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October 30, 1984

TO: All Recipients of Transcripts of Proceedings of
Docket No.: 50-322-1 (OL)
Long Island Lighting Company
(Shoreham Nuclear Power Station)

I. Enclosed are corrected transcripts in the above matter for the following days:

September 10, 1984
September 11, 1984
September 12, 1984
September 13, 1984
September 17, 1984
September 18, 1984

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II. A corrected transcript for September 19, 1984 is in the process of being prepared and should be distributed in the near future.

III. Portions of the following pages have been questioned by the Commission. The items are being checked against the original notes by the subcontractor. New pages will be distributed when the items are resolved.

Date	Page	Line(s)
9/17	22687	5-6
9/17	22725	14-16
9/18	22829	14
9/19	23030	16

Sincerely,

Alan I. Penn
Vice President

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UNITED STATES
NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF: DOCKET NO: 50-322-OL

SHOREHAM NUCLEAR POWER STATION

(Long Island Lighting Company)

THIS IS A CORRECTED TRANSCRIPT

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NATIONWIDE COVERAGE

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY & LICENSING BOARD

In the matter of: :

SHOREHAM NUCLEAR POWER STATION : Docket No.50-322-OL

(Long Island Lighting Company) :

State Office Building

Veterans Memorial Highway

Hauppauge, New York

Wednesday, September 12, 1984

Hearing in the above-entitled matter was convened at 9:05 a.m., pursuant to notice.

BEFORE:

JUDGE LAWRENCE BRENNER,
Chairman, Atomic Safety & Licensing Board

JUDGE PETER A. MORRIS,
Member, Atomic Safety & Licensing Board

JUDGE GEORGE A. FERGUSON,
Member, Atomic Safety & Licensing Board

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APPEARANCES:

On behalf of the Applicant:

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ADRIAN F. JOHNSON, ESQ.

On behalf of the Intervenor, Suffolk County:

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C O N T E N T S

P R O C E E D I N G S

JUDGE BRENNER: Good morning. Mr. Dynner.

E X H I B I T S

EXHIBIT	FOR IDENTIFICATION
Suffolk County Diesel No. 69 (Article from MOTOR SHIP TECHNICAL MAGAZINE entitled Sulzer's Four-Stroke High and Medium Speed Engine Range)	22365
Suffolk County Diesel No. 70 (Article entitled "The Development of a Highly Rated Medium Speed Diesel Engine of 7,000 to 9,000 Horsepower for Marine Propulsion" from THE INSTITUTE OF MARINE ENGINEERS)	22384
Suffolk County Diesel No. 71 (Photo of Piston removed from EDG 103 taken by Anesh Bakshi at June 1984 at SNPS of scuffing)	22421

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PROCEEDINGS

JUDGE BRENNER: Good morning. Mr. Dynner. If there are no preliminary matters, you may continue your cross-examination. Are there any preliminary matters?

MR. FARLEY: May we approach the bench?

JUDGE BRENNER: I would rather have things on the record unless there is a good reason not to. If you feel strongly about it, we will go off the record.

MR. FARLEY: I would prefer off the record.

JUDGE BRENNER: All right.

(Side bar conference held out of the presence of the public).

JUDGE BRENNER: All right, Mr. Dynner. We discussed yesterday our desire that you finish cross-examination by the lunch break.

MR. FARLEY: Judge Brenner, I think Mr. Johnson is prepared now to talk about the Kodiak thing that we ended up with yesterday, if Mr. Dynner would like to pursue that.

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Whereupon,

DAVID O. HARRIS,

DUANE P. JOHNSON,

ROGER L. MC CARTHY

FRANZ F. PISCHINGER,

CRAIG K. SEAMAN,

LEE A. SWANGER,

and

EDWARD J. YOUNGLING

were called as witnesses on behalf of the Applicant and, having been previously duly sworn, were examined and testified as follows:

CONTINUED CROSS-EXAMINATION

BY MR. DYNNER:

JUDGE BRENNER: All right.

DR. JOHNSON: I'd like to clarify the Kodiak results. Two pistons were removed from the Kodiak engine number 4. The two pistons that were removed, and if we refer to the third page of Exhibit 29 --

JUDGE BRENNER: This is LILCO Exhibit P-29?

DR. JOHNSON: Yes, sir. The two pistons that were removed are the ones labeled on that page as 1R and 1L. The stud boss area of both of those

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pistons was examined by both PT and ET. No indications were detected by either method.

In addition, the rib near the wrist pin boss area was inspected with PT, penetrant inspection. No linear penetrant indications were observed in the piston which we are calling 1R, a three-quarter inch linear penetrant indication was observed in the piston we are referring to as 1L. The region in the vicinity of the penetrant indication observed in 1L was inspected with eddy current and no linear indication was found.

The 1L piston, that is the piston that had the three-quarter inch linear penetrant indication, was shipped to FaAA laboratory. The other piston, 1R, I understand, was shipped to TDI. In the Failure Analysis laboratory we reinspected piston 1L using both penetrant and eddy current technique, and no linear indications were observed with either method. We conclude that there were no relevant indications observed in either piston.

DR. SWANGER: I'd like to add to that answer if I might. The ET that Dr. Johnson referred to is abbreviation for eddy current testing which has been discussed earlier. Also I think part of the pending question was, what was the load on the

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piston that was removed from these engines. Our basis for evaluating this piston or assigning it a load of 1200 pounds per square inch peak firing pressure is based on the information that we received from the Kodiak Electric Association, that over the 6000 hours of exposure that all of these pistons had had, the engine had operated at an average load of 80 percent of its nameplate rating.

The data shown on this page, taken on March 2, 1982, at 5600 kilowatts, is pressure data taken with the Kiene type gage at 80 percent load. The 5600 kilowatts is 80 percent. We thought given the questions of the accuracy of the Kiene gage and to be conservative in the credit that we were going to take for the exposure of the AE piston in the Kodiak engine, that we did not want to claim that it saw a load of more than 1200 psi, peak firing pressure.

As you can see from the table, based on the Kiene gage, every piston in that engine experienced loads above 1200, from 1240 up to 1340.

Q. Dr. Swanger, to follow up on that, could you explain on the chart we are speaking about, which is the third page of Exhibit P-29, the first part of the chart says "March 31, 1983, 4000 KW,

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7200 hours."

Does that reflect the peak pressures of all of the cylinders during the period ended March 31, 1983?

DR. SWANGER: Each of the sets of data on Page 3 of P-20 represents the results of a test at one point in time at one particular load taken by the Kodiak Electric Association for diagnostic purposes, taken with the Kiene gage. One of the purposes of having both LILCO and FaAA engineers go to Kodiak Alaska, was to gather information from the Kodiak Electric Association on the operation of their engine with the AE pistons in it.

As I had said earlier, Kodiak Electric told us that the engine had been operated at an average load of 80 percent of its nameplate for the 6000 hours preceding the inspection, which is the time that it had AE pistons in it. The hours referred to in these two charts are the total engine hours from the time that it was new.

JUDGE BRENNER: I think that completed the answer.

Q. Dr. Swanger, do you know what the peak firing pressure of the cylinders on the average is for the 80 percent load?

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I'm confused because if you look at the page we have been looking at, one set of data for, apparently as you testified, the tests done on March 2, 1982, shows a significantly higher average peak firing pressure than shown at March 31, 1983. Is that because the March 31, 1983 test was taken at 4000 KW?

DR. SWANGER: Yes, it is. There is a direct correlation between the peak firing pressure and the total output of the engine. The data taken on March 2, 1982, at 5600 kilowatts is, at 80 percent of the nameplate output of this, which is 7000 kilowatts, and the peak firing pressures reported there from 1240 to 1340 psi represent the peak firing pressures associated with operation at 80 percent of the nameplate load.

Q. Since the information that you received as a result of the February 17 trip, which is reported in the document in Exhibit P-29, and the data associated with the peak firing pressure, have you done anything to update that information?

DR. SWANGER: I'm not certain that I know what you mean by "update the information", Mr. Dynner. Specifically what are you referring to?

Q. All right. Have you had any

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communications with the Kodiak Electric Association since the timeframe of February to March of this year concerning their AE pistons?

MR. SEAMAN: Mr. Dynner, we have spoken to Kodiak since February, and asked them if they had any new information to report on the AE pistons. I don't recall the precise date but they did report that they had had no problems with the AE pistons at that time.

Q. Do you recall the approximate date?

MR. FARLEY: Approximate date of the conversation? The question is not clear.

JUDGE BRENNER: Is that what you meant, Mr. Dynner?

MR. DYNNER: Yes, of course.

MR. SEAMAN: To the best of my recollection, it was the May to June timeframe.

Q. You said that during this conversation you asked them whether they had any problems, or they indicated they had no problems with the AE pistons. Could you further describe the conversation.

MR. SEAMAN: The actual conversation that occurred occurred with a member of my staff, not myself, who reported to me that the pistons were

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still operating satisfactorily. That's why I don't recall the details of the conversation except that they were still operating satisfactorily.

JUDGE BRENNER: We are going to get a little remote in terms of what this witness will tell us, Mr. Dynner, a conversation with somebody else about a conversation.

MR. DYNNER: Yes, I am moving on.

Q. Gentlemen, if you turn to page 56 of your testimony.

Dr. Johnson, you testified in answer 88 that FaAA inspected two AE pistons from the TDI R5 prototype engine after approximately 622 hours of operation at 2000 psi.

Would you identify the type of engine that is designated as the TDI R5 prototype engine. R5, two separate things -- excuse me.

Dr. Johnson, this is your testimony in answer to 88. Do you know what the TDI R5 engine is?

DR. JOHNSON: The inspection we performed was on two pistons. That information was taken off the box that the two pistons were in. That's what we were told by TDI.

JUDGE BRENNER: What was the designation of the engine? You personally don't know what the TDI

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R5 engine is; is that correct?

DR. JOHNSON: Yes.

Q. Then anyone can please describe it, the TDI R5 engine.

JUDGE BRENNER: Mr. Dynner, I think it would be more efficient if you could have them focus in on any point of similarity or differences you want them to focus in on instead of hearing a recitation by the witnesses on what --

MR. DYNNER: All right. I will rephrase the question then.

Q. Is the TDI R5 prototype engine the same type engine as the EDG's at Shoreham?

DR. SWANGER: The TDI R5 engine is an evolutionary development of the R4 type engine which is in use at Shoreham. The key dimensions describing the engine, the bore of 17 inches and the stroke of 21 inches are identical to the engines at Shoreham.

This is borne out by the fact that the same piston, the AE piston can be used interchangeably in the R4 or the R5 engine. The R5 engine has been developed by TDI to provide a higher specific output. I think the nominal rating is 275

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psi, brake mean effective pressure compared to the 225 psi brake mean effective pressure in Shoreham. So it is more highly stressed both from a mechanical load standpoint and from a thermal load standpoint.

In addition, the testing that was done by TD with these AE pistons, was accelerated testing, even for the R5, and that for the 622 hours of operation, the brake mean effective pressure was a figure of 304 psi, which is substantially above the 275 psi rating of the R5. The R5 is a large medium speed turbo charged diesel engine of very similar type to those employed at Shoreham.

Q. It is a V16 engine as opposed to a straight 8 engine that we have at Shoreham, isn't it?

DR. SWANGER: The R5 designation, just like the R4 designation, applies to a family of diesel engines.

Q. I am talking about this particular engine identified in the testimony as the R5 prototype engine. That's a V16 engine rather than a straight 8 engine as we have at Shoreham, isn't it?

DR. SWANGER: No, you are wrong, Mr. Dynner. It happens to be a V12 engine.

Q. All right.

DR. SWANGER: However, as I was trying to

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explain in the answer, that doesn't make any difference to the testing of the individual components and what's referred to --

Q. I didn't ask you whether --

MR. FARLEY: I object. He is interrupting the witness.

MR. DYNNER: I would like an answer to the question.

JUDGE BRENNER: In this case he answered it. I think what we are getting is fair explanation in addition to the answer.

DR. SWANGER: The reason the testing was significant to FaAA is that the components of the power cylinder, namely the cylinder head, the piston and the liner, the valves, the fuel injection equipment, are identical for any R4 engine. Also they are identical for any R5 engine independent of the number of cylinders in that engine. And, therefore, testing of a component, specifically testing of an AE piston would be independent of whether it was in a 6, an 8, a 16 or even a 20 cylinder engine.

Q. You said the cylinder head is the same in the R5 V12 as in the EDG's?

DR. SWANGER: I did not say that. I said

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within the R4 family, the powered cylinder components are the same, and separately within the R5 family the power cylinder components are the same.

Q. Could you describe the differences, if any, between the AE piston skirts you examined in the R5 engine and the AE piston skirts in the EDG's at Shoreham?

DR. SWANGER: The differences between the AE pistons at Kodiak Electric Association which are the same as the AE pistons in the Shoreham EDG's, and the AE pistons that were tested in the R5 are referred to in our direct testimony at question number 89 at page 56. I can expand a little bit on that answer by referring to LILCO's exhibit P-29. On Page 10 of that exhibit there are photographs of the interior of the AE pistons at the Kodiak Electric Association which are the same as the pistons at Shoreham, and on Page 28 of exhibit P-29 there are photographs of the interior of the AE piston that was tested in the R5 development area.

