5 percent. That's a little broader than Mr. Dynner's point but it encompasses it.

BY MR. STROUPE:

Q. Dr. Bush, in calculating the fatigue limits of the Shoreham replacement crankshaft, did you in fact use a certain percentage figure for meter error?

A. (Witness Bush) Yes.

Q. And what was that figure?

A. (Witness Bush) We had the problem of not knowing of the ordering of test -- the item was discussed this morning -- and so what we did was we set up a whole series of postulated combinations of loads, namely, that the 3900 occurred first and the 3600-plus occurred second and 3500 and then these values in turn were corrected for the meter error, the same meter error -- again, because of ignorance it was assumed to apply -- and then we finally took the 3300 and then we permuted the combinations to see whether it had an impact on the apparent fatigue life and the endurance limit.

But kind of inherent in this in those calculations was the fact that we did kind of assume a similar error in these values and some calculations.

It doesn't contribute very much because when you convert 70 kilowatts to stresses, you are talking of stresses that are measured in 100 or 2 ksi -- I mean 100 or 2 psi, I'm sorry, and that's very very small indeed percentage-wise, so it probably wouldn't have mattered much if we

had used it or not.

JUDGE BRENNER: Dr. Bush, I got lost a little bit, could you point me to the results of the calculation in your testimony that you are talking about?

WITNESS BUSH: It isn't in there.

JUDGE BRENNER: Okay.

MR. DYNNER: I move to strike his answer insofar as there is nothing in his testimony, apparently, in his prefiled testimony, that his answer relates to.

JUDGE BRENNER: Mr. Stroupe, I'll hear from you first, you asked the question, and then from the Staff.

MR. STROUPE: I frankly thought, until he finished the answer to that question, that he was indeed referring to the calculation I asked him about at the outset. Apparently that's not what he meant as a result of the question that you asked him.

JUDGE BRENNER: I was never clear, and I'm sure it was my lack, as to what calculation you were asking him about.

MR. STROUPE: I was asking him about his fatigue limit calculation, I believe that's what I prefaced my question with. And certainly if that didn't respond to my question about fatigue limit and is not in the testimony I think I would have a difficult time opposing a motion to strike.

JUDGE BRENNER: Could you show me where in the testimony he has the fatigue limit calculation or conclusion that you are asking him about?

MR. STROUPE: Yes. I believe it really goes from page 13 of his testimony over to approximately -- it really goes to the end of his testimony on crankshafts on page 23. All of that I believe is dealing with fatigue life.

JUDGE BRENNER: All right.

Let me hear from Mr. Goddard and then I want to consult with my colleagues.

MR. GODDARD: It was my impression that Dr. Bush's answer was referencing question and answer eight on page 12, which discusses instrument error and its effect upon calculation of endurance limits. I thought that was the -- also on the last line of page 16 of the Staff testimony.

If that is not the basis on which that second subpoint of answer six was based, then I don't have much to oppose a motion to strike with either. I assumed that those were the bases on which Dr. Bush was relying.

WITNESS BUSH: Maybe I should clarify. The specific question, at least as I understood it, had to do with what I call a specific series of calculations.

We conducted the calculation but they are not a part of the evidence. The conclusions that were derived from the calculations exist here but not the calculations

per se.

In other words, we went through a series of permutations as I cited --

JUDGE BRENNER: Which conclusion, Dr. Bush?

WITNESS BUSH: That we considered that these crankshafts are acceptable for operation under a series of loads including even some period of time at 3900 with the caveat that you have to do an inspection thereafter.

This, in essence, is based on the fact that we did do a series of permuted calculations, they all indicated pretty much the same thing and on that basis we concluded that there is a margin--an undefinable margin because they all came out the same way--and therefore pretty much convinced ourselves that these shafts were good for operations under the conditions that are cited in these pages.

That's not the same thing as having all the calculations.

JUDGE BRENNER: Give me a few moments, please.

(The Board conferring.)

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JUDGE BRENNER: We are going to strike the answer of Dr. Bush to Mr. Stroupe's question as well as his further explanation, not because the subject matter is prohibited but because the connection is just too vague for us at this point, and we think anyone else, to get a careful handle on, particularly given the fact that he's talking about calculations he did that are not described in the record. We understand he claims his conclusions are here.

The way to get at it is for the questioner to be very specific, and I know you started out with a specific point, Mr. Stroupe, and did not anticipate that the answer would get as vague and broad as it did. But both the questioner and the witnesses are going to have to take it one small step at a time.

The parties may still cross-examine these witnesses as to the bases for their conclusions in the testimony, and the witnesses can tell us what their bases are, and if they are calculations, that's fine, and we'll accept that information. But they are going to have to be very specific as to what conclusion in the testimony is being supported in what fashion by the information being offered in support.

And of course it becomes more difficult and therefore more incumbent upon the questioner and witness to be specific when it is not spelled out in the written testimony.

So those are our reasons for granting it, not simply because the calculations are not in the testimony. That by itself would not be a basis for granting it.

And it is our hope with that that to the extent you want to you are free to back up and pursue that point or any other point, Mr. Stroupe. And the other parties in turn will be able to, also.

MR. STROUPE: Thank you, Judge Brenner.

BY MR. STROUPE:

Q Dr. Bush, let me direct you to page 16 of your testimony, and the last paragraph on that page.

Do you see that?

A (Witness Bush) Yes.

Q Based on that paragraph, Dr. Bush, isn't it true that in calculating the high-cycle fatigue limit, setting a lower bound of 3430 kw in this paragraph, you relied on and assumed an instrument error of plus or minus 70 kw which is 2-1/2 percent?

A (Witness Bush) Minus....

Q Is that true?

A (Witness Bush) No, --

Q Minus 70 --

A (Witness Bush) -- one direction only.

Q If you had used a minus .6 percent error factor in this calculation, would the 3430 lower bound kw have changed?

A (Witness Bush) I guess I would have to say off the top of my head the answer probably is Yes. But I am trying to mentally do a calculation on what it is--

Q Let me just ask you in a ballpark fashion, Dr. Bush, would the lower bound of 3430 that you determined have increased as a result of using that assumed instrument error?

A (Witness Bush) My problem is I am trying to reconstruct the 3430 that was an error of 70 and the 3500 there and get up with the percent, and that is what I haven't been able to do.

(Pause.)

.6 percent obviously would be less than the 2 . percent.

Q So the 3430 figure would correspondingly increase by some percentage?

A (Witness Bush) Yes. Let's see.

One percent would be 35. .6. So it would be around 20, roughly 20 kilowatts lower, rather than 70.

JUDGE BRENNER: Could I get a clarification?

I am looking at page 16 of your testimony, and on that last line it says:

"Based on an assumed instrument error of plus or minus 70 kw...."

Now did your oral testimony correct that to be only

one direction? Is that what you are saying?

WITNESS BUSH: I believe that that should not be written that way. Isn't that correct?

Adam actually did the calculations but I believe we found by looking at the actual calibration curves, which is what we used there-- Now I confess that the digital values, the first time I heard that was today.

JUDGE BRENNER: You have said that already.

WITNESS BUSH: So that would really be a minus 70 kw, I think would be correct.

WITNESS HENRIKSEN: That's correct. I used the actual calibration values.

JUDGE BRENNER: All right.

One direction; you are saying minus. That confuses me, too.

WITNESS HENRIKSEN: 3500 minus 70.

I took the calibration value of that 40 kw plus I assume a quarter percent or a half percent in the rest of the loop where we had no information.

JUDGE BRENNER: I guess it is just sematnics. The instrument error would be an instrument error plus 70 kw because it would have read higher than the actual load and to adjust for the possible positive instrument error, you then subtract. Is that it?

WITNESS HENRIKSEN: Correct.

JUDGE BRENNER: Okay.

I'm sorry, I was confused, Mr. Stroupe.

BY MR. STROUPE:

Q Dr. Bush, again directing you to your testimony on page 16 wherein you say:

"A conservative view is to assume that the beginning of the high-cycle fatigue limit is less than 3 x 10 to the 6th cycles."

Can you tell me why that is a conservative view?

A (Witness Bush) If it were substantially less than 3 x 10 to the 6th the intersection with the endurance limit would be moved, shifted to the left, and therefore, any calculations that you do would tend to be accentuated with regard to the ratios of the number of cycles to the number of cycles to failure.

In other words, you would have a ratio. This is the same thing that Dr. Pischinger was discussing this morning.

Q Going over to page 17, Dr. Bush, could you tell me what you mean by the statement:

"A significant message from this data is that the onset of the fatigue limit is close to 1 x 10 to the 6th cycles, regardless of the ferritic alloy, heat treatment, or surface hardening treatment."

A (Witness Bush) Yes, that helps, in my opinion. If you look at a set of data where you vary the material, namely the chemical calculation, and where you vary the surface condition and the heat treatment and they all give you about the same value with regard to the onset of the endurance limit, it says that with a reasonable degree of confidence you can benchmark that onset and therefore, your calculations that you make are not going to vary markedly because of that. That's the basic reason for it.

Otherwise the slope of the line from the ultimate tensile strength to the intersection with the endurance limit line can vary markedly and therefore, your calculations will vary equally markedly. So I was simply using that to indicate that the use of 10 to the 6th is a reasonable one in the absence of absolute values obtained on that specific material.

Q Dr. Bush, on page 13 of your testimony you talk about loads that may result from operator error during the first hour of a LOOP/LOCA event, taken as 3800 to 3900 kw for times of 40 to 60 minutes.

Is that correct?

A (Witness Bush) I thought something got crossed out on the minutes, but initially-- That's true. That was the statement that was made.

What we were doing was looking at some of the Staff testimony and some of the other testimony that was introduced

where operator error would be a factor, and so we tended to bound it by the maximum rack position and the assumption that it would go undetected for that period of time.

Q Now you say that you thought that some of the minutes were eliminated? Is that correct? What did you mean by that?

A (Witness Bush) Well, on my copy it's crossed out and I'm trying to think of that. But that doesn't make it the official copy. And so presumably this must have come up but it must have never been transferred and so I would consider that what I have here is not valid, and that the 40 to 60 still applies.

Q Is it still your testimony, Dr. Bush, that the Shoreham replacement crankshafts can sustain loads between 3800 and 3900 kw for times up to 40 to 60 minutes?

A (Witness Bush) Yes.

Q If indeed these figures of 3800 to 3900 kw assuming operator error in a LOOP/LOCA were not the correct figures and the correct maximum figure was 3583.5 kw, would that add even more conservatism to your opinion with regard to this category of loads?

A (Witness Bush) Probably yes, since the stress is directly related to the kilowatt values even though the change between, say, 3600 and 3800 isn't that marked in stresses.

I believe you recognize that I have a caveat with

regard to this. And any time a crankshaft would operate for this period of time, I would, as indicated, expect an extensive examination of same afterward.

Q And when you say "for this period of time," are you referring to the period of 40 to 60 minutes?

A (Witness Bush) Yes.

Q Would I be correct then, Dr. Bush, in inferring that if the period were less than 40 to 60 minutes that you wouldn't have any concern for this sort of exam?

A (Witness Bush) No. You are correct in that assumption. I would have less concern because the number of cycles are reduced as a function of the time.

(Counsel conferring.)

JUDGE BRENNER: Dr. Bush, maybe I didn't understand your answer, or only part of it.

Did you say that any time the crankshaft operated for 40 to 60 minutes, that approximate timeframe, you would recommend a complete examination of it?

WITNESS BUSH: At 38 to 39 hundred kilowatts. In other words, this is not an expected condition of operation. It should occur only during a LOOP or LOOP/LOCA. In fact, it isn't even expected in there because it is strictly an output of operator error.

I think it would be the prudent thing under those circumstances to reexamine such a crankshaft, both volumetrically

and by surface techniques.

JUDGE BRENNER: Is that a studied minimum load on your part before you would trigger the prudency of such an examination in your mind?

WITNESS BUSH: I guess any time that one had an operator error that was observed and it was definitely above the anticipated conditions, I think it would be a prudent condition because a control room during an accident condition is, under most circumstances, not the-- It is subject to considerable variation; there are perturbations in there.

I would never know whether to trust the values that were cited under those circumstances, so I think it would simply be a prudent thing, if you had a LOOP or a LOOP/LOCA and you had operated and there was definite evidence that you had markedly exceeded the kilowatt values for a p eriod of many, many minutes -- I am not talking about a half a minute or something, but for 40 to 60 minutes, then it would seem to me it would be a prudent thing to do.

Now that's a personal opinion on my part. I am not expressing a general position.

JUDGE BRENNER: Thank you.

Mr. Stroupe.

BY MR. STROUPE:

Q Dr. Bush, let me see if I understand this.

Would I be correct that your advocacy of examination

of the crankshaft would be where it has sustained a load of between 38 to 39 hundred kw for a period of 40 to 60 minutes?

End 15

A. (Witness Bush) That's correct.

Q. Would I be correct in assuming that if the load that the crankshaft had to sustain for 40 to 60 minutes was not as high as 3800 kw that you wouldn't advocate this kind of examination or inspection?

A. (Witness Bush) If it were around 3450 to 3500, in that range, I probably would be somewhat more relaxed, on the basis of the testing; that's true. It's kind of a subtle line. The biggest problem there would be to establish unequivocally that it had not, indeed, exceeded that value for that period of time, which would mean one would need digital meters or something. You couldn't base it on hearsay evidence, I guess would be the problem.

Q. Mr. Henricksen, am I correct that it is your testimony that, in your opinion, the Shoreham replacement crankshafts can, indeed, reliably handle the loads that have been postulated in the Staff's testimony that they might be subjected to?

MR. DYNNER: Objection. I think that the question is too broad and vague. I don't know what loads he's talking about. There are a number of loads in the Staff's testimony that are referred to, and there are different qualifications and conditions put on the Staff's testimony as to those particular loads. So I think the question is vague and incomprehensible.