By comparing those two pictures, the differences in the evolution of the AE design can be seen, and they are in two areas: One is in the wrist pin boss area, the area of the casting in which the 6 and three-quarter inch diameter wrist

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pin goes through the casting, and the difference is that the earlier version of the AE, the one that was tested in the R5, is similar to the AF piston in that the wrist pin boss has a reinforcing rib around it, and also has some longitudinal reenforcing ribs.

In the more advanced AE design as shown on Page 10, that wrist pin boss has additional material added to it to stiffen it and strengthen it.

The other difference is that the circumferential rib part way up the skirt of the piston which connects the wrist pin bosses together has been enlarged, tapered, and the radii made more gentle and more blended in the advanced AE design, the one at Kodiak and the one at Shoreham.

The R5 engine had the AE piston with a narrower rib which is similar to the ribs in the original AF pistons at Shoreham.

The NRC Staff has addressed these differences in its testimony and has said that in their opinion the R5 piston, the earlier version was improved when the changes were made to generate the AE pistons that were provided for Kodiak and for Shoreham, and that they had no doubt that these changes made an improvement to the AE piston.

We think this makes the experience with

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the R5 test engine even more valid because the pistons which are at Shoreham are actually stronger than the AE pistons tested in the R5 engine at 2000 pounds per square inch for essentially ten to the 7 cycles. Therefore, we think that experience with the R5 is very strong and our conclusion that the AE pistons at Shoreham are adequate for their purpose, will not initiate and will not propagate any cracks.

Q. Are the differences that you described the only differences between the R5 AE piston and the AE pistons in Shoreham?

JUDGE BRENNER: While they are conferring, I assume Exhibit P-29 is one of the exhibits where the pages will be numbered for the version that goes as the official exhibit?

MR. FARLEY: Yes, Your Honor.

DR. SWANGER: The differences in design that I just discussed are the only ones I am aware of.

Q. Dr. Swanger, I didn't ask you about differences in design. I said, are those the only differences. So I would like to know, aside from design differences, are there any other differences?

JUDGE BRENNER: Mr. Dynner, is there a reason why under cross-examination you cannot just

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point to whatever difference you have in mind and say, what about this, isn't that a difference? So we can get quick answers.

MR. DYNNER: If I knew all the answers, that would be the approach I might take, but I don't know all the answers. I have reasons to believe that there may be other differences, but I don't know the answers. That's why I am asking the questions, sir.

JUDGE BRENNER: Not the typical approach to cross-examination.

MR. DYNNER: Sometimes we don't always know the answers to questions that we ask, as you have noted during this examination.

DR. SWANGER: There are some other differences which are contained in the memo by Donald O. Johnson dated February 3, 1984, which is included in the middle of LILCO's exhibit P-29. I'd like to explain those differences, but before I do I think it is important to know while you are listening to the explanation of the differences, that they have no effect on the conclusions drawn from the FaAA report. My explanation of the answer will make it clear why they have no effect on the conclusions, namely that the AE pistons at Shoreham

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will not initiate or propagate cracks.

The differences that I am referring to are those that were noted by Donald Johnson during his inspection of the R5 pistons. The first one is in the fourth paragraph of the memo, and is as follows: "During the inspection I observed there was a layer of plating on the inside of the skirt and that the casting was very smooth, different from general production runs of cast material. The inside of the skirt was clean and all the flash was removed. The boss area was very smooth as if polished by Cratex and all the ground areas were very carefully polished with smooth radius in the boss."

Then the plating is explained in the following paragraph where it says, "There was evidence of plating on the inside below normal areas. The plating was very thin, approximately .0005 inch to .0001 inch."

I can comment on the measurement of the plating. It was done with the eddy current technique. One of the features of the eddy current technique is that the signal that is developed on the oscilloscope during testing is proportional to the lift-off of the eddy current probe from the cast

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iron surface being examined, and by calibrating the eddy current probe on known thicknesses of tin plating in the laboratory, we were able to use it to demonstrate that this plating which is between 1/15th and 1/3rd of the nominal plating on the piston probably resulted from some leakage current to the inside of the piston due to this not being a production piston but being a test piston at TDI.

The other more important area or the one that might seem more important is the polishing of the boss areas on the inside of the piston. Since this was a test piston at TDI, they used techniques which are standard in evaluating the design of a component. In development of components such as pistons, the manufacturer wants to be certain that he separates the effect of the various variables on the performance of a component, and in this case TDI was being careful to separate the effect of manufacturing from the effect of design of the component, and took normal precautions which would be taken during a test program to make sure that they were testing features of the design by being sure that the area in the boss area was smooth.

What FaAA has shown with its more detailed and more exhaustive design analysis is that

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the precautions that TDI took in their test actually were unnecessary. We have demonstrated that it is highly unlikely that any fatigue cracks would initiate in that area. We have also demonstrated that fatigue cracks will not propagate. We have been mentioning in these hearings that fatigue cracks up to -- excuse me -- that cracks or preexisting defects up to half an inch deep will not propagate. But I'd like to clarify that by saying -- I'd like to continue by referring to LILCO's Exhibit P-25, which is a plot of the stress intensity factor range versus hypothetical crack depth compared to the threshold stress intensity factor range.

By looking at this chart, it goes out to.5 inches, half an inch on the right, but even at that point the actual delta K working on the defect is well below the delta K threshold. It is just that half an inch was such a ridiculously large feature to presume being in these pistons that we stopped the analysis at that point.

If we had gone on, it might turn out the defects three quarters of an inch, an inch, maybe an inch and a half may be demonstrated by fracture mechanics to be nonpropagating in AE pistons.

Q. Are you through?

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DR. SWANGER: I would like to summarize, if I may, that it is because of the experience in the R5 engine at 2000 psi for enough cycles to demonstrate that it was operating below its endurance ratio for a condition which the AE pistons at Shoreham, I don't think, even could reach. That is the 2000 psi peak firing pressure, that we are extremely confident that the AE design as demonstrated by TDI's test and by FaAA analysis is very conservative.

Q. Now, Dr. Swanger, let's go back to your initial answers to my question which is about the differences between the AE piston and the R5 engine and that in the Shoreham EDG's as stated in Donald Johnson's memorandum. The first thing it notes there is that there was a layer of plating on the inside of the skirt.

Is there a layer of plating on the inside of the skirt of the AE pistons at Shoreham?

DR. SWANGER: In my own visual inspection of the AE pistons at Shoreham, I have seen some evidence of very minimal amounts of tin due to stray electroplating currents which will get inside the piston and deposit a little bit of tin in some areas. It is extremely innocuous and has no effect on the

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piston one way or the other.

DR. MC CARTHY Could we have a moment on this?

MR. DYNNER: Is the answer complete.

DR. SWANGER: I don't think I have anything to add to that.

Q. Do you mean to suggest, Dr. Swanger, that any tin plating that was found by FaAA, not just yourself, or LILCO, on the inside of the AE skirts at Shoreham was there inadvertently and unintentionally, or is it there by design?

DR. SWANGER: I have discussed the tin plating of pistons with design engineers from TDI, and I know that the tin plating is on the outside of the pistons by design, on the inside of the pistons inadvertently as a result of the electroplating process to put one and one half mil of tin on the outside of the piston to protect it during break-in and to protect the outside of the piston during storage.

Q. And the plating that was observed on the inside of the skirts in the two AE pistons from the R5 engine are the ones that were plated very thin as described in the penultimate paragraph in the first page of Dr. Donald Johnson's report, is that correct?

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DR. SWANGER: I apologize.

Q. The next to the last paragraph where it says the plating is very thin.

DR. SWANGER: I was going to ask you to define penultimate. Does that mean next to the last?

Q. I was getting even with you. You used a lot of words that I don't know.

JUDGE BRENNER: Why it doesn't mean fifth from to the last? I don't know. But it does mean fifth from to the last.

DR. SWANGER: Thank you, Judge Brenner. Could you rephrase the question for me. I lost the trend of thought.

Q. Is the plating that was observed on the inside of the AE skirts in the R5 engine the tin plating referred to in the last sentence of the next to the last paragraph in Donald Johnson's memorandum, which says, "The plating was very thin, approximately .0005 inch to.0001 inch"?

DR. SWANGER: I still didn't understand that question. I just heard, does the tin, and then you went on to describe it. I didn't detect it. Please help me.

Q. I will say it for the third time. Is the tin plating where it says there was a layer of

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plating on the inside of the skirt of the AE pistons in the R5 engines, is that layer of tin plating the plating which is described as being .0005 inch to .0001?

MR. FARLEY: I still object to the form of the question. He hasn't said whether by design or inadvertence, which is what we are talking about.

JUDGE BRENNER: He doesn't have to say that in the question.

DR. SWANGER: In the paragraph preceding the penultimate paragraph, there is the statement that, "I observed that there was a layer of plating on the inside of the skirt."

Then in the following paragraph he goes on to quantify that plating by saying, "The plating was very thin, approximately .0005 inch to .0001."

Both sentences refer to the same electroplating on the inside of the piston skirt.

Q. All right. Now, in the same next to the last paragraph, Mr. Johnson also says the plating inside and out. Do you know whether his description of the thickness of the plating also refers to the plating on the outside of the skirt?

DR. SWANGER: Donald Johnson reports directly to Dr. Duane Johnson and in addition to this memo has had conversations with his supervisor.

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I believe Dr. Johnson is better able to answer this specific question.

Q. Go ahead.

DR. JOHNSON: The measurement .0005 to .0001 was the measure obtained on the inside of the piston skirt.

Q. Dr. Johnson or anyone, did he take the measurements of the thickness of the tin plating the outside of the skirt as well?

DR. JOHNSON: He checked the plating measurements on the outside and they were equal to the standard which he had set up on, which was a piston containing -- excuse me, the nodular iron piston skirt with a normal plating on the outside, which, as I recall, was on the order of 1.5 mils, which is, in materials we have here, 0.0015.

Q. And is the tin plating on the outside of the AE skirts in the R5 engine the same thickness as the tin plating on the outside of the AE skirts in the Shoreham EDG's?

DR. SWANGER: The only data we have for skirts in the R5 engine are the two that we inspected. We don't know what they are in the rest of the R5 engine. But the two that we inspected were similar to the plating thicknesses on the AE

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skirts at Shoreham.

Q. When you say they are similar, what were the precise differences in the thickness of the tin plating of the AE skirts at Shoreham and the two AE skirts in the R5 engine?

DR. SWANGER: FaAA has made no measurement of thickness of the tin on the outside of the AE piston skirts at Shoreham. However, we have reviewed the engineering drawing for the AE skirt which specifies a thickness of tin on those skirts of.0015 inches. Our measurement of the tin thickness on the R5 AE pistons as discussed by Dr. Johnson showed that its thickness was nominal. That is, it was within the expected range based on calibration standard taken from a nodular iron piston which was made by TDI and passed all of the manufacturing and acceptance inspections that would have been given to it by the manufacturer and by LILCO, the customer.

This is significant to us because we think that the successful operation of the normally tin plated AE skirt in the R5 engine demonstrates that certainly there was no adverse effect of the tin plating on the outside of the skirt, and in fact it was probably a benefit of the tin plating the

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outside of the skirt even in an accelerated high load test in the R5 engine.

Further, we think that the test in the R5 demonstrated that the flash-over or inadvertent amount of tin which may be present on the inside certainly has no effect on the fatigue performance of those pistons because no indications were found in the critical high stress areas of those pistons. The memo we have been discussing, February 3, 1984, by Don Johnson, does in its last paragraph, discuss three eddy current indications --

MR. DYNNER: I move to strike everything he said after what he told me that the tin plating is the same after what is normally called for in the drawings. This witness is not being responsive to my question. He is giving speeches based upon what he thinks I will ask in the future.

JUDGE BRENNER: I will not go back and strike it. The comment is correct. He has the facts on the record. Let's leave it there for a couple of reasons, including efficiency. Let's get the answers more directly to the question and hold the rest of what you might want to say. I am going to become more aggressive in insisting that that's done now. I think we have given you fair leeway and

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it takes witnesses a while to adjust being in this, what I am sure, is an unusual situation for most people.

I have been a witness myself and it is stressful and unusual even when you are used to proceedings, than to certainly sit in a witness stand. Nevertheless, you have had a few days to acclimate yourself. The object is to answer the question and not just to fill in on all other things that you believe might be of interest within the same or related subject matter.

All right, Mr. Dynner.

Q. Dr. Pischinger, do you know what the purpose was of tin plating the inside of a skirt as in the R5 AE skirts?

DR. PISCHINGER: As was mentioned before, the tin plating on the inside of the skirt was unintentional. That means it was usually a stray of tin plating which is occurring to tin plates of the piston on the outside. That's what I heard.

Q. I am talking, Dr. Pischinger, about the tin plating, the layer of tin plating on the inside of the skirts in the R5 engine that are .0005 to .0001 in thickness. I believe what you are referring to is the inadvertent tin plating on the inside of the

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AE skirts at the Shoreham facility, the Shoreham engines.

DR. PISCHINGER: I can only suppose that tin plating on the R5, the AE pistons used on the R5 engine is also to a little higher degree unintentional.

Q. Does anyone on the panel know whether or not the tin plating layer on the inside of the piston skirts, of the two piston skirts in the R5 engine was intentional or unintentional?

DR. SWANGER: Yes. I have had a discussion with engineers from TDI and learned from them that the tin plating the inside of the AE skirts in the R5 engine was unintentional.

Q. Did you ask them how they could make that kind of unintentional tin plating in an engine, experimental prototype engine used for testing that particular component?

DR. SWANGER: No, I did not ask them that question.

Q. Thank you.

Dr. Pischinger, can you tell me what the effect would be, if any, of having this thin layer of tin plating on the inside of the AE piston skirt?

DR. PISCHINGER: None.

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Q. You also testified that on the R5 AE skirts that we are referring to, Mr. Johnson reported that the casting was very smooth, different from general production runs of cast material.

Was the smooth casting different from the casting on the AE pistons in the Shoreham EDG's?

DR. JOHNSON: Yes. The condition was smoother than the surfaces which we generally observed on the Shoreham pistons on the inside. Of course, that also made it easier to inspect.

Q. Would the smoothness result from a polishing of the boss area of the skirt? I will direct your attention, for your convenience, to the third from the last paragraph of Mr. Johnson's memorar. 'um.

MR. JOHNSON: It could have resulted from polishing, but we don't know that it was the result of polishing.

Q. Has anyone -- Dr. Swanger, when you testified previously, you said that TD was being very careful to be sure that the area and boss is smooth. How did you find that out?

Dr. Swanger, can I have your answer before you confer with your colleagues because I am asking you a question about your prior testimony.

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DR. SWANGER: My answer was based on my years as director of product development for Imperial Clevite, Incorporated, Engine Parts Division, and our standard procedures used in development of components. It is typical to use a smooth surface to test for the design of a component as opposed to its manufacture, and to make it easier to detect any indications which might develop on it.

Q. And the polishing and smoothing out of these boss areas and the ground areas would also eliminate or reduce any stress areas in those riser areas, wouldn't it, Dr. Pischinger?

DR. PISCHINGER: Could you please repeat the question.

Q. Yes. The polishing and grinding -- the polishing of the boss areas and the ground areas of the AE skirt would also reduce or eliminate stress risers in the skirt, isn't that so?

DR. PISCHINGER: I wouldn't put it that way. I want to point out that it is very often used and practiced in engine development and development of such parts that if you run such a piston prototype for stress evaluation, you try to get a clean, smooth surface so you are sure you have no crack initiation afterwards, and that it is easier

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to detect crack initiation.

DR. SWANGER: You asked about --

Q. The effect also is, Dr. Pischinger, an effect would also be that it would reduce or eliminate any potential stress risers in that area; isn't that true?

DR. PISCHINGER: It gives -- such a surface gives evidence of the property of the effect of crack initiation. You want to see if such a piston is prone to crack initiation. Usually in such a run it is not the intention to watch crack propagation of a prefabricated crack. It is to see crack initiation.

DR. SWANGER: I'd like to augment Professor Pischinger's answer.

MR. DYNNER: I'd like Dr. Pischinger to answer the question. I don't think he understood the question.

JUDGE BRENNER: Yes. I think he misunderstood the question.

Q. Let me try to explain once more the question. Dr. Pischinger, do you know what a stress riser is? Do you know what that term means in English?

DR. PISCHINGER: Maybe you think of any

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flaw which can develop into a higher crack, a larger crack.

Q. Or an area where the stress concentrations could cause a defect?

JUDGE BRENNER: I haven't heard the term stress riser. Maybe I don't know what it means in English either. In any event, that's not the question you are trying to get at. We don't have to start with overall definitions. I think what he is trying to ask you is whether the process of taking special care to polish the surface would leave the situation such that there would be no areas conducive to flaw or crack initiation. We understand in your answer that it also makes it easier to observe any later indications.

Mr. Dynner is asking you whether or not it would also remove any flaws, if you will, of an incipient nature, and it would be more conducive to the development of indications during test runs.

DR. PISCHINGER: I think it has to be broken down in two parts. If surface treatment or polishing is going to such an extent that you really change the shape of the region, then, of course, you influence the whole stress fatigue and the result of the experiments with such a piston would not be

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representative.

If you clean or smooth the surface, you, of course, will not have the effect of a casting flaw -- I hope this is the right expression. In this respect, of course, you remove, if you call it that way, a potential crack initiation, or if you call it that way, a stress riser. But I think there are two different questions to address. One is, will a crack initiate, which has not been there, and the smooth surface gives you better evidence of that.

The other question is, will a crack, a flaw, be the first step of a crack, propagate, and to this purpose, of course, you should not clean the surface.

DR. SWANGER: I think it would be helpful if I explain the concept of stress riser just a little bit.

JUDGE BRENNER: Just a little bit.

DR. SWANGER: Certainly there is a concept of a stress riser, that is a geometric deviation in the surface which causes the tensile stress or the applied stress at that area to increase. There is also the effect of the stress riser, whether or not it would potentially cause a crack or cause a crack to grow. That is directly

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what the fracture mechanics calculations of Dr. Harris have addressed.

What they have shown is that stress risers, even as deep or deeper than one half inch in the surface, will not propagate. Certainly by polishing the surface, we have not removed stress risers half an inch deep.

Q. It is true, isn't it, that the radius into the boss area of the AE skirt is the area of higher stress in the AE skirt?

DR. HARRIS: To a large extent, Mr. Dynner, your statement is correct. However, the geometry in the stud boss region of the AE piston skirt was quite complex. So it is difficult to put in the words where the maximum stress occurred. In the Failure Analysis Associates piston report which has been entered as County Exhibit 8 --

JUDGE BRENNER: Not yet, but it has been identified. I said that for counsel's benefit. There is some discussion that has to go on with counsel regarding some of these reports.

Go ahead. I'm sorry.

DR. HARRIS: As indicated in at least two places in the report that I just mentioned, there are pictures and photographs of models that indicate

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where the highest stresses occurred.

On page — on figure 3-3 of that report there is a photograph of the stud boss region of the AE piston skirt. This is the skirt to which stress coat was applied in order to identify the region of highest stress.

In this figure, if you look carefully, it is possible to see the small cracks running in the high stress region. There is a white circle on the figure that surrounds the region where the cracks were. So this, in a photo, shows the location of the maximum stress.

DR. MC CARTHY: I might add, these were cracks in the stress coat which is a brittle lacquer, not the metal itself.

DR. HARRIS: Then on figure 4-5, there is a photograph of the results in the finite element model in the stud boss region, and the different colors in this photograph depict different stress levels. The red, deep red stresses, the deep red areas in the photograph are the regions in which the stresses were the highest.

Q. Gentlemen, on page 57 of your testimony, you state that the R5 has operated successfully, and I underline "successfully" for over 622 hours at

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2000 psig. What do you mean by "successfully"?

DR. SWANGER: This statement refers to the fact that the two AE pistons in the R5 engine had operated successfully for the time at the pressure indicated, and by "successfully", we mean that there were no propagating cracks in that piston; that there was no adverse wear in this piston.

In fact from a friction wear and lubrication standpoint, it had operated very successfully. Also, further evidence of that is that in the inspection done by Don Johnson in LILCO's Exhibit 29, it refers to three small eddy current indications that were found.

Q. We are going to get to those. My question, and I am interrupting you because you are going beyond the question.

The question referred to your statement that the R5 is operating successfully, not that the AE piston skirts in the R5 were operating successfully. I asked you what did you mean by "successfully."

JUDGE BRENNER: I think he is answering that question, Mr. Dynner, as long as he is talking about the pistons operating in the R5 engine. Don't you think so?

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MR. DYNNER: My question, or the statement in the testimony is not that the --

JUDGE BRENNER: You asked him what he thought the statement?

MR. DYNNER: What he meant by "successfully".

JUDGE BRENNER: He is telling you. Let's not go overboard the other way, either.

DR. SWANGER: Continuing with my answer, what we meant was that the three eddy current indications that were found, which happened to be found in low stress areas of the piston, namely on the lip adjacent to the washer landing opposite from the highly stressed area in the stud boss had no evidence of having been propagating. They were similar in nature to the kinds of manufacturing induced indications that were removed from the AE pistons that Shoreham purchased from TDI.

Q. Dr. Swanger, you are referring, I take it, to the pages that are attached to Donald Johnson's memorandum, which is part of exhibit P-29, and referred to piston C-31 as far as the eddy current test is concerned, is that correct? My copy, for the convenience of the parties, are the two pages following Mr. Donald Johnson's memorandum.

JUDGE BRENNER: The February 3rd

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memorandum?

MR. FARLEY: Yes.

MR. DYNNER: That's correct.

JUDGE BRENNER: What's your question about that page which contains certain drawings?

MR. DYNNER: Are those the indications that he was referring to in his prior answer?

DR. SWANGER: Yes. The three indications I referred to are discussed in the attachments to the trip report of Donald Johnson dated February 3, 1984.

Q. If we look at the second page, which on the corner of my copy, it says Page 3 of 3, it shows some, I suppose you would call them simplified drawings of a piston skirt. There is a notation on number 2. It shows the line in the lower left hand corner and under that it says, one, it looks like D.

JUDGE BRENNER: 1DIV at 1.5, and to the right of that it says 25 percent. Will you explain what that line and what that notation means.

MR. JOHNSON: This page which you are referring to says Page 3 of 3, and these simplified drawings are, of course, two views of the same crack area. The comment that says -- and it is there to illustrate with the lines that you will see on 2, 4

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and 3, and they are to indicate where the indication was observed, and the comment 1 division at 25 percent, for example, is a notation recording the magnitude of the eddy current indication, and the percent is the percent of the standard signal that we use in this calibration.

Q. Could you tell me, Dr. Johnson -- and we are looking now at the number 2 drawing, labeled number 2. How can you tell what the size of that indication is?

DR. JOHNSON: The number indicates the size.

Q. Which number?

DR. JOHNSON: Either the 1 division had a certain position on the screen or the 25 percent, those two numbers that correspond.

Q. What does the 1.5 mean?

DR. JOHNSON: The eddy current test is done by observing an oscilloscope screen, and the 1.5 refers to -- it is an oscilloscope screen and a two dimensional display of the information. The 1.5 simply is saying where on that screen it is located. The 1 division is indicating the magnitude of the --

Q. What is the magnitude of this indication, if you could put it into inches or fraction of

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inches or in terms of length and depth?

DR. JOHNSON: Maybe it would be best to express it in terms of the standard we use and then the fact that this signal is a quarter of a signal we get. The standards that we use are such that -- the standard will give a signal not greater than a signal one obtains from a 1/16th inch long by 1/32nd inch deep crack-like defect in the material. This is one quarter of such a signal.

Q. A 1/32nd inch would be the length or the depth?

DR. JOHNSON: Depth.

Q. What would the length be?

DR. JOHNSON: 1/16th.

Q. One quarter that size? I can't tell from this drawing but what is the precise location of the crack-like indication on number 2?

DR. JOHNSON: Well, there are two views of that indication. So you have to look, also, at the second figure. It is on the same page but you have a circle and once again, the numbers 1, 2, 3, 4 repeated. We are looking at that figure and we are looking down, and in fact I can probably give you an example on the photographs if that will help.

Q. Before we get to the photographs -- that

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might be helpful if I could decipher mine which are Xerox copies. Perhaps you can describe it with words.

MR. JOHNSON: We are looking down in the figure which is right below the diesel engine piston. You will see number 2. That's looking down on the boss number 2. If we go to the number 2 which is in the upper left hand corner of Page 3 of 3, that's a blow-up or expanded view of that boss area. But now not looking down on it but at right angles.

Q. So this is a crack-like indication in the boss area of the piston?

DR. JOHNSON: A crack-like indication on the washer landing area adjacent to the washer landing area away from the high stress area noted earlier.

Q. I see. This is in an area which is not as high as the highest stress area identified in the report: is that correct?

DR. SWANGER: We can be quantitative about the location and the stress at that location by referring to County's Exhibit 8 and some of the photographs depicted in it. Looking first at photograph of figure 3-3, which is an actual photograph of the inside of an AE piston, we can see --

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Q. Excuse me, Dr. Swanger. Just for the record, we can identify that the County's Exhibit 8 is in fact the FaAA piston report.

JUDGE BRENNER: We have done that several times. So I think we have that. We will follow you and let you give your description in the record. We don't have the original photographs in front of us. That brings up two points I wanted to raise.

First of all, I would like for some of these exhibits, before they are put in -- we will have to back up on at least one, I think. Before they are put in, even if it is just marked for Identification, to get the original versions in and the three copies that are going to become part of the official record. It is clear to me already that regardless of how much of what will become County's Exhibit 8 will be in evidence or for Identification, it is going to be marked for Identification. These witnesses have referred to it numerous times already in the nature of identification, namely the photograph as well as some other things. So I'd like the County to, before we put it in, to get original copies in there for 8. If you don't have enough, we will direct LILCO to assist you in getting the three copies.

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8 is the example I have in mind. But think ahead and for any others that you are going to put in that have photographs, the witnesses may end up wanting to refer to, and do the same thing. Rebind the books so we have it done easily for the record and for the court reporter.