MR. STROUPE: I'm talking specifically to those loads set out on page 13, with the exception of the load in Category 1 being reserved for later cross-examination.

JUDGE BRENNER: All right. With that clarification, the objection is overruled.

MR. DYNNER: I am going to renew the objection, because I think then it is a multiple question. If he wants to ask them one at a time, that's fine. But I think it is -- there are five different loads. He's asking the witness to respond to five different questions.

JUDGE BRENNER: He doesn't have to ask it one at a time. He can attempt to see if there is some general principle that would encompass it all; and, depending upon the witness' answer, he may have to proceed further or differently.

JUDGE MORRIS: Mr. Stroupe, may I interrupt for a moment?

MR. STROUPE: Certainly.

JUDGE MORRIS: On page 13, these numbered paragraphs refer to loads in several categories. It seems to me you're asking the witnesses if the agree that the crankshafts can withstand a certain loading pattern. I suggest, maybe, that you look at page 22, where a specific load sequence is laid out and ask your question about that, if you feel that's appropriate.

MR. STROUPE: Judge Morris, the only problem I have

with that is we don't believe that's an accurate analysis of the load, in view of the testimony that has been taken in this proceeding; and I think, perhaps, the loads that are set forth on page 13 may, indeed, be more detailed than the table that is set forth from the FSAR here on page 22.

JUDGE MORRIS: You think they are more restrictive?

MR. STROUPE: I'm not sure they are more restrictive. I'm not sure about that.

JUDGE MORRIS: Well, that possibility occurred to me, which is why I raised it.

MR. STROUPE: We can certainly ask the question for both of those. I can certainly get the answer to that question if I can get the answer to this question to start with.

WITNESS HENRICKSEN: Could you repeat the question, please?

BY MR. STROUPE:

Q Mr. Henricksen, with regard to the loads that are set forth on page 13 of your testimony, with the exception of the load in Category 1, is it your opinion that Shoreham replacement crankshafts can adequately maintain those loads?

MR. DYNNER: Objection. Again, I'm not trying to delay anything, but it is a vague question. Maintain those loads for how long under what conditions? I think it is a very vague and ambiguous question.

MR. STROUPE: The conditions are stated in the categories.

JUDGE BRENNER: That's what I was going to say. Let's get the answer and find out where it goes. If we end up with a problem, in fact, because of the different categories of the loads, we can deal with it if the answer indicates that.

Mr. Henricksen?

WITNESS HENRICKSEN: Based on my knowledge of the subject -- which, I will be the first to admit, does not qualify me as an expert -- I would have no qualms about No. 2, 3 and 5. Number 4 I have no opinion on.

BY MR. STROUPE:

Q. Dr. Bush, let me ask the same question of you with regard to loads set forth as 2, 3, 4 and 5 on page 13.

A. (Witness Bush) I have no particular problem with them, since I was the one that did the followup calculations on them.

Q. And, Dr. Bush, I will ask you: would you have no particular problem with regard to those loads set forth on page 22 of your testimony?

A. (Witness Bush) No. Those are substantially less restrictive than the loads on page 13.

MR. STROUPE: Judge Brenner, that's all the questions I have at this time.

JUDGE BRENNER: Mr. Dynner, give us one minute.

(The Board conferring.)

JUDGE BRENNER: We are going to let you proceed with your cross-examination momentarily, Mr. Dynner. I want to alert the Staff now that, based on some of the testimony we have had from the witnesses, we have a concern that the witnesses and the Staff may not fully appreciate the significance of these witnesses, under oath, saying that they are adopting the testimony there as their own, including every sentence that may occur in an answer where the testimony was previously jointly sponsored by Professor Sarsten along with one or more of the present witnesses.

And I won't ask you what has occurred up to this point. But what we want to occur between now and tomorrow morning, in the overnight recess, is for the Staff, with these witnesses, to rigorously go through every sentence of this testimony -- it should have been done before now; maybe it was -- and make sure it has been accomplished to your satisfaction -- if not by now, then tonight -- and come back in the morning and let us know whether there is any part of this testimony that does not have a sponsoring witness present on this panel. And we'll find out what the situation is.

There are questions about torsional stress calculations that the Board -- at least I might have wanted to ask if Professor Sarsten had been here. Of course, we

have already, with sadness, noted that he is not here.

If you will not consider it a breach of confidence, Mr. Stroupe -- I don't think you would, so I'll go ahead and just state generally that LILCO also had some questions in its cross plan going to that subject which it has elected not to ask. I don't know precisely why not, but I'm guessing that the reasons may be similar to the fact that I am not going to ask questions on that subject that I might have asked.

And yet, nevertheless, there are arguably still some sentences remaining in the testimony that bears on the subject of torsional stress calculations. That may be okay, and maybe Dr. Bush and Mr. Henricksen can, together, still sponsor testimony that overlaps with the subject. But I want you to go through it as we have asked, and let us know tomorrow morning.

Of course, the cross-examiners, through their cross-examination, will uncover evidence going to the weight the testimony, and we will have that to consider. But beyond that, as an added check, we would like the Staff to reliably inform us also in the event there are things the cross-examiners did not ask about that the Staff, on reflection, should call to our attention.

MR. STROUPE: Judge Brenner, I just would like to state that I would like to preserve my right to renew my

motion to strike, particularly with reference to some of the aspects of the answer to Question No. 5, because I believe some of the answers that came out reflect that some of that information may, indeed, not be capable of being sponsored by Dr. Bush.

JUDGE BRENNER: All right. Let's come back to it at the end of the day, if that would be acceptable to you, Mr. Stroupe.

MR. STROUPE: That's fine, Judge Brenner.

JUDGE BRENNER: And please remind me to do it. Consider whether the testimony has solved your problem or not; and then you may want to do something procedurally beyond that, and we'll then give you that opportunity.

Mr. Dynner, we can proceed with your cross at this time.

MR. DYNNER: Yes. Can we take our afternoon break now, Judge?

JUDGE BRENNER: Okay. Do you think you might finish with these witnesses today?

MR. DYNNER: I hope.

JUDGE BRENNER: One of these days I'm going to learn how to pin you down better, because all you leave me left to point back to is your hope. But I will accept that for now.

Let's take a 15-minute recess until 3:45.

(Recess.)

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MR. GODDARD: Judge Brenner, the Staff has one brief preliminary announcement.

There are a number of matters that have come up regarding the quantification of the loads which were furnished to these witnesses, and I think also involving the blocks, especially the cam gallery settlement. I just wanted to make it clear to the Licensing Board, after your earlier admonition, at the earliest time, that Dr. Berlinger will be empaneled with these two witnesses when we get to the subject of the blocks

JUDGE BRENNER: Okay.

I don't know what you mean by questions as to quantification of loads. However, you can make your motion at the time you want to put him on the panel, and we might not permit him to testify, given our view of whether or not he has direct testimony.

MR. GODDARD: I understand.

JUDGE BRENNER: So part of putting him on that panel, you point to what substantive testimony he has prefiled.

MR. GODDARD: There is one page of prefiled testimony which we'll introduce at that time.