MR. DYNNER: We never got any copies of the original photographs.

JUDGE BRENNER: It is going to be taken care of now. You got copies. We have the reports along the way.

MR. DYNNER: We have the original photographs here that --

MS. TARLETZ: LILCO would be happy to cooperate with the County. I will renew LILCO's offer to provide the Board with the originals if you like.

JUDGE BRENNER: If you can do that now while we keep talking, I would appreciate it. Do you have a copy of the photograph now?

MR. DYNNER: I now have the photograph figure 3-3 that Dr. Swanger alluded to.

JUDGE BRENNER: In terms of backing up, I would like for LILCO exhibit P-29 to be replaced by a version that has the original photographs for

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purposes of the official record copy. If you could discuss it with the court reporter during the break, I'm sure he can figure it out, some logistical way to do it so it is easiest for the court reporter and note it on the record as to how it was done. It would be acceptable to me, since he has already got a bound version, if you can have just an additional exhibit along with that bound version also labeled P-29. There is no need to use a different number. I don't know if there are any other LILCO exhibits or exhibits that are likely to be referred to. But there are, it strikes me, the exhibits in the beginning, P-1, P-2, perhaps just those also should be similarly supplemented with the original photographs for the exhibit file.

In addition, the Board would like copies of the original photographs marked P-1 and P-2. You don't have to worry about -- and also P-29.

MS. TARLETZ: I believe the copy originally served on the panel did have originals of P-1 and P-2. We will supply another copy with P-29.

JUDGE BRENNER: You think our copy in the office has the originals?

MS. TARLETZ: Yes, and we will supplement originals for P-29.

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JUDGE BRENNER: All right. Don't worry about that. I will have that system well in order.

I'm sorry to digress. I had some concern about our ability and the ability of the official record to follow this through Xerox photographs.

DR. SWANGER: Referring to figure 3-3 of the piston report, the location of the indication, the lip adjacent to stud boss number 2 can be referenced to the center of the white circle in that photograph. The location is approximately 7/8ths of an inch to the right of the middle of the white circle, and approximately 3/8ths of an inch below the center of the white circle. It is essentially right at the bottom middle of the stack to have Belleville washers that's depicted in this photograph.

The Belleville washers were not there during actual eddy current inspection. So that the entire machine surface can be examined and such machining induced indications as this easily seen.

Also, I might point out that similar small machining induced indications were removed from the AE pistons supplied to LILCO before they left the TDI factory.

Dr. Harris then can refer to another photograph to discuss further the position of this

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indication.

Q. Excuse me. You stuck something in there that I hadn't asked, about machining induced indications. Did you conduct any failure analysis or studies in order to ascertain the cause of the crack-like indications that were found in the AE piston skirt from the R5 engine? Can I have your answer, Dr. Swanger.

JUDGE BRENNER: Why does that have to be just him?

MR. DYNNER: Because he just testified. He is the only one that talked about some kind of machining.

JUDGE BRENNER: I understand. You are asking now whether any testing or evaluation was done of the cause. Why can't you direct it to the entire panel?

MR. DYNNER: Presumably if he didn't know he wouldn't have said it is machining induced. I don't see anything wrong with getting this witness who just made that comment to give the answer. I don't want to argue about it.

JUDGE BRENNER: All right. You may answer.

DR. SWANGER: My knowledge is based on

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conversations with Dr. Duane Johnson, whether or not based on his experience he is able to recognize such conditions as machining induced. We did not conduct an independent failure analysis. It was not necessary to conduct such an independent failure analysis since no such indications were on the pistons supplied to LILCO.

DR. HARRIS: If I could proceed on.

JUDGE BRENNER: Let me interject. If you could remember, Dr. Harris. We will get right to you. I am confused on the views, and perhaps it is my problem only. I am looking at the drawings in P-29 that we have been discussing. I understand the overhead view but the enlarged views state that these are side views looking out from inside. Yet when I compare that to the photograph, it doesn't appear as if one would be looking from the side. Would you help me a little bit.

DR. SWANGER: What we mean by the inside looking out is if you were right here in the middle of the piston looking toward the outside of the piston, that is looking right in the same direction this photograph was taken. Then view number 2 shows that if indication is off to the left-hand side of the lip, and the way we have located it on figure 3,

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it is off to the left-hand side of the exact center of the lip if you were looking at exactly from the center of the piston.

JUDGE BRENNER: Thank you. That helps. Dr. Harris, please.

DR. MC CARTHY: In this picture, in our report, figure 3-3, sometimes you see people make ashtrays out of pistons where the head is down and the open bottom of the piston is up. It is exactly that same sort of view. You are standing in the center.

DR. HARRIS: Turning now briefly to the discussion of the stress load in the area of the machine induced indications --

Q. Before you do that, Dr. Harris, if I could just ask a clarifying question. In figure 3-3, the circled area there, is it specifically meant to refer to the crack-like indications in the R5 engine or is it meant to show where the lack of crack or something else is?

DR. SWANGER: Yes. The circle indicates the area where the stress coat cracked, and then I oriented the location of the indication on stud boss number 2 relative to the center of that circle. I indicated that the crack-like indication is at coordinates 7/8ths of an inch to the right of the

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center of the circle and 3/8ths of an inch below the center of the circle.

Q. But this photograph is not a photograph of the R5 AE skirt, is that correct?

DR. HARRIS: That's correct.

Q. Go ahead. I wanted to clarify that.

JUDGE MORRIS: While we are on that, gentlemen, can you tell me the approximate diameter of that white circle, what it represents?

DR. SWANGER: Do you mean to scale or what it would measure on this photograph?

JUDGE MORRIS: What it would represent in real life.

DR. MC CARTHY: Approximately a half inch. It is a half inch to 5/8.

JUDGE BRENNER: Dr. Harris, you may answer.

DR. HARRIS: Thank you, Judge Brenner.

Turning to figure 4-4 of the piston report, this figure provides a summary of the results of the finite element analysis on AE piston skirt, and the different colors in this finite element model depict different stress levels within the skirt. Backing up for a moment, I should point out that this model is a 1/4th of a complete piston.

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one quadrant of a complete piston. Due to the symmetrical nature of the piston and the symmetry of the loading, you can break the complete piston up into quarter segments and analyze just one quarter. From the results for that one quarter, you can determine where the stresses are in the pistons.

The various colors on this photograph provide information on the stress levels. You can see that the colors vary all the way from a fairly dark brown to a very light blue. The stresses are highest at the very dark brown position as indicated by the numbers to the right of the color scale on this photograph. You can see down close to the stud boss region but over where the stud boss meshes into the wall by the wrist pin that the stresses are quite high. This is where the dark brown colors are. That point corresponds to the point at which the stress coat crack that was shown in figure 3-3 that we discussed a moment ago appears.

Hopefully it is apparent where the hole is. There is a hole that goes down through the -- in this case the bottom of the skirt. That's the hole that the stud protrudes through. Then you can see a horizontal landing area around that hole which is the region in which the Belleville washer is

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seated upon. You then proceed around the lip of this horizontal surface and you can come around to approximately the point that Dr. Swanger indicated that the indication was, and you find that this corresponds to the very light blue. Looking over on to the color scale on the right-hand side of this figure, you can see that the very light blue is the lower stresses of any of the stresses depicted in that color scale.

This shows that that indication was located in a region of relatively very low stress.

Q. Is that true, Dr. Harris, with respect to the crack-like indications that are identified as numbers 3 and 4 as well as number 2?

DR. HARRIS: Yes, Mr. Dynner.

Q. Was this area as depicted before in figure 3-3 of the piston report, is this one of the areas that was highly polished in the R5 skirt?

DR. MC CARTHY: It is our understanding that the general area was polished up. We wouldn't use the term "highly polished ", but it was smooth.

Q. Did you conduct -- and by you I mean FaAA or anyone on the panel, if you know -- did you conduct a dye penetrant examination in eddy current test of the R5 AE skirt that we are talking about

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before it ran for 622 hours?

DR. JOHNSON: No, we didn't run any kind of test, non-destructive examination on these areas before they were run. Neither penetrant nor eddy current.

Q. If you didn't run an eddy current test before the run and if you know that area was highly polished, or polished, I am interested in the basis for your conclusion that these crack-like indications were the result of some machining error or operation rather than the possibility that they were the result of stress or operation of the AE skirt in the R5 engine.

DR. HARRIS: I would like to start out answering that question and quickly pass off to Dr. Johnson. The results of the stress analysis indicate that they were not meeting the crack initiation criteria in that very low stress region based on the stress analysis. We would not expect to see any cracks initiated in that region. They would be much more concentrated over where the high stresses are.

Dr. Johnson, I believe, has some other words he would like to add.

Q. You understand my question. I know you

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didn't expect to find it there. My question then is how you came to the conclusion that these crack-like indications were the result of some machining or manufacturing operation after they had been polished and not the result of the operation of the engine?

DR. MC CARTHY: I guess I would say I'm extremely confident that these indications were not the result of operation but fabrication because we have seen very similar indications in as-fabricated pistons. What you are looking at is a very thin edge that results from the way the stud boss is machined outboard, and it is not relevant in any way to the strength of the piston, and more important, it is not just that we don't expect cracks to grow in this area. This is, in fact, one of the lowest stressed areas in the whole piston. There is no conceived indication that that could conceivably grow.

Q. I understand you said two things there, Dr. McCarthy. You said you have seen similar indications in as-fabricated pistons. Which ones are you talking about?

DR. MC CARTHY: In the ones that were delivered to the Shoreham Power Station. When we inspected these at TDI, one could occasionally see very thin line machine-induced indications in the

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outboard area of the stud boss. Any such indications we removed required a minimal amount of touching up, and they were gone. They are just not in any conceivably related structural part of the engine. They are just an artifact of manufacture.

Q. How did you remove the indications in the edge fabricated pistons you saw at TDI?

DR. JOHNSON: Failure Analysis did not remove those. TDI removed them under the supervision of LILCO's QA representative, and they used a grinder, a surface grinder to remove the source of the indication prior to shipment.

Q. You just polished them out?

JUDGE BRENNER: Mr. Dynner, while they are conferring, after the answer, I think it is about time to take a break.

MR. YOUNGLING: TDI used a simple pencil grinder to grind the indications out.

Q. A pencil grinder? Do you want to please help me out with that?

MR. YOUNGLING: A small tip grinder to get down in the area.

Q. What was the nature of the abrasive material on the grinder, if it was abrasive?

MR. YOUNGLING: I don't know.

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JUDGE BRENNER: We will take a break at this point and come back at 11:10.

(Recess taken)

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JUDGE BRENNER: We're back on the record. I'm concerned about the time estimates. It is 11:15. We're going to break at noon for lunch and then come back at 1:30.

Are you ready at -- excessive side thrust yet?

MR. DYNNER: Almost.

JUDGE BRENNER: How long do you think it would take you to finish the excessive side thrust and tin plating which would be sub-parts B and C of Part 4 that you mentioned?

MR. DYNNER: If things go the way they've gone this morning the rest of the day, frankly, I don't want to criticize the witnesses, but as you know there have been enumerable conferences and lengthy periods of time where the answer is given to a question and I realize that the material that we're dealing with is complex and I don't want to criticize the witnesses, but it has taken a lot longer than I ever anticipated.

JUDGE BRENNER: Within reason. That's a fair comment; however, if we're going to be fair there are also times when you take some detail out of an answer either because somebody is handing you a note and you may think it's interesting at the

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moment or I think it's interesting at the moment, and it turns out to be a nonmaterial point that you've been off on it for 15 minutes when if you had more directly asked the question that you were trying to get to, we would have found out it was nonmaterial.

What I'm saying, Mr. Dynner, you have a better view or are in a better position to exercise a decision as to what's material to the issues before us in controversy as distinguished from a technical person's point of view of something that may be technically interesting or technically inconsistent but is going to really turn out to be a difference without a distinction.

And I don't think we're prepared to give you the rest of the day to complete your cross-examination.

My view of reading the cross plan and what you can more importantly get to is that you should be able to finish it in about two-and-a-half hours, so what we'll do is we'll -- I'm allowing about 15 minutes for you to work up to those two topics because you said you were almost there, so what I would say is we're going to direct you to complete your cross-examination of this panel by two

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hours after we return from lunch, which would give you a total of two-and-a-half hours, maybe a little more to get there sooner than 15 minutes. We'll re-evaluate the situation. If my present view turns out to be wrong based on the value on efficiency on your part of everything you've asked up until that point, but as of now, that's where we'll stop you so you have to assume that you'll be stopped then. And if there has been a problem with length of answers and so on in the time from now on, we'll take that into account, but as I said, right now we will assume that we will require you to complete the cross-examination of this panel by two hours after our return from lunch.

Why don't you proceed at this point.

BY MR. DYNNER:

Q. Gentlemen, did TDI do an eddy current examination or a liquid dye penetrant examination of the AE piston skirts in the R5 engine before they started their 622 hour run?

DR. SWANGER: We don't know whether they did or not.

Q. How many AE piston skirts were in the R5 V12 engine at the time that you selected the two AE skirts for examination?

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DR. SWANGER: The pistons were already out of the engine at the time they were made available for our analysis.

I believe that there were only two AE pistons in the R5 engines as part of a development experiment.

Q. Are you aware of an incident with the R5 engine in which a portion of the cylinder liner broke off and fell into the crank case?

MR. FARLEY: Objection. Irrelevant and immaterial.

JUDGE BRENNER: You're going to have to explain that objection to me, Mr. Farley.

MR. FARLEY: I don't think it's relevant to any of the contentions, Your Honor. Or to what's been discussed about the R5 engine.

JUDGE BRENNER: Wasn't it relevant to the contention that the FaAA analysis depends on an ideal situation which is not valid for the actual conditions which may be experienced by the Shoreham diesel?

MR. FARLEY: I think we've demonstrated that wasn't the case.

JUDGE BRENNER: I don't understand. I'm going to overrule the objection.

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I'll add that I believe it's apparently relevant, at least at this point, because your witnesses are relying on the experience with the R5 engine to justify the fact that the expected experience in the Shoreham engine will be acceptable and will not be inconsistent with the assumptions in the analyses leading to the predictions by your offices.

You have a question?

DR. SWANGER: If Mr. Dynner would repeat it, it would be helpful.

Q. Are you aware of an incident in which a portion of the cylinder liner in the R5 engine broke off and fell into the crank case?

DR. SWANGER: Yes, I have heard a little bit about that incident.

Q. Could you briefly describe -- retract that.

Did that incident involve in any way the AE pistons in the engine or liners which were in the cylinders that were using AE pistons?

DR. SWANGER: There were only two AE pistons of the type similar to those delivered to LILCO in the R5 engine, and neither of these AE pistons were involved in any incidents involving

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cylinder liners. Had they been, those pistons would have suffered extreme distress, would not have looked the way they did.

Q. Do you know what kind of piston was involved in that incident?

JUDGE BRENNER: Now, Mr. Dynner, you're going to have to tell me why it's material.

MR. DYNNER: It might have been an AE piston. He said it wasn't only the ones that he looked at.

JUDGE BRENNER: Maybe I can add one and one as well as other people, but he said there were two and he looked at the two.

Maybe I can't add.

MR. DYNNER: But at the time that they selected those two to be tested he said they were to his knowledge two.

I don't know whether it's an AE piston or AF piston or what but if he doesn't know, that may be significant.

JUDGE BRENNER: He said it was not an AE piston and anything further is going to be immaterial.

MR. DYNNER: I don't think he said it wasn't an AE piston, sir. I think his answer was

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that he doesn't think it was an AE piston because if it had -- the two AE pistons they examined had no damage and they would have had damage if they had been the ones involved.

JUDGE BRENNER: Dr. Swanger, were there ever any other AE pistons ever run in the R5 engine from which you removed pistons or from the engine in which the cylinder liner incident occurred beyond the two that you looked at?

DR. SWANGER: No. Those two pistons were the only AE pistons ever tested in the R5 development engine.

Q. Was any evidence of scuffing of the skirts or fretting of the AE piston skirts from the R5 engine noted by you?

DR. SWANGER: I believe your question referred just to AE pistons. Is there any specific AE pistons you're interested in?

MR DYNNER: Yes.

Q. Yes. I stated in the R5 engines.

DR. SWANGER: I have discussed this point with Donald Johnson who inspected the pistons and I have reviewed the photographs that Don Johnson took of those pistons, and I saw no evidence of scuffing or fretting on the AE pistons from the R5 engine.

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JUDGE BRENNER: Dr. Swanger, could you tell me what you mean by the term fretting on the piston?

DR. SWANGER: Fretting is the result of small amounts of relative motion between two metal surfaces which results in the transfer of metal from one metal surface to the other. It's recognizable by a roughened condition of the surface relative to its original appearance.

JUDGE BRENNER: Could you compare that to scuffing -- in my own mind I thought scuffing was a roughened condition of the metal.

DR. SWANGER: Scuffing is the result of large relative motions between two metal surfaces such as when a piston slides up and down 21 inches inside the cylinder.

Fretting would refer to motions on the order of a few thousandths of an inch relative to each other.

Q. Gentlemen, do you know whether DeLaval tested the AE piston before supplying it to customers in the field?

DR. SWANGER: DeLaval conducted at least two engine tests of the AE skirts. These were the tests of two AE skirts in the R5 engine and also the

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placement of AE piston in the engine at Kodiak Electric was a test of the engines conducted jointly between TDI and Kodiak for the purpose of evaluating the AE piston design.

Q. Is it your testimony that that testing was done by DeLaval before supplying the AE piston to customers in the field?

DR. SWANGER: As I had testified earlier, by supplying the pistons to Kodiak we do not consider supplying pistons to a customer in the field. TDI has a special relationship with the Kodiak Electric Association in which their engines are designated as lead engines for the purpose of gathering test experience for TDI.

Also, it is our information that the AE pistons were put into the R5 engine for test purposes about the same time that AE pistons went into the Kodiak engine and they had been successfully tested and removed from the R5 engine prior to the delivery of pistons to LILCO.

I believe Mr. Youngling can give you further information about delivery of AE piston to customers.

MR DYNNER: I don't want further information. I just want to know whether that's

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your answer.

JUDGE BRENNER: All right. He's answered the question. I'm beginning to worry about the materiality of this line if I let it go too far, unless it gets tied into something specific. We discussed that --

MR. DYNNER: I have a few questions to ask concerning their testimony regarding the importance of the testing of the operation of the AE piston skirt in the R5 engine and at DeLaval and their testimony regarding it at Kodiak.

JUDGE BRENNER: Well, I know. You've been asking questions about that, and you can go ahead. Maybe I'll ask you on your cross plan --

MR. DYNNER: Right now I just jumped outside of the cross plan for a minute to ask a few questions and I think the pertinence will be quickly obvious.

JUDGE BRENNER: It's too abstract to be helpful. I don't want to hear about overall testing that was done and what testing was first. Ask him about the -- tie it up to the particular point. For example, I don't know if you want to talk about side thrust load with that question or tin plating or Part A of Part 4 of the contention, so you're going to have to be more specific in your questions.

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Q. Does the testing that you alluded to give you confidence that the AE piston will last the lifetime -- or it will have unlimited life?

DR. SWANGER: Yes. The test experience with the pistons confirms our conclusion that cracks will not initiate or propagate. It also adds to our opinion that there is no problem associated with the friction wear or lubrication of these skirts and we feel very strongly that this is important evidence and confirmatory evidence that these pistons will fulfill their intended function at the Shoreham Nuclear Power Station.

DR. PISCHINGER: I think I could add to this question.

This AE piston is from the development of the previous AF pistons, modified AF piston, and from a diesel engine engineering man's point of view, this is a minor design modification which had been taken and the design modification is in the -- in all -- in each respect in improving or in strengthening of this piston skirt, and it is clear that in such a case, and it's general use and it's practice in the industry that you rely on the prior experience with the model from which you derived this piston.

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That means that you have to take into account the prior experience with the AF piston, and that very wide experience with several hundreds of pistons have been delivered and there's a lot of tens of thousands of hours that have been run with this AF which is the DeLaval AF pistons without, to my knowledge, as when I visited the DeLaval in February, without to my knowledge any unfavorable events which can be related to this AF piston.

The only reason why there was a design change was that there could -- cracks could be seen in the stud region, but these cracks didn't lead to any consequences to the engine.

It is in -- it is common use in the diesel engine industries that in such a case you take a further development step, but you rely on all the other experience. The outside of the piston remained completely the same, the ring portions, taking into account what has been investigated by FaAA and the pre-experience with the AF piston that there is additional evidence that this piston will last and do the required -- or fulfills the required functions.

Q. Well, based on that testimony, Dr. Pischinger, evidence of failures of AF pistons would

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be relevant to your analysis of the quality of the AE piston: isn't that true?

MR. FARLEY: Objection, your Honor. It doesn't necessarily follow.

JUDGE BRENNER: Well, let the witness explain why or why not.

DR. PISCHINGER: Let's say failures which couldn't have been addressed by this design change.

Q. Have you done an analysis of all the failures of the AF pistons in order to determine that they have been effectively solved by the change in the design, Dr. Pischinger?

DR. PISCHINGER: No. I only have knowledge that a number of engines have run for thousand, tens of thousands of hours without piston failure.

Of course, I am aware that this is only information which I got from -- at my visit at TDI, if this is reliable, yes.

Q. Dr. McCarthy, would you turn, please, to page 55 of your testimony for a moment.

I believe you alluded to this earlier in answer to one of my questions, and I'm referring to your answer 37, particularly at the bottom of page 55 continuing to page 56, to where you refer to the

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fact that, information contained in the Iron Castings Handbook by Walton and Aupar, 1981 page 341, Exhibit P-29 shows that the cyclic stress for cracking in ten million cycles is 93 percent of the cyclic stress for cracking in 1.35 million cycles, scatter of seven percent on stress is commonly observed in fatigue data. Therefore, it is likely that cracking indications would be observed in the population of inspected stud bosses if they had been operated for a 1.35 million cycles at stresses above the endurance limit.

Now, does that statement refer to the comment that you made earlier about steel, which you also said applied to nodular iron?

JUDGE BRENNER: Didn't you ask that yesterday and get the answer?

MR DYNNER: No, I didn't. He made a comment about it. I never asked a question about it.

JUDGE BRENNER: No, I mean, did you then follow up and ask him, make sure he was talking about steel, why that referred to this question?

MR. DYNNER: Sure. I want to make sure that this written testimony is what he was referring to yesterday.

JUDGE BRENNER: That's not what you asked,

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though.

MR. DYNNER: I think I did.

I'll rephrase the question.

JUDGE BRENNER: Why don't you just -- draw it up. I'm sorry, I may have lost your point. You asked him yesterday why, if he was talking about steel, we should be concerned with that and he said if he said steel he didn't mean to say it. He meant to talk about ferritic material in general and that his answer referred to metal.

Q. I just want to clarify, does this statement refer to steel?

JUDGE BRENNER: What statement, answer 87?

MR DYNNER: The one that I just read in quotation.

DR. MC CARTHY: The phenomena I described earlier discussing a stress level at which ferritic materials exhibited unlimited life is characteristic of both iron and steel. The specific numbers and referenced exhibit on page 55 -- by the way, it should be Exhibit 28, not Exhibit 29 is for the iron as reflected in the iron castings handbook.

Q. Do you know what the cycles, the millions of cycles approximately would be for steel?

1.35 million cycles for cast iron. What

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would be the approximate number of cycles for steel?

DR. MC CARTHY: The difference for all ferritic materials, the difference between the stress level for failure between one million and ten million cycles and infinite life is a few percent. In this particular case, it's seven percent for this iron. It would not be uncommon to see steels range from five to less than ten. It would depend on your exact material, but it's always a few percent.

Q. Then it's true, isn't it, that based upon this testimony, it would have been highly unlikely or unlikely for the crankshaft on diesel 102 to break; isn't that true?

DR. MC CARTHY: Perhaps I missed something in my previous answer. I don't remember discussing the probability; however, that's an excellent point. We ran three crankshafts, one broke, the other two cracked, and they were all within a few percent of their endurance limit. They had enough strength to get them into the one million to ten million cycles, but didn't have enough to get past ten million, and it wasn't that one crankshaft failed and the two came out looking cherries. On the contrary, the physical laws applying to crankshaft apply just as well to pistons.

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You found one failed crankshaft and when you pulled the other ones out you found crack indications on both of them.

Just a textbook example of how reliable this particular theory is.

Q. Yes. And you have confidence that would take care of that seven percent factor if you ran the AE pistons in the Shoreham engines for ten million cycles, wouldn't you?

DR. MC CARTHY: Once again, maybe I missed something. Not one but all three pistons having been run into this seven percent range -- excuse me, not one but all three crankshafts run into this very narrow seven percent boundary had cracks. Now, we have run 80 fillets, 40 piston bosses into this same range and we got indications on three of three crankshafts.

Now, one can do a probability calculation of what you -- what events would have had to transpire where three of three crankshafts showed cracks, indeed one failed and the other two had cracks and yet turn around and run 40 of 40 piston bosses without a single indication. Of course, the odds are vanishingly small and it's just confirmation that the piston as we've indicated

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before is not going to crack or propagate.

Q. Would you answer my question which was that if you ran the AE piston skirts in the Shoreham engines for ten million cycles, that would give you the confidence to take care of the seven percent differential in your test that's referred to in your testimony at the bottom of page 55 and the top of page 56?

DR. MC CARTHY: On the contrary because we ran so many, I have high confidence that there's nothing in the seven percent value that needs to be resolved.

If nothing else, the cranks have demonstrated that. They ran --

Q. I'm talking about piston skirts. Sorry. That possibly isn't --

JUDGE BRENNER: Let him finish his answer because you drew an analogy, and I think he's continuing with that thinking.

DR. MC CARTHY: The three cranks were run into exactly this range --

JUDGE BRENNER: Let's say crankshafts.

DR. PISCHINGER: Crankshafts.

DR. MC CARTHY: Yes. I'm sorry. You're correct. The three crankshafts were run into this

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range. They all showed crack- like indications. In fact, one failed.

Once again demonstrating that if you take a part that is above its endurance limit into this one million to ten million cycle range, you would expect to see some crack indications.