JUDGE BRENNER: Yes; with emphasis on "substantive."

MR. GODDARD: I understand.

JUDGE BRENNER: Mr. Goddard, just to make sure,

wb2

because the Staff filed new testimony later in the proceeding, as you might recall, than the original filing date, if at the end of the day you can give me a copy of that one page that you now plan to say is Dr. Berlinger's testimony, I can make sure we are focussed on the same thing, and read it tonight.

MR. GODDARD: The Staff will do that.

JUDGE BRENNER: All right. Thank you.

CROSS-EXAMINATION

Mr. Dynner.

BY MR. DYNNER:

Q. Dr. Bush, would you please turn to page 10, Answer 5, which you are, as I understand, adopting as your testimony now?

A. (Witness Bush) Yes, sir.

MR. STROUPE: I'm going to object to that because I think it is a mischaracterization. I think Dr. Bush indicated specifically with regard to one statement in there that he would not say that.

JUDGE BRENNER: All right; let's just proceed based on the prior record.

It is certainly what he said at one point in time, and we've got further testimony in response to your questions, Mr. Stroupe. And we're aware of that testimony also. And I guess I would go so far as to agree with you that that characterization is no longer accurate -- Mr. Dynner's

wb3

characterization is no longer accurate. But he is just leading up to where he is going, and now he's going to get there.

BY MR. DYNNER:

Q. Dr. Bush, do you adopt the first sentence of Answer 5 as your testimony?

A. (Witness Bush) Yes.

Q. What do you mean by the word "uncertainties?"

A. (Witness Bush) An obvious example, when you have a geometry like this one can use various techniques and come with a variety of values for stress concentration factors. Geometry per se may vary; in other words, the actual versus the drawing values differ, which would introduce either a more relaxed or a more restrictive value on such things as stress concentration factors.

The business of the way you combine the stresses is a factor, a significant factor. To handle it correctly you have to use a vector addition technique, taking into account the fact that one may be leading or lagging the other one.

So all of these can lead to what I call -- I wouldn't call them errors necessarily, but certainly variations in the values which you might obtain under these circumstances.

Q. What are the crankshaft calculations that you are referring to in that first sentence?

A. (Witness Bush) The ones I just referred to would

wb4

tend to have to do with what I would call the probable life of the crankshaft; in other words, the cycles, the cumulative cycles, things of that nature.

Obviously, another aspect of it would have to do with the actual modal analyses which can be dependent on these factors, too. And as I had indicated earlier, that is an area I am disavowing any expertise in.

Q. Do you mean to include in the term "crankshaft calculations" the torsional vibration calculations?

A. (Witness Bush) That would certainly be the basis. As I say, I wouldn't do such calculations, but I could take the outputs therefrom. But that would probably be inherent in there. And, as I say, that's the one I disavowed myself from, the modal calculations.

Q. Let me clarify. I'm not asking you now what you have performed or can perform, I'm only asking you: in that particular sentence what you mean by the term "crankshaft calculations."

Did you mean to include--

A. (Witness Bush) I cannot answer that specific one specifically.

Q. You don't know what you meant by the term "crankshaft calculations?"

A. (Witness Bush) Well, I didn't put down the specific words. I guess that's the case, yes.

wb5

Q But you're--

A (Witness Bush) My interpretation of what I would have said is not necessarily what is there. What I have expressed is my interpretation to date.

Q What I'm trying to get at, and the reason I asked the question, do you adopt the first sentence as your own testimony necssarily means do you adopt that sentence and every word in that sentence as if you had written that rather than Professor Sarsten?

Maybe you'd like to, with that clarification, answer that question; again, Do you adopt the first sentence as your own testimony? And please take the time to read it again.

A (Witness Bush) I would say, interpreted in that fashion, the answer is I could not do it. The way I interpret it I could, but not in that fashion, no.

Q I don't understand the answer. Perhaps you could explain to me--

A (Witness Bush) I would disavow the ability to do it word-for-word.

JUDGE BRENNER: Dr. Bush, you have got to let the questioner ask the question. Even if you are correct in guessing what the end is, we won't have it on the record.

Mr. Dynner, go ahead.

MR. DYNNER: All right.

wb6

BY MR. DYNNER:

Q As I understand what you said, it is that you cannot adopt the first sentence word-for-word; is that correct?

A (Witness Bush) If it is interpreted in the fashion it has been, the answer is I cannot adopt it word-for-word.

Q Well, let me ask you this:

Can you restate the first sentence in a way in which you would be comfortable, stating that?

MR. STROUPE: I'm going to object to that question because that is the creation of testimony on the spot, which doesn't, I don't believe, give the kind of notice that these proceedings require.

JUDGE BRENNER: Your objection is possibly premature, Mr. Stroupe. Let's see what he says.

In the pure sense, cross-examination always creates new evidence, new testimony, except when it's redundant, which at times it is in these hearings.

You know, if it's some startlingly new information you might have problems of notice, and so on, and we'll hear from you. But if it's just an explanation, but in line with something in the answer, that would be something else. And maybe there are other possible variations.

I don't understand most of his answers so far to Mr. Dynner either. He says "depending on if that's the way

wb7

it's being interpreted." I don't know what's being interpreted in what way. And I think Dr. Bush may be wrongly projecting inferences of interpretations based on questions asked by a questioner. But, in any event, we'll allow him to ask that question, and we'll see where it goes.

Do you recall the question, Dr. Bush?

WITNESS BUSH: Yes, I recall the question.

Let me give it a try, and I'm trying to assert the fine line between what I call the actual calculational process and the utilization of the data: that's where I'm getting into difficulty.

Several factors can influence the calculational results in the calculation of crankshaft stresses. The geometry of the crankshaft -- the complex geometry of the crankshaft is a specific instance. The variation in the stresses, both torsional and bending, as a function of the position around the crankshaft are other examples, all of which can lead to substantial uncertainties and output results.

BY MR. DYNNER:

Q Am I correct, then, that what you are saying means, in part, that, for example, the complex geometry of a crankshaft can have an impact on the life of the crankshaft?

A (Witness Bush) I guess the simplest way to answer that is yes, it can.

wb8

For example, the fillet configuration, things of that nature, obviously have an impact. It's true of most rotating machinery.

Q. And by the same token, the torsional stress characteristics of the crankshaft also have an impact on the life of the crankshaft; isn't that right?

A. (Witness Bush) That's correct. If they're sufficiently high in a particular location that has a high stress concentration factor at or below the surface, then they certainly will have an impact on the failure of the crankshaft.

Q. And is it also, then, your testimony that the bending stresses could also have an impact on the life of the crankshaft?

A. (Witness Bush) That's true.

Q. And is it fair to say that although you are not an expert in designing crankshafts or in performing torsional stress calculations, or bending stress calculations, that nevertheless you know enough about those areas to know that they do in fact have an impact on the crankshaft life?

A. (Witness Bush) That's correct.

Q. And is it your testimony that given the complexity and difficulties in interpreting crankshaft geometry, torsional stresses and bending stresses, that there are uncertainties which require a large factor of safety in order to be assured that the crankshaft's life would be sufficient

wb9

for its purpose?