The crank -- once again -- the crankshafts demonstrated this phenomena.

Now, let's turn around, take what we've learned from crankshafts in these engines at Shoreham and apply it to pistons.

We now run 40 piston bosses, 80 stressed areas into exactly the same range and see not a single relevant indication.

Q. Do you know how many millions of cycles the crankshaft on an engine 102 was run before it broke, approximately?

DR. MC CARTHY: It's a few million -- it's a few million -- just one second.

Q. I think if it would help you, Dr. McCarthy, as I recall, and anyone in the panel can correct me, I think it was about 680 hours, as I recall. Mr. Seaman or Mr. Youngling will probably know the exact figure.

DR. SWANGER: The hours that are

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significant to the fatigue analysis are the hours at full load where it collects stress cycles at the maximum cyclic stress. EDG 102 had run about 250 hours at full load, so that is the relevant number.

Q. How much is each of the piston skirts run at full load at Shoreham?

JUDGE BRENNER: Maybe I'm wrong. I thought they were going to complete their answer and give you cycles.

Q. I'm sorry. I thought they had completed. Go ahead, please

JUDGE BRENNER: If you still want it.

DR. MC CARTHY: In answer to your question, 3.4 million cycles at full load.

Q. Thank you.

And how many hours has each of the -- or how many hours have been accumulated on the most utilized piston skirt at Shoreham at full load, if you know?

JUDGE BRENNER: On the AE piston skirts.

Q. The AE piston skirts, yes.

DR. MC CARTHY: On EDG 103, the most highly utilized AE piston skirt has gone 1.35 million cycles after which it was inspected. Additionally, and currently operated AE piston skirt

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in EDG 103, eight of them have gone 1.75 million cycles and are still running, but haven't had a subsequent inspection, but are still performing and service fine.

MR. DYNNER: Judge Brenner, I am ready to go on to excessive side thrust if you wish to break a little early for lunch and then we can go straight through if that's convenient for the Board.

JUDGE BRENNER: Let me ask one clarifying question.

Dr. McCarthy, you've referred to the fact that there are eight fillets involved, I guess, on each piston, if I've got it straight. Did you mean welds when you said fillets or did you mean something else?

DR. MC CARTHY: Did I say welds?

JUDGE BRENNER: No. You said fillets. What do you mean by fillets?

DR. MC CARTHY: I'm sorry. In the area where the stud boss blends into the wall of the piston, because of the geometry there, there are two areas that have been termed fillets. They're much less pronounced on the AE design than on the AF design where we started talking about fillets, and thus I've always been -- I've tried to be consistent

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in distinguishing boss areas and then fillet areas.

JUDGE BRENNER: That's fine. It took me a few days earlier in this case to know what a welder meant by fillets and now I know what you mean by fillets.

Let's break until 1:20.

(Whereupon, at 12:00 p.m., the hearing was recessed, to reconvene at 1:20 p.m., this same day.)

AFTERNOON SESSION

JUDGE BRENNER: Mr. Dynner, I guess you're going to pick up on page 14 of your cross plan, excessive side thrusts.

MR. DYNNER: That's correct.

CONTINUED CROSS-EXAMINATION

BY MR. DYNNER:

Q. Gentlemen, please turn to page 58 of your testimony.

Dr. Pischinger, in your answer to question 92 at the bottom of the page, you state that --

DR. PISCHINGER: Could you give me just a minute?

Q. Certainly. Page 58 of the LILCO direct testimony.

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DR. PISCHINGER: Yes.

Q. In your answer to question 92, you state that in current diesel engine design side thrust, the excessive side thrust related by the County is simply not a consideration.

What current diesel engine design were you referring to in that statement?

DR. PISCHINGER: Diesel engine designs at least back-dated to the mid-sixties.

Q. Would you specify the engines, the design of which you were referring to?

DR. PISCHINGER: I do not want to specify a certain engine to which this refers because I know in the state of the art that it refers to all engines.

Q. So is it your testimony that since 1966 no diesel engine design considers side thrust?

DR. PISCHINGER: Yes. Side thrust is no special concern. I can explain to you, if you want, why.

Q. Are you familiar with diesel engines manufactured by Sulzer?

DR. PISCHINGER: Yes.

Q. Is side thrust a consideration in the design of engines manufactured by Sulzer since 1966?

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DR. PISCHINGER: I have to add that as we are talking on four strokes, I only referred to four strokes.

Q. Four stroke engines?

DR. PISCHINGER: Four stroke engines.

Q. Are you --

JUDGE BRENNER: Are you trying to tell us that the Sulzer engines are not four stroke engines?

DR. PISCHINGER: They have both types.

Q. Is side thrust a consideration that the design of the four stroke Sulzer diesel engine?

DR. PISCHINGER: As is worked out in the testimony, side thrust is no concern as long as proper lubrication is provided by the design and that is the case with modern design of diesel engines, at least in the state when they are working with the customers.

Q. Is side thrust a consideration in the design of the four stroke Sulzer diesel engine?

DR. PISCHINGER: I am not aware if they have the proper lubrication system.

Q. Isn't Sulzer one of the largest diesel engine manufacturers in the world?

DR. PISCHINGER: It is one of the largest diesel engine manufacturers.

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Q. And do you consider Sulzer to be a manufacturer of high reputation and quality?

DR. PISCHINGER: Yes.

Q. Are you at all familiar with the rotating piston which is part of the design of the Sulzer engine?

DR. PISCHINGER: Yes.

Q. That rotating piston is a design element which is specifically directed towards avoiding the distortion of the piston skirt caused by side thrust; isn't it?

DR. PISCHINGER: No. The rotating piston is designed to distribute the wear of the piston skirt equally on the surroundings of the piston, so the rotating piston is a means to prolong the lifetime of a ship engine, to prolong the lifetime of a ship engine. You know, ship engines of the Sulzer design are expected to have the lifetimes of ships and lifetimes of ships are updating from 50,000 to 100,000 hours.

Of course, in such an application, the distribution of wear around the equal -- the equal distribution of wear around the piston is -- and each moving part is wearing and, of course, in this -- in this connection is wearing according to side

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pressure. This wear is quite normal. It's not dangerous in short running times, and to distribute this wear equally over the skirt, the piston is rotating.

DR. SWANGER: At this point, i would like to add --

MR. DYNNER: Excuse me, if I may. Yes. I'm asking these questions of Dr. Pischinger because he is the sole sponsor of that testimony and I'm about to follow up on this Sulzer engine.

JUDGE BRENNER: I'll let you follow-up but Dr. Swanger's response to 91 which is the start --

MR. DYNNER: Which talks about lubrication and I'm really talking about the diesel engine design issue which was raised by Dr. Pischinger in his answer to 92.

JUDGE BRENNER: I'll let you follow up and then get back to Dr. Swanger.

MR. DYNNER: I'm going to distribute and ask that there be marked for identification Suffolk County Diesel Exhibit 69.

JUDGE BRENNER: I'm sure you're going to use this one before I mark it.

MR. DYNNER: Yes. Which is an article from MOTOR SHIP TECHNICAL MAGAZINE entitled "Sulzer's

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Four Stroke High and Medium Speed Engine Range."

JUDGE BRENNER: What did you say this was from?

MR DYNNER: Article from the MOTOR SHIP as identified on the first page, and it's February 1978, and as seen on page 52, which is the first page with text on it, it is entitled, "Sulzer's Four Stroke High and Medium Speed Engine Range."

JUDGE BRENNER: And it runs through page 60?

MR DYNNER: And it runs through page 60, yes, sir.

JUDGE BRENNER: So this will be marked as Suffolk County Diesel Exhibit 69 for identification.

(The document referred to was marked Suffolk County Diesel Exhibit No. 69 for identification.)

Q. Dr. Pischinger, I'd like you to please turn to page 60 and in the left-hand paragraph near the left margin is the following statement.

"The pistons --

DR. PISCHINGER: I didn't find it.

Q. Yes. The last page in the left-hand margin. It states: "The pistons of larger engines are more prone to piston seizure because of the

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higher deformations involved.

The risk of seizure is aggravated by the customer's demand for low lubricating oil consumption -- and by the requirement to burn low quality heavy fuels.

It goes on to say: "In order to solve these problems and to satisfy the demands connected with high specific output and good reliability, the well-known rotating design piston was adopted for the Z40/48, figure 16 left, as well as for the larger 65/65 engine.

The advantage of such a design is that local overheating is avoided due to the rotary movement."

Now, Dr. Pischinger, does this article refresh your recollection concerning the independent purpose of the design of the rotating piston in the Sulzer engine?

DR. PISCHINGER: It's one point to be stated that engines of the same rating and performing equivalent functions are working with an unrotated piston, though this rotating piston is not in general a requirement.

In this case of an engine as is stated here which has to burn low quality heavy fuel, the

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well-known increased wear of this heavy fuel coming down the piston is, of course, a concern, and a rotating piston may help in this respect, but this is in no contradiction, when I say, and I remain with it, that side thrust -- side thrust is not addressed here. Side thrust is no concern in modern design diesel engines.

JUDGE BRENNER: Mr. Dynner, maybe I'm totally in the dark. I'll let you read the part and put the question that I assumed you were going to put to him and you didn't disappoint me.

How is anything in what you read inconsistent with what he said and more -- another way of saying that is, how is anything that you read from this exhibit remotely related to side thrust load?

MR DYNNER: I'll explain very succinctly.

As the County's direct testimony states: "Side thrust is a factor which causes the temperature on the piston skirt to be asymmetrical, so that part of the skirt is heated whereas the other side of the skirt is not heated as much."

As the side thrust continues and as the County's testimony states, "The increase temperature on one side of the skirt causes deformation of the

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skirt which can lead to piston seizure."

It is precisely that issue of side thrust as described in the County's direct testimony which in this article states is the -- an important purpose of the design of the rotating piston in the Sulzer engine. The article as appeared in the paragraph that I read also goes on to state: "The risk of seizure is aggravated by low lubricating oils, but the thrust of the article and statement and testimony goes to the fact that it is a modern current diesel engine design that is specifically addressed to the issue of side thrust.

JUDGE BRENNER: You've got to get a lot of links in there in order to get there, and what you just read here for identification which you're using for cross-examination doesn't supply many of those links. But as you said, we'll have the County witnesses and Dr. Pischinger's testimony in answer to your question.

DR. PISCHINGER: Judge Brenner, may I add something?

JUDGE BRENNER: Is it in answer to this question? I didn't really have a question of you. My question to Mr. Dynner was for a different purpose. But go ahead and add it.

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DR. PISCHINGER: Well, I stated that if proper lubrication is supplied, the side thrust is of no concern, and in this article just given to me, there is written, "With every stroke a fresh oil wetted part of the skirt is turned into load carrying zones substantially reducing the danger of seizure."

That means exactly that also here is one technology for using -- for solving this lubrication problem used, but this is not the only technology in light of the -- that can be seen from the fact that all other engines in the world do not have this rotating piston

JUDGE BRENNER: Incidentally, Mr. Dynner, is this some independent magazine or something published by the Sulzer Company?

MR DYNNER: Independent technical magazine and it is a technical article. The authors are noted as G. Luftgarten and R. Stoffel. The first gentleman according to the asterisk as as having development and design for four stroke engines and I believe that's for Sulzer. The other gentlemen is head of development test beds according to the double asterisk.

DR. PISCHINGER: I know the first

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gentleman and had a lot of discussion with him on this business of pistons. He's head of development of Sulzer.

MR. DYNNER: Thank you.

JUDGE BRENNER: Maybe it doesn't matter but the company got quite a plug from the cover of this magazine and it looks to be more like advertising literature rather than trade magazine.

MR. DYNNER: I don't believe that's a fair comment because I think it is a technical article written by the people that presumably best know the engine since it's the head of development design for the company as well as the head of development test beds, so I do think that the information in the article is not subject to attack that it's puffing or that it is written by the advertising department for Sulzer.

MR. FARLEY: Judge Brenner, LILCO has an entirely different position about this particular article.

JUDGE BRENNER: It's not in evidence.

MR. FARLEY: Not now. The extent to which Mr. Dynner has used it now was appropriate, to try to impeach the witness, which he was unable to do.

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JUDGE BRENNER: All right. Doctor Swanger, you wanted to jump in before. We'll get back to you now. Only if it's in answer to the question that was pending, and the question was whether side thrust load was a design concern for the Sulzer engines, and I thought Dr. Pischinger answered it.

Do you have something to add?

DR. SWANGER: No. My comment was not going to directly answer that. I was going to put this hundred thousand hours into the context at Shoreham and at the same time correct a misconception I may have given in my earlier testimony.

I testified that the engines at Shoreham would run for three thousand hours. That three thousand hours is the amount of operation expected after the plant goes on line.

I neglected to include in that that the pre-operational testing so that the total accumulated hours on the Shoreham engines over their entire life will be about 4,500 hours and the source of this is from the affidavit of John Kammeyer (phonetic) which has recently been filed.

MR. DYNNER: May I ask what the witness

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is testifying relative to? Because I don't understand what he's talking about.

JUDGE BRENNER: Well, in the first place he said he was correcting a misimpression that he might have given and I think he -- in terms of the number of hours that the diesels were run, and I guess he was concerned that comparing the number of hours of shipment engines as testified to by Dr. Pischinger would make the wrong comparison if we went back to Dr. Swanger's earlier testimony.

MR. DYNNER: That would be appropriate for redirect examination, I think.

JUDGE BRENNER: Well, it would be, but we also give witnesses flexibility to correct something when they may have made an error, which error may be leading to another question on it: As to the rest of what he had to say would have been more appropriate for direct.

DR. MC CARTHY: May I just add --

JUDGE BRENNER: No. Let's wait for another question.

Q. Dr. Pischinger, in connection with your answer to question 92, I'd like to ask you whether the side thrust load is an -- a critical parameter of the Mirrlees KV12 engine.

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DR. PISCHINGER: You mean in light of what has been said now, you mean if I know if the lubrication of the Mirrlees engine piston is done that way that, as usually, side thrust is no concern.

As far as I know, Mirrlees engine -- could you repeat the --

Q. The KV12 I was referring to.

There are thousands of engine abbreviations in the world, so if I remember right what the KV12 is, I think this engine is a good engine.

Q. It's a good engine?

DR. PISCHINGER: Yes.

Q. Who is Mirrlees, are they one of the largest diesel engine manufacturers?

DR. PISCHINGER: Mirrlees is a well-known English -- British diesel engine.

Q. Do they have a high -- good reputation for quality engines?

DR. PISCHINGER: Mirrlees has, to my knowledge I have not been detailing the Mirrlees engines, but to my knowledge Mirrlees has a good reputation.

JUDGE MORRIS: Excuse me, Mr. Dynner, Dr. Pischinger, do you know if this is a ship engine?

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DR. PISCHINGER: This is mainly a ship engine, yes.

Q. And it's also used extensively in stationary applications, isn't it, Dr. Pischinger. the Mirrlees diesel engine?

DR. PISCHINGER: Each ship engine could be used if adjusted to stationery application.

MR. DYNNER: I'd like to distribute and have marked for identification Suffolk County Diesel Exhibit 70.

MR. FARLEY: I'll object to that because I don't even think he's allowed -- established the foundation for even using it.

MR. DYNNER: You don't know what it is yet.

JUDGE BRENNER: Why don't we hold off on marking it if there is no foundation. Let's see what you're going to do with it for a little bit first, rather than just marking for identification. We can do that but I don't want to go through the process and find out some of these things go nowhere. Let's establish what it is and we'll be done with it.

You've asked your question about Mirrlees and he's answered it.

Q. Now, Dr. Pischinger, does Mirrlees

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consider the maximum thrust pressure on the piston to be a critical parameter?

DR. PISCHINGER: In that very moment when I look at this picture without reading anything, I would think this piston, which is not the very latest design, could have problems besides thrust.

JUDGE BRENNER: Wait a second. You're anticipating them. Let him take a question at a time. He hasn't asked you about the article yet. Although I hope he gets to the question quickly.

You asked him if he's acquainted with Mirrlees. He said yes and in fact in answering that he answered the question you should have asked him more specifically as to lubricating oil and so on. Now I assume by handing up this document you want to follow-up on his answer. So why don't you directly ask whatever it is you want to ask him.

MR. DYNNER: I have a question pending, Judge Brenner, if you want to reread the question.

JUDGE BRENNER: Unless it's my fault. I don't recall what the question is.

MR. DYNNER: I can repeat the question.

Q. Dr. Pischinger, does Mirrlees consider the maximum thrust pressure on the piston to be a critical parameter of their engine?

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DR. PISCHINGER: I am not in the thinking of -- or in the brains of the Mirrlees people of 1966 from which this article is stating.

So I cannot answer your question what the Mirrlees people considered at that time.

Q. All right. The County's exhibit, Diesel Exhibit 70, which I've requested to be marked for identification, is an article from the Institute of Marine Engineers, Transactions, January 1966, Volume 78, Number One, and beginning with the first text page, which is page 325, there is an article entitled: "The development of a highly rated medium speed diesel engine of 7,000 to 8,000 horsepower for marine propulsion."

JUDGE BRENNER: 9,000.

MR. DYNNER: Sorry?

JUDGE BRENNER: It's 9,000.

MR. DYNNER: I'm sorry. 7,000 to 9,000 horsepower for marine propulsion.

The authors were shown as J. A. Pope, who is identified as the research and technical director of Mirrlees National Limited and W. Lowe identified as the chief development engineer for Mirrlees National Limited.

MR. FARLEY: Judge Brenner, I will object --

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excuse me. I thought you were finished.

MR. DYNNER: I was about --

JUDGE BRENNER: He thought you were finished.

MR. DYNNER: I was about to ask a question on this exhibit.

JUDGE BRENNER: What is your objection?

MR. FARLEY: I'll wait until the question.

JUDGE BRENNER: You're going to ask him, I assume, whether he's familiar with the article or something like that. I let you slide with some of the niceties on the other one because we got some direct answers but from Dr. Pischinger's previous answer if he doesn't know anything about this article I'm not going to proceed very far with taking some excerpt out and asking him what he knows about it and so on, but maybe I'm misguessing as to where you're going with this.

He offered some comment as to the relevance of the fact that it's a 1966 article.

Q. Are you familiar with this article at all, Dr. Pischinger?

DR. PISCHINGER: No.

JUDGE BRENNER: Now. You can go a little bit if you have a particular point and you want to

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know if that refreshes his recollection as to some --

MR. DYNNER: I was about to ask those questions.

JUDGE BRENNER: Someone he knows in the industry, but --

MR. DYNNER: Yes.

Q. All right, Dr. Pischinger, if you look on page 327, in the left-hand column entitled reliability --

DR. PISCHINGER: I can see.

Q. -- there is a statement from the author's experience of continuous duty diesel engines, the critical parameters to be carefully watched are -- and then there's a table given, and on the left-hand column citing parameter, if one goes down, one finds in the one, two, three, fourth line from the bottom maximum thrust pressure on piston pounds per square inch.

As you see on the Mirrlees engines, those figures are 35.8 for the KV12 engine and then following are figures for 33.5, 34 and 34.8.

Does this information assist your recollection considering whether or not the side thrust pressure on a piston is a critical parameter?

DR. PISCHINGER: Yes. This helps a lot.

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and I am hopefully given the time to explain to you.

In the '50s, '40s, '50s and early '60s, it was usual to use an oil scrape ring down the piston skirt. This was partially traditional, partially due to the inferior oil scraper technology at this time, and partially was taken from two stroke piston, and this aggravates the lubrication, obviously, the lubrication of the piston skirt; and, therefore, manufacturers of modern engine design switched over beginning with -- let's say 1960 -- well, even a little earlier, to move up this piston ring to the upper part of the piston skirt so that the fuel has undisturbed access to the piston skirt.

And this, of course, improved a lot the lubrication which is the main important factor in the sliding of the piston on the thrust, on the anti-thrust side, and since that time I myself was involved in such developments. The lubrication of the piston skirt was so much improved that side thrust figures today are never given with engines, to my knowledge are never given.

But in addition, I can say just to say if you calculate side thrust, you can calculate for each of today's engines, if you calculate side

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thrust, you can find a lot of engines which have much more excessive, as you call it, side thrust as a TDI engine, for instance, the famous MANL 32, 36 which has 36 percent higher side thrust than the TDI R48 or the MWMD-50 which has 18 percent higher side thrust.

All these engines are in operation on ships for years and are at least as renowned as the Sulzer and today's Mirrlees engine.

Q. Dr. Pischinger, did you personally calculate -- did you personally calculate the side thrust pressure of the MANL 32-36 piston?

DR. PISCHINGER: Yes.

Q. And what was the figure that you arrived at in pounds per square inch for the side thrust for that piston?

DR. PISCHINGER: I unfortunately have here not an explicit figure, but you can arrive at it if you multiply the figure for the side thrust of the TDI engine, which is mentioned in your -- how do you call it, testimony or --

Q. Dr. Pischinger --

DR. PISCHINGER: By 1.36.

Q. Dr. Pischinger, do you have those calculations that you made to calculate the side

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thrust of the MAN engine with you?

DR. PISCHINGER: Part of it, but certainly I can make it available to you.

Q. When did you make those calculations, Dr. Pischinger, approximately?

DR. PISCHINGER: Was it two or three weeks ago? Just to address this. When I heard the side thrust was -- in advance of writing this opinion involved in this testimony.

Q. And did you also personally make the calculation as to the side thrust in the MWND-50 engine?

DR. PISCHINGER: Yes.

Q. And you did that about the same time?

DR. PISCHINGER: Yes.

Q. Do you have those calculations with you?

DR. PISCHINGER: Well, of course, I didn't -- I don't have it here. I have the results here, but it is also possible to make it available to you.

Q. Could you briefly tell me the MAN engine that we're speaking of, what is the approximate horsepower per cylinder of that engine?

DR. PISCHINGER: The horsepower per cylinder is -- of this engine is 370 kilowatts.

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You have to be aware in Europe we are even diesel engines rating in kilowatts.

Q. And what is the RPM speed of that engine?

DR. PISCHINGER: 750 RPM.

Maybe I should mention another MAN engine which is the L 52 which has about the same side thrust as the TDI engine. This is an engine with five 120 millimeter running at rpm's of 500 or also 514, the maximum rating, and the cylinder -- the power per cylinder is 885 kilowatts.

JUDGE BRENNER: Mr. Dynner, are you finished with the Institute of Marine Engineers testimony?

MR DYNNER: Yes, sir.

JUDGE BRENNER: Do you see any reason to mark it for identification given its limited use?

MR DYNNER: Yes. I would like it marked as Exhibit 70, if we may.

MR. FARLEY: LILCO objects, Your Honor.

JUDGE BRENNER: It's only going to be marked for identification.

MR. FARLEY: I don't think he even laid the proper foundation for it to be marked for identification in view of Dr. Pischinger's testimony.

JUDGE BRENNER: You really don't need

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much for foundation, in fact you need very little foundation to mark something for identification. The reason I held off was because of the experience of the other day. It was just a mechanical prerogative on my part. I didn't want to start marking things and clutter up the record with exhibits marked for identification if it wasn't going to be used at all. As it turned out it was used in a question. I don't know if it needs to be marked for identification given the fact that the questions and answers combined will give the record a picture of what was there but if he still wants to mark it for identification, I always bend to counsel's view and mark it for identification.

MR. FARLEY: I understand.

JUDGE BRENNER: You also get in same rank.

We'll mark that for identification as Suffolk County Diesel Exhibit 70 and it was previously described by Mr. Dynner, I believe.

In any event, it's the article entitled "The Development of a Highly Rated Medium Speed Diesel Engine of 7,000 to 9,000 Horsepower for Marine Propulsion," and it is taken from the Institute of Marine Engineers Transactions, January 1966, consists of pages from that publication 325 through

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347.

Since you were so insistant on marking it for identification, and also asking the question you asked about it, Mr. Dynner, maybe you would like to ask Dr. Pischinger one or two questions about the very part that you pointed him to and also talk about the dangers of excerpts from articles with which people are not familiar.

(The document referred to was marked Suffolk County Diesel Exhibit No. 70 for identification.)

BY JUDGE BRENNER:

Q. Dr. Pischinger, do you know whether this table from which you -- from which Mr. Dynner in his question directed you to the figures for maximum thrust pressure for, I believe the same engine, under different power operation in those four columns whether those figures are the actual values that you would derive from the engine while it was operating as opposed to parameters that were warned to assure that they were not exceeded, can you tell from that table?

DR. PISCHINGER: I'm not completely sure if I understand your question. You are referring to what table?

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JUDGE BRENNER: It's the ending publication involving the Mirrlees engine. It's the table that Mr. Dynner asked you about. And he directed you to the figures for maximum thrust pressure on the piston, pound per square inch.

DR. PISCHINGER: Yes.

JUDGE BRENNER: I guess my first question is whether it's -- let me change my first question, is it clear to you that that means side thrust pressure to determine maximum thrust pressure?

DR. PISCHINGER: Yes. You are right. This is here entitled maximum thrust pressure on piston pounds per square inch. There is, of course, a problem, always how you define and calculate such a figure.

I only at the moment can guess that that is the figure which is meant in the Suffolk County's testimony; but there is no completely general definition, because the real maximum pressure on the side of the piston can only be calculated if you know the oil distribution, the piston distortion, the oil viscosity, the piston movement, and I think at that time when this was written, nobody could, really could calculate this real maximum pressure

JUDGE BRENNER: All right. My question

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was a little simpler, can you even tell whether this is meant to be side thrust?

DR. PISCHINGER: I would have -- it would be necessary for me to study the whole article and maybe to make a request by the authors if they mean the same, which we are discussing.

JUDGE BRENNER: Beyond that, there are four columns here. Do you know whether these are measured values for whatever that table means by maximum thrust pressure on the piston as opposed to something else? For example, could it be a parameter that the authors are warning should not be exceeded at that operation as opposed to maximum as opposed to the actual measured parameter?

DR. PISCHINGER: These parameters -- again, I'd have to say, supposedly, are no limitations. Furthermore, they are certainly in the mind of the authors, I think, far below limitations; otherwise, they wouldn't have put it in a scale -- in a table of the engines whether these are critical parameters.