A. (Witness Bush) I would say generally that's the case.

One of the reasons for a factor of safety is the uncertainty. There are other reasons for a factor of safety, but that certainly is one.

Q. And what are some of the other reasons for the requirement for the safety factor?

A. (Witness Bush) Really, you don't want to be surprised, quite frankly. And I'm not being facetious.

Obviously, in many components we use factors of safety of 2 to 2.5. As our knowledge increases we reduce these factors of safety, and typically in many components now we are using factors ranging from 1.25 to 1.5. That's a function of both experimental evidence and of improved analytic techniques.

You recognize, I'm making this as a generalized statement, and it applies to many components, and I am not trying to relate it explicitly and specifically to a crankshaft.

End 17

Q. Does that statement, in fact, relate specifically to crankshafts as well as to other large rotating machinery?

A. (Witness Bush) In a general sense it applies, yes.

Q. And that would include the crankshafts at Shoreham, right?

MR. STROUPE: I'm going to object at this point, Judge Brenner, and renew my motion to strike this portion of the testimony on the basis that the witness has already testified that he does not do tortional calculations. I don't see how he can testify in response to Mr. Dynner's questions about these various uncertainties if, indeed, he does not do them.

JUDGE BRENNER: Mr. Dynner?

MR. DYNNER: Yes. I think there is a long history of evidence and case citations in our proceedings which demonstrates that for a witness to have the requisite experience, knowledge, training and expertise to understand the application of a calculation or a process, then it is not necessary that he know how to actually do the process himself. And, therefore, I think that the --

JUDGE BRENNER: He said he wasn't an expert in the process, didn't he?

MR. DYNNER: But that certainly is not the

testimony I heard him give. In fact, I specifically asked him that, notwithstanding the fact that he didn't know how to actually perform these, does he know enough in order to determine whether or not they are important to crankshaft life. And I think he answered, "Definitely yes."

I think that distinction has been made in his testimony.

JUDGE BRENNER: Let me hear from the Staff.

MR. BORDENICK: Mr. Goddard had to step out temporarily. I'll try to --

JUDGE BRENNER: How can you handle an issue that we've had extensive discussion on previously, involving him? I'm not even sure, in fairness to you, that you were in the room for some of it.

MR. BORDENICK: You're correct. That's a good question. If I could have just a moment, though, I'll attempt to --

JUDGE BRENNER: All right. You take a moment. I'll talk to the Board during that same moment. And then I want to address a broader subject, off the record.

(The Board conferring.)

JUDGE BRENNER: All right. Let's take care of the motion first.

We are going to strike Answer 5 from the testimony. We find, based on what we have heard so far, now that we have

a better understanding of what the source of that information is and what Dr. Bush can tell us about it, that we can give it no weight, literally no weight, and therefore that leads to the conclusion to strike it.

To be sure, Dr. Bush has some general knowledge through years of laudable experience and education in the general field of doing metallurgy and working generally with rotating shafts, as he said, in pressure vessels and so on. But the important thing before us gets into a very particular field of the particular effect of the torsional vibration calculations that Professor Sarsten apparently had in mind in writing this sentence. I am inferring that he actually performed some, although we don't see it in the testimony. And the things of importance that this paragraph would lead to would be what factor of safety would be appropriate in light of what particular torsional calculation, using what particular methodology -- very much the exact process we went through in great detail earlier.

We had testimony from expert witnesses that the factor of safety that would be appropriate depended on how the calculations were drawn. And that's the reason we can give it no weight.

You know, as a generalization it might have been acceptable for Dr. Bush to be able to accept the generalization, and that's probably where we are in our own mind after Mr.

Goddard finished asking him the questions he did, which helped. But then, on reflection, we realized that generalization does us no good. It's only useful when the specifics are probed. And Mr. Dynner is trying to probe those specifics, and we certainly welcomed that opportunity. But that led to the realization as to where we have ended up, as I have just described it.

For that reason, we are striking it.

There has been testimony stemming from it, and we certainly cannot go back and point out, line by line, as to what is struck of that in oral testimony. But we don't have to do that. Anything that stemmed from this we are not going to rely on, and it should not be relied on in proposed findings. We are truly sorry that we can't take it further. I have already indicated that LILCO maybe had some questions that they believed supported their point of view on torsional calculations. I think the County, on its part, had an approach that it thought would support its point of view. We had questions in mind, just to find out what the sensitivities were to support some of these conclusions as to short-time operation at certain load levels, given the record we already had at 3500 and on the load levels earlier, and the record we have at other load levels here.

That record still exists. And I was going to make this point when when we talked about findings, but as long as

I have alluded to it, permit me to digress slightly and make the point now.

In writing the proposed findings as to the acceptability or lack of acceptability of the crankshaft and the proposed operation of the qualified load concept, including uncertainties in that load and including possible intermittent or short-time operation at loads over 3300 kw, where there is evidence in the earlier record that parties believe should be used to support their positions one way or the other -- that is, the divergent positions of the parties -- that record should be pointed out in the context of the proposed findings here. Do not depend on our ability to go back and look at the proposed findings we already have to pull them out. We may feel free to do that, but don't depend on our ability to do it without your help in the next set of proposed findings because the context is different, even if the evidence is the same being relied upon.

You may recognize that point as something you, yourself, raised, Mr. Dynner, when we granted the motion to reppen. I thought it was a good point. At that time, I had not been prepared to address it. But what I said then is that we wouldn't preclude it. We have given it thought since you first raised it and have come to the conclusion I have just indicated.

All right. That's the ruling on the motion to

strike.

Off the record.

(Discussion off the record.)

JUDGE BRENNER: On the record.

All right. We will return to the continuation of your cross-examination, Mr. Dynner.

BY MR. DYNNER:

Q. Mr. Henricksen, would you look at page 11, Answer 7 of your testimony?

A. (Witness Henricksen) Yes.

Q. You talk about the oscillation of the watt meter between 3200 and 3400, and say that this is probably as close as the load can be controlled unless the governor load limit is blocked.

Is there any reason why the governor load limit should not be blocked in order to better control the oscillation?

A. (Witness Henricksen) I'm not 100 percent familiar with what type of governor they have on these engines, but most governors today have the ability to block.

Q. So you have not investigated that issue in the case of the Shoreham diesels?

A. (Witness Henricksen) No.

Q. Have you investigated the issue of how closely the load can be controlled?

A. (Witness Henricksen) Not other than the testimony

that has been given and the request I wrote to ask the NRC to run plus-minus 100 kw.

Q. Well, I'm asking you the question because you say this is probably as close, and I wonder: what are you basing that on? Is there any particular analysis that you have performed on that issue?

A. (Witness Henricksen) No. This is just based on experience, that if you don't block the governor it will oscillate some, depending upon the varying load.

Q. And that oscillation is not necessarily 100 kw, so far as you know, is it?

A. (Witness Henricksen) Not necessarily, no.

JUDGE BRENNER: Mr. Dynner, I wonder if I could jump in with a question here, if you're finished with that discrete subject.

MR. DYNNER: Yes, sir.

JUDGE BRENNER: Earlier today, Mr. Henricksen, you implied or I inferred from your answer that that's not the way you would perform the surveillance testing -- that is, at 3300, plus or minus 100. Is what you had in mind there exactly what Mr. Dynner has asked you about now -- that is, blocking the governor -- or did you have something else in mind?

WITNESS HENRICKSEN: Judge Brenner, the type of testing I've been involved in over the years has usually been

where a precise power was essential, because these were fuel and load, and the various codes only allow you so much difference from -- if you run, say, a three-hour load you would have, probably, six readings, and the code would only allow so much difference in percentage from hour to hour, from last reading to last reading, depending on what the agreement is set up beforehand. This you cannot get when you have an instrument that oscillates 50 to 100 -- whatever be the case. You need to block the governor to run the precise load.

JUDGE BRENNER: All right.

I don't want to digress or interrupt you too much, Mr. Dynner. I may come back to the subject.

End WRB 18

BY MR. DYNNER:

Q Dr. Bush, I note that at the bottom of page 12 in answer 8 of your testimony you used the word or the term "endurance limit." What do you mean by "endurance limit"?

A (Witness Bush) That can best be seen by looking at Figure 2 on page 20.

This is a characteristic of ferritic materials where below a certain value of stress and above a cert in number of cycles, in essence the line is horizontal assuming that the component that is being examined is free from defects because if there are flaws present that can propagate, then in essence the material doesn't have an endurance limit. It continues on down.

This characteristic is not common to all materials. Many materials do not have endurance limits.

Q Well, what I'm trying to get at, does the endurance limit have some meaning that you can describe in words other than just referring to this graph? I mean what happens when something reaches or does not reach the endurance limit?

A (Witness Bush) If the stresses are below the endurance limit, which are defined in terms of stress, you should be able to go -- assuming that the component is free from defects in a location where they can propagate, it should go for an infinite number of cycles without failure.

Q And above the endurance limit, what happens then?

A (Witness Bush) If you are above the endurance limit and you exceed the number of cycles or you intersect the line that is coming down at an angle and meets the endurance limit, you can initiate a flaw with that combination of stress and cycles and further operation would permit flaw propagation and could lead to ultimate failure of the component.

Q So speaking specifically about the Shoreham crankshaft, is what you're saying that above the endurance limit, you would expect that a crack would initiate in the crankshaft?

A (Witness Bush) If I am above the endurance limit and if I have a sufficient number of cycles so that I have exceeded that, there is the finite probability a crack will initiate; that's true.

Q Is the term "high-cycle fatigue limit" the same as endurance limit?

A (Witness Bush) It is used sometimes synonymously. I think "endurance limit" is more definitive, but one can find many definitions.

Q Well, as you have used those terms in your testimony, have you used them synonymously?

A (Witness Bush) Yes. What we are talking of here is in contrast to low-cycle fatigue or intermediate cycle fatigue; we are talking of something where we would expect

it to occur-- Well, at the stress levels we are considering, we are talking of well above 10 to the 5 cycles before we would anticipate anything occurring insofar as crack initiation.

That would assume that we have pretty high stresses there, well above the endurance limits.

Q On page 13 at the top of the page, continuing over in answer 8, you refer to the statement there that:

"....the crankshaft stresses at 3300 kw are quite close to those at 3500 kw."

I am correct, aren't I, that you didn't calculate those crankshaft stresses, did you?

A (Witness Bush) No, I did not.

Q And are these the crankshaft stresses that were calculated by Professor Sarsten that were referred to in question and answer 12 on page 21?

A (Witness Bush) I thought that was deleted from the testimony.

Q Yes, it was.

JUDGE BRENNER: Are you looking at me?

WITNESS BUSH: I don't know what to do.

JUDGE BRENNER: Answer his question.

WITNESS BUSH: I'm not sure that 12 is the optimum place to cite it but in the general sense, there were a series of stresses calculated, as I had indicated earlier, by

Dr. Sarsten that covered the range from 2400 kilowatts to 3900 kilowatts that were indeed used in the analysis of high-cycle fatigue.

BY MR. DYNNER:

Q Do you know what method Professor Sarsten used to make those calculations?

A (Witness Bush) No.

Q Mr. Henriksen, did you make any of those calculations?

A (Witness Henriksen) No.

Q Do you know what method Professor Sarsten used to make those calculations?

A (Witness Henriksen) No.

MR. DYNNER: Judge, I move that this testimony regarding these crankshaft stresses, 3300 kw and 3500 kw, be stricken. Unfortunately they were--

JUDGE BRENNER: Give me the particular line and--

MR. DYNNER: I am referring here to page 13, and I'm referring to line 3. I am referring specifically to line 3 in this instance.

The reason for my motion to strike is that the calculations were unfortunately performed by Professor Sarsten, and I cannot cross-examine any of these witnesses as to the validity of those calculations, methdology, and whether they were properly performed.

JUDGE BRENNER: You want me just to take line 3 out?

MR. DYNNER: I am starting at that point, but I will go on to say that there is testimony here, including lines 1 and 2, which are based upon line 3, and therefore I would move to strike those if you agree with my initial motion to strike because it follows that without being able to ascertain the validity of the crankshaft stress calculations that the conclusions that flow therefrom also should be stricken.

JUDGE BRENNER: Try to take it all at once. If we agree with your reasoning it may follow; it we disagree with your reasoning it may not follow. Did you want to ask some further questions and then bring it all together, or did you want to make the arguments now?

MR. DYNNER: I was going to take it one step at a time, but I can if you prefer.

There are other places in the testimony in which there is reference made to calculations, and I am going to try to ascertain whether they are the same calculations, that is, Professor Sarsten's calculations.

JUDGE BRENNER: I didn't mean to go too far out in the testimony, and I will give the other parties an opportunity. I just want to mechanically identify this.

I am looking at line 3 which starts:

"....crankshaft stresses at 3300 kw are

quite close to those at 3500 kw."

MR. DYNNER: That's correct, sir.

JUDGE BRENNER: And I guess-- Do you want to extend it back up to the beginning of that sentence?

You see, if I strike that line then what you are left with is "Additional testing...." and so on through the end of that second line.

MR. DYNNER: I would strike it. Yes, I would move to strike it in view of the word "because" that appears in the second line at the end. And therefore, if the reason for the testimony is stricken then the testimony itself should be stricken.

JUDGE BRENNER: All right.

Maybe you should ask him a question or two about the dependence or the lack thereof of the first part of that sentence on the second part, and then we'll take up your argument, at least as to that sentence, and hear from the other parties.

MR. STROUPE: Judge Brenner, may I make a point before you do that that I think bears on this?

I believe there are-- On at least two prior occasions there is evidence in the record, particularly today, from Dr. Pischinger that the stresses between--

JUDGE BRENNER: Wait a minute. We're talking about this witness' evidence.

MR. STROUPE: I understand that but what I'm saying is I believe there is evidence in the record today and Professor Sarsten's prior testimony relating to stresses at 3300 kw and 3500 kw that this answer could be based upon.

JUDGE BRENNER: Well, let's see what the witness has to say, and then we'll hear from you. We have some problems here which we will have to deal with due to the unfortunate circumstance we have.

Do you want to ask him about the first part of the sentence?

MR. DYNNER: Yes.

BY MR. DYNNER:

Q I am correct, aren't I, first of all, Dr. Bush, that when you answered my last question about Professor Sarsten's calculations that these calculations which you said he performed from 2400 kw to 3900 kw were the ones that you were talking about in your testimony here? Is that right?

A (Witness Bush) That's correct.

Q Is it also correct that beginning at the top of page 13 that the statement that:

"Additional testing of 7 x 10 to the 6th cycles at engine loads near 3300 kw would have been sufficient to propagate any cracks that may have been present...."

is, as shown by the word "because," dependent upon the assertion that --

"....the crankshaft stresses at 3300 kw are quite close to those at 3500 kw."

A (Witness Bush) The answer to that is No.

Q All right.

Can you tell me why you used the word "because"?

A (Witness Bush) If I have cracks present, regardless of the stresses, and now if I have an extended number of cycles at a somewhat lower stress, because effectively I no longer have an endurance limit, I would anticipate that those cracks would continue to propagate with a possibility of failure.

So those two things are not interrelated in that respect.

Q What if the stresses were substantially different between 3300 and 3500? Would that change your conclusion?

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A (Witness Bush) No.

Q. Why did you include in your sentence the phrase "...because the crankshaft stresses at 3300 Kw are quite close to those at 3500 Kw?"

A. (Witness Bush) That simply gives the additional warranty that 7 times 10 to the 6, if I had cracks present, would have caused failure. That's the only reason for that. I would still have expected it to fail if I had a crack present and if I am not moving into a compressive stress field which I would not expect under these circumstances then I would anticipate failure.

Q. Well let me put it this way:

You are relying here, as I understand it, on the additional testing of 7 times 10 to the 6 cycles at 3300 by saying that that would have been sufficient to propagate any cracks.

Is it your belief that that testing at 3300 would have been sufficient to propagate any cracks if the stresses at 3300 were only 1/1000th as great as they were at 3500?

A. (Witness Bush) Probably not but that's not the case in point.

Q. Well how do you know that's not the case in point?

A. (Witness Bush) I could take the strain gauge data, for what that's worth, that exists for these and I could analyze them to establish the stresses, which does not require an analysis on my part, and pretty much establish

what the stresses are.

And that is -- If you mean did I run the strain gauge data, the answer is no, I didn't. However there is a report here which unfortunately has not been made too available which does include such test data.

Q. I understand that.

But it's correct, isn't it, Dr. Bush, that you didn't actually do that, that what you did was rely on Professor Sarsten's calculations when you wrote this, isn't that right?

A. (Witness Bush) I took all the data I had available at the time.

Q. Did you take the strain gauge data that you just referred to?

A. (Witness Bush) I looked at the strain gauge data, I also looked at the bending stress data, which unfortunately Professor Sarsten had not completed which I got from other sources and incorporated that in the analysis, that's correct.

Q. All right.

Supposing you didn't use any of the bending stress data, then what data are you -- first of all, are you....

What is the difference in your view between the crankshaft stresses at 3300 and 3500, not taking into consideration any of the crankshaft stress calculations performed by Professor Sarsten?

A. (Witness Bush) Well if I go to the strain gauge data I would expect about....

(Pause.)

I would expect it to be about -- I would expect it to increase by about 2 to 3 percent, in that range.

Q. All right.

Now what strain gauge data are you referring to specifically?

A. (Witness Bush) Well I haven't had a chance to -- I saw some strain gauge data and then I have a report that was the subject of a conversation this morning that I haven't had a chance to evaluate in depth.

Apparently the ones I have are in an abbreviated form only from this report and were cited in previous testimony; that's the ones I've looked at.

Q. Dr. Bush, did you or did you not make an actual calculation of the crankshaft stress differences between 3300 and 3500 Kw based upon strain gauge data?

A. (Witness Bush) The answer is I did not run any strain gauges, that's true.

Q. No, that's not my question.

I said did you or did you not make a calculation of the crankshaft stress differential between 3300 and 3500 Kw based upon certain strain gauge data?

A. (Witness Bush) I looked at the micro-inches and

I made a conversion into stress, if that's what you're talking about.

Q So your testimony is that you did make such a calculation?

A (Witness Bush) I did a calculation for the values that I had available, but I had not had access to this paticular report at that time.

I will have to look back and see -- and I don't have my calculations with me -- as to whether I have explicitly at 33- and 3500, or what I have in that range of values.

Q In making whatever calculation you made, specifically what strain gauge data did you use?

A (Witness Bush) Well I confess I would have to look back at the reports and see which one it was. I can remember the data and I can remember how it was organized but I can't tell you specifically what report.

JUDGE BRENNER: Mr. Dynner, give me a moment. I would like to get the solution to this and I would like to talk to my Board members a moment and then we'll see where we're going.

(The Board conferring.)

JUDGE BRENNER: Judge Morris has a few questions that may help us understand better what the situation is.

JUDGE MORRIS: Dr. Bush, at the top of page 13,

in line three, which we have been discussing here, as I understand the colloquy, you said that your conclusion is not based on the fact that the stresses are quite close at 3300 and 3500 kilowatts, is that correct?

WITNESS BUSH: That's correct, unless we go down to a thousandth of a percent or something like that.

JUDGE MORRIS: True.

But if that is correct what is the important thing there, is it the range in which these stresses lie?

WITNESS BUSH: No, the important thing is that we have already initiated a crack. You go to the preceding page, you now have a crack there and you continue your testing at a lower stress level, albeit not a very large change, for an extended number of cycles. You no longer have an endurance limit.

Therefore, the crack will -- unless you are moving into a compressive field, which I would not believe would exist in here, at least not a very high one -- I would expect the crack to continue to propagate.

It would first propagate -- if it is initiated because of the torsional stresses, I would expect it to initiate slightly below the surface. Then the bending stresses, which will be higher, will tend to propagate at first to the surface and then in.

And therefore if I am at what I will call a

reasonable stress level and I go to a large number of cycles, I would anticipate failure.

JUDGE MORRIS: If I understand you correctly you are saying that if the crack exists it will propagate for the stresses, the cyclic stresses that occur at these power levels, is that correct?

WITNESS BUSH: That's what I would expect to happen, yes. That presumes that I have initiated the crack so I am using this as a -- it was used as an example because I can postulate four cases: for instance, one would be where the endurance limit clearly is below my testing values and at 3 times 10 to the 6 I would either have failed the shaft already or I would have initiated a substantial crack and any further testing would have taken it to failure.

I could be at a case where the endurance limit is still below my test levels but I may be moved over enough so that I have not initiated a crack and so I am in a never-never-land, I cannot unequivocally predict what happens.

The third case would be where my endurance limit clearly is above essentially all of my testing conditions and under which circumstance, barring the existence of a pre-existing crack, I would not expect the shaft to fail at well above 10 to the 7 cycles; I could go to much higher than that without failure.

So what this was essentially establishing was a

postulate as to where, what I could infer from the 3 times 10 to the 6 test, presuming the positioning on the endurance limit.

JUDGE MORRIS: Well given your conditions set forth on page 12, supposing that the 7 times 10 to the 6 cycles were run at 3000 kilowatts, would a crack propagate?

WITNESS BUSH: I think it would. I did find indeed some of the data I used in the report with regard to the change in stresses as a function of kilowatt loads as high as 3900 kilowatts on the replacement crankshafts and there isn't very much difference between, say, 3500 and 3900 and one can infer the same thing between, say, 3300 and 35- or 3035.

And so I would anticipate at stresses of perhaps if I had initiated a crack with my combined loads at and above 3500, I would anticipate perhaps a 3000 psi difference in stress, say, at your 3000 kilowatt level. And I believe that 7 times 10 to the 6 cycles with an existing crack near the surface would be sufficient to cause failure.

JUDGE MORRIS: But your point in this sentence is simply about propagation under these conditions.

WITNESS BUSH: That's correct.

JUDGE MORRIS: We have focused on that exact point and we have established that it is not whether or not the stresses are quite close or not, it is whether or not they are

sufficient to cause propagation of a crack under the test conditions.

And I have just postulated in a hypothetical test at 3000 kilowatts and the direct answer is what I want as to whether the crack would propagate.

WITNESS BUSH: And the answer I believe would be yes.

JUDGE MORRIS: Thank you.

WITNESS BUSH: That answer presumes the pre-existence of a crack prior to the 3000 kilowatt test.

JUDGE MORRIS: Yes, your conditions set out on page 12.

WITNESS BUSH: That's correct.

JUDGE BRENNER: All right. Here is what I propose to do procedurally.

We are not going to rely on Dr. Bush's testimony to support the point as to whether or not crankshaft stresses at 3300 Kw are quite close to those at 3500 Kw. We have testimony by Dr. Bush as to why he believes the first two lines at page 13 are correct independent of the point in the third line to which I just referred that we would not rely on him for and that testimony stands for what it's worth and we will evaluate it.

Furthermore, we in our mind will convert what he says as a potential hypothetical in addition for his independent

reasons, at least the reasons that he thinks are independent -- whether or not they are truly independent we will consider.

But in addition to those reasons he gave for supporting his view that if you have crack initiation that additional testing of 7 times 10 to the 6 cycles, as he stated in the first two lines, would be sufficient to propagate cracks.

In addition to that, we will accept his testimony converted as follows: that if crankshaft stresses at 3300 Kw are quite close to those at 3500 Kw that that supports the point that additional testing of 7 times 10 to the 6 cycles at engine loads near 3300 Kw would have been sufficient to propagate any cracks that may have been present and of course assuming against a starting point that you have crack initiation at the 3 times 10 to the 6 cycle testing at 3500 Kw.

Now since it's a hypothetical at this point there will have to be other support in the record for us to use that part of the point.

Mr. Stroupe thinks there is ot[illegible]t in the record from Professor Sarsten's testimony and we'll look at that. We know that Dr. Pischinger believes that to be the case and we will evaluate the extent to which we want to rely on Dr. Pischinger's conclusions for that point also.

That's the best we can do at this stage. If Professor Sarsten were here there would be --

MR. DYNNER: Judge, I should point out to you that essentially the same testimony appears on page 17 in the last paragraph beginning with the sentence: "Because crankshaft stresses at 3500 Kw....," and that particular sentence specifically refers to question 12.

JUDGE BRENNER: All right.

Are we still on that long question 11?

MR. DYNNER: Yes.

JUDGE BRENNER: All right.

I had noticed that earlier and I was going to come to it in the context of our ruling on answer 12. Now we have a better context and my statement applies to this testimony also.

I'm not going to let you add anything, Dr. Bush, because I am concerned with digressing. I've got it where I understand it and to the extent other people want to adduce information from you, including your own counsel, I will let it proceed that way.

There's a lot going on here, unfortunately for you, besides the technical information and that is the difficulty of all of us in separating out what support you are relying on for certain things. If somebody was on the panel with you who had performed some of the torsional stress calculations, we could turn to that witness for some of this and of course we cannot do that.

#21 WRBbrb

Mr. Dynner, it's almost five o'clock. How much do you have? I'm not going to cut you off, I just want an estimate.

MR. DYNNER: I think I have another hour and a half to two hours, looking at my cross plan and seeing how things went.

I'm taking into consideration the difficulty that we're having in determining what Professor Sarsten's testimony was, and where he is being relied upon, and where people are saying what they themself know to be the case.

JUDGE BRENNER: Remember, mere reliance on his view is not necessarily a problem, it depends on whether you are deprived of effective cross-examination, depending on the extent of the reliance; as to the torsional stress calculations you were, especially given Answer 12 which we have struck.

I don't know what methodology was used, and the other witnesses didn't either.

All right; we might as well adjourn for the day at this point. And the Staff at the outset tomorrow morning will tell us what the situation is with respect to sponsorship of every sentence in that testimony.

Is there anything further that we should do today?

MR. ELLIS: No, sir; I think we can take up the cam gallery monitoring thing in the morning, if that is agreeable with the Staff.

WRBbrb2

JUDGE BRENNER: Right. Let's do it in the morning.

MR. ELLIS: The only other item that we had open was the possibility of enlisting the aid of the Board in overcoming an impasse among the parties. It is still LILCO's view, and I think the Staff's, that we'd be willing to participate in such a conference. It's LILCO's view it would be beneficial. I have not heard from Mr. Dynner as to whether he has changed his view that he doesn't think such a conference would be fruitful.

MR. DYNNER: The State and the County -- I'm authorized to speak for the State -- do not believe that such an intervention, or discussion would be useful at this point.

JUDGE BRENNER: All right; we'll think about it.

In any event, if we're willing to talk about it a little bit, I'd like not to interrupt the witnesses' testimony this week, and let's see where we are come Friday on that subject.

The parties also have to get back to us with respect to the findings schedule, and I'll remind you of that.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: I'm reminding you of that now. Now you remind us next time.

All right, let's adjourn until nine o'clock.

(Whereupon, at 5:00 p.m., the hearing in the above-entitled matter was recessed, to reconvene at 9:00 a.m. the following day.)

CERTIFICATE OF OFFICIAL REPORTER

This is to certify that the attached proceedings before the UNITED STATES NUCLEAR REGULATORY COMMISSION in the matter of:

NAME OF PROCEEDING: LONG ISLAND LIGHTING COMPANY
(Shoreham Nuclear Power Station)

DOCKET NO.: 50-322-OL

PLACE: HAUPPAUGE, NEW YORK

DATE: WEDNESDAY, MARCH 6, 1985

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission.

Anne G. Bloom/sg
William R. Bloom/sg
(sigt)

(TYPED)
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Official Reporter
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