JUDGE BRENNER: Also, I guess it's kind of a follow-up to the question Judge Morris asked you about, whether the Mirrlees engines were ship engines and also Mr. Dynner's follow-up as to that.

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as to whether they were also used in stationary applications.

The last sentence of the text before that Table 1, and Mr. Dynner had asked you about reads as follows: "From the author's experience of continuous duty diesel engines, the critical parameters to be carefully watched are..."

If you see the term continuous duty diesel engines, what would that mean to you?

DR. PISCHINGER: Continuous duty engine is an engine which is supposed to be continuous on duty. That means that it's most of the lifetime in motion.

JUDGE BRENNER: Would a ship engine be a continuous duty diesel engine?

DR. PISCHINGER: Yes.

JUDGE BRENNER: I suppose from your answer that a stationery application planned to run most of the time could be so described as a --

DR. PISCHINGER: Yes. A power generator plant which continuously has to deliver electricity, of course, is a on continuous duty.

An emergency diesel engine certainly is not on continuous duty.

JUDGE BRENNER: Okay. I guess the point

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of my concern, Mr. Dynner, we have no lack of paper or witnesses before us in this case. And it gets difficult, I didn't want to -- I did want to give you some freedom to conduct the cross-examination the way you see fit but it gets difficult when you have an article, certainly more than two or three pages in there that the witness is not familiar with and then to try to get some useful information based on that article, it's true it's only marked for identification and we're not going to rely on this for anything, but the time has pretty much been wasted with it, I believe, in terms of tying it up, the materiality of the point that you -- that the County just could make with respect to side thrust. Certainly at a minimum, something like this should have been emphasized in reference for support in the County testimony, if you believe that it was an important contradiction of the view of LILCO and its witnesses that excessive side thrust load was of no concern, but let's proceed.

MR. DYNNER: I would just like to ask one follow-up to your list of questions on this document.

Dr. Pischinger, in your experience, if you could briefly take a moment and look down the list of what are termed critical parameters, in

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Table 1, could you tell me whether the -- whether those critical parameters would be, in your judgment, be equally applicable to the operation of the diesel engine in a nuclear power plant as they would be for diesel engines that are continuous duty engines?

DR. PISCHINGER: I have to reread it.

MR. DYNNER: Yes. Please take your time and, also, if there's some of them that you don't feel are or some aren't, maybe you can quickly identify them. I don't want to take too long on this but given Judge Brenner's questions may be a significant one.

JUDGE BRENNER: I don't understand the significance at all. Tell me again what you're asking to do.

MR. DYNNER: Yes.

JUDGE BRENNER: I don't want to take time either --

MR. DYNNER: Okay. You asked the question about emphasizing, I think, in your question the fact that the author in his introductory statements said these were critical parameters for continuous duty diesel engines and I want to see if he agrees or disagrees they're also critical parameters for nuclear engines which are

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operating in nuclear power plants to provide on-site electrical power.

JUDGE BRENNER: You mean the actual numbers?

MR DYNNER: The parameters, that is the identification of the parameters in the far left column.

DR. MC CARTHY: Excuse me --

JUDGE BRENNER: I understand your question. That's not going to be significant in terms of my point. I'll be pleased to tell you the conclusion I've reached right now on this minor point and that is that nothing you've asked Dr. Pischinger from the Suffolk County Exhibit 70 for identification to the extent we're able to get anything intelligent out of it, given the lack of knowledge of most of us as to what's in the article including the witness of whom you were inquiring, that Dr. Pischinger's earlier answers to you with respect to the Sulzer engine in terms of -- that you might want to worry about side thrust load, if you wanted to design an engine that would be good for ship-type applications. It's not inconsistent with the kind of applications that apparently these authors have in mind. And I emphasize it apparently

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because I certainly haven't read the article, but that one sentence there, introducing that table, and the only reason I looked at that table is because you asked all of us to do so, is discussing continuous duty parameters so I didn't mean to imply that you don't have parameters in a diesel engine, but that you look at for all applications.

DR. PISCHINGER: Judge Brenner --

JUDGE BRENNER: If you still want an answer to the question, we'll try it, but I don't want to --

MR. DYNNER: As long as the record shows what you just clarified, I don't need to spend -- have Dr. Pischinger spend his time going through either one of these.

DR. MC CARTHY: Excuse me --

DR. PISCHINGER: Judge Brenner --

JUDGE BRENNER: Wait a second. With all of this we haven't moved one whatever measurement you want to use, mil, angstrom closer towards getting to the merits of whether we should agree with the County or disagree with LILCO with respect to possible concern for excessive side thrust load. That's what I'd like to get some cross-examination on.

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MR. DYNNER: Okay. I'm moving on it.

DR. PISCHINGER: Judge Brenner, may I just, it's important for clarification, because I now, while reading a little more in detail, I see we all have been misled and I think it should be said, because critical parameters are not in Table 1. But the critical parameters which are to be watched at the side thrust is not on it as the parameters one to seven on the next column. The text is going on there, and in Table 1 are only the design and performance characteristics, so this comes from quick reading.

JUDGE BRENNER: Okay. I can understand -- let me try to give you a quick lesson. I can understand why you were anxious to jump in and try to assure that we were not misled by that.

I was not going to be misled, and the reason I was not going to be misled is in my words to Mr. Dynner I intended to let him know and maybe I was too subtle that we're not -- I, at least, as one judge am not going to rely on this article for anything, given the state of direct examination hereof because of lack of familiarity and because of lack of connection to get directly to the merits of the issue. I'm sure there will be a whole bunch of

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these articles I could misunderstand if I sat back at this hearing and read it but it is not admitted into evidence and one of the important reasons why it's not admitted into evidence is we don't have evidenciary foundation, as your counsel has been quick to point out and properly so, at least with respect to this article.

DR. PISCHINGER: Thank you, Judge.

JUDGE BRENNER: When something is marked for identification, it doesn't mean it's in evidence. Mr. Dynner.

Q. Yes. Dr. Pischinger, in your judgment, does the AE piston skirt have proper lubrication incorporated in its design?

DR. PISCHINGER: Yes. In my opinion, in consideration of the design, and although the -- watching the results of performance, I conclude that the lubrication of the piston skirt of the R45 is in order.

Also, as can be seen from the drawing, the piston rings lubrication, piston rings oil scrape rings are up on this skirt and not one down, as has been in old designs.

Q. Is there a different number --

JUDGE BRENNER: I'm sorry. I didn't hear

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you at the end. You said and not down on the skirt --

DR. PISCHINGER: Not down on the skirt as in old designs.

Q. Is there a difference, Dr. Pischinger, in the number of oil leak holes in the design of the AE piston as opposed to the design of the AF piston?

DR. PISCHINGER: I didn't count the leak holes. I just saw that the cross section is sufficient to give enough back flow to the oil, but I do not have the figure with me now.

Q. Dr. Pischinger, you earlier referred to two engines. The MAN and the MWN engine that you said that you had calculated the side thrust on.

Before I forget, I just wanted to ask you two quick questions on the MWN engine.

What is the horsepower per cylinder of that engine?

DR. PISCHINGER: Maximum horsepower, 370 kilowatt.

Q. That's the same as the MAN?

DR. PISCHINGER: It's practically the same.

Q. And what is the speed in rpm's of that nature?

DR. PISCHINGER: Ranging from 600 to for

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special application, 750.

Q. Thank you.

Now, Dr. Pischinger, you testified, I think, that the MANL 32-36 engine had side thrust load 36 percent higher than that calculated for the DeLaval AE piston skirt.

Did you make an independent calculation of the side thrust of the AE piston skirt?

DR. PISCHINGER: Yes.

Q. And did your calculation agree with the calculation made by Professor Christiansen, which is set forth in the County's direct testimony?

JUDGE BRENNER: Can you point the doctor to the page reference, if you can.

Also this is the record of Dr. Pischinger.

MR. DYNNER: That would be Suffolk County Diesel Exhibit 18.

DR. PISCHINGER: Maybe you could help me a little, where in this text side thrusts final result is defined, to speed up the situation?

MR DYNNER: Yes. If you turn to the last page in Exhibit 18, you'll see a computer readout, be on the far left, the first grouping of figures under the column one, you'll see the figure 123.44.

DR. PISCHINGER: I am still on the --

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seeking -- well, I, again, have to ask, what is the unit of this -- of these figures?

MR DYNNER: It's explained on page 48 to 49 of the County's direct testimony, Dr. Pischinger.

It is 123 pounds per square inch.

JUDGE MORRIS: Excuse me, Mr. Dynner, I wasn't sure what your question was, whether he agreed with the result or whether he agreed with the methodology or perhaps both.

Q. My question was, did he agree with the results of the calculation of Professor Christianson on the side thrust.

If you look on page 49 of the Suffolk County testimony, it says the calculated mean units side thrust of the AE Piston is 123 psi, exceeded the upper value by 44 percent.

There's a reference on the previous Page 2 to Exhibit 18. Exhibit 18 contains the calculation. The last page of Exhibit 18 shows in the last column, that is, in the first paragraph of numbers, in the first column, number one, you go down to the last number. It says 123.44 unit thrust -- unital thrust, so that's his conclusion.

DR. PISCHINGER: I -- yes. I have to say that my calculation gives a lower side thrust than

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this which is given in the -- in your reference.

The calculated side thrust with TDI is 78.7 psi. The calculation is done by computer program using the gas pressure, using the gas pressure and the mass forces in the point of maximum side thrust. The mass forces counteract the gas forces, and the maximum value which is calculated as 78.7 psi, which means I calculated it in bar, of course, 5.42 bars, which is, by the way, less than the limit of 85 psi which you give in your testimony as a standard design value.

Q. Yes. So your figure of 78.7 is the maximum unital side thrust; is that correct?

DR. PISCHINGER: Yes, yes.

Q. So the numbers that you gave for the MAN engine is 36 percent higher. Was that 36 percent higher than your number of 78.7?

DR. PISCHINGER: Yes, it is, yes.

Q. And it's not 36 percent higher than Professor Christiansen's number of 123 psi; isn't that true?

DR. PISCHINGER: Yes.

Q. And the same is true with the number you gave for the MWN engine, that would be 18 percent higher than your calculated side thrust of 78.7; is

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that correct?

DR. PISCHINGER: Yes.

MR DYNNER: I would like in view of this testimony, if possible, to get a copy of your calculations which show this difference of opinion with Professor Christiansen's calculations, if that's possible.

If you could state the methodology of it.

JUDGE BRENNER: Why don't you ask him how he did it. He's here to give testimony.

BY MR. DYNNER:

Q. What methodology did you use in calculating the maximum side thrust on the AE piston?

DR. PISCHINGER: The method is to use the gas pressure diagram versus crank angle to calculate the mass forces out of the acc leration of the piston to combine these two forces, and then to calculate the side thrust force for each crank angle or certain distances of crank angles which can be done geometrically by the angle of the connecting rod for each position, and to use this force to calculate a pressure and a nominal pressure which is related to the projected area of the piston skirt, the dimensions of the piston skirt are known and by the side thrust. It's a unital pressure that can be

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calculated.

Q. Dr. Pischinger, in looking at Professor Christiansen's calculations in Exhibit 18, if you could take -- I think it might be worthwhile in this case, if you could take a minute or two and perhaps tell me whether you have, in your calculations, any significant disagreement with the figures that Professor Christiansen sets forth in his calculations.

Dr. Harris, did you want to add something?

DR. HARRIS: If I'm permitted, I'd like to confer with my fellow panel member.

JUDGE BRENNER: Let me see if I understand what you want to do, Mr. Dynner. In effect you want them to critique with the proposed County Exhibit 18 which are the calculations by you to see if they agree or, more to the point, where they might disagree with figures used and the methodology.

MR. DYNNER: I wouldn't say critique was the word. What I was looking for was to see whether there was any -- since these are not -- whether there was any obvious or significant error or difference in the figures which would result in such a significant difference in the result. I don't

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know how long it will take. If it will take too long, we obviously can't sit here and use up hearing time to do it but if there's something that jumped out at him that could account for the difference in result, I'd like that to be identified.

JUDGE BRENNER: We can try that, if there's nothing that jumps out at them, we could let you come back to just that one point and then take a break to give them time to look at it although I don't know if a break is sufficient time to do that.

How much time would you need? I don't know if they're prepared for something like this already or not.

Dr. Pischinger, if you -- or in conjunction with the people on the panel, if you go through these calculations and the County Exhibit 18 the point is if we give you a little of time you can tell us if you disagree with what was done. We know you disagree with the result but whether you can identify why you do.

DR. PISCHINGER: Yes. Of course, I can try to follow up. I didn't do it until now, to follow up the way which this was done and -- but I cannot say how long it was. It's a question how obvious. There must be a disagreement how obvious

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it is and how long it takes to find.

JUDGE BRENNER: All right. Let's pass it for now and come back to the -- and we'll come back to that.

Q. Dr. Pischinger, we'll move on to something else and then perhaps during the break you'll be able to examine that.

BY MR. DYNNER:

Q. Dr. Pischinger, in your judgment, would proper lubrication be capable of handling any side thrust load regardless of its magnitude?

DR. PISCHINGER: If this question is a general engineering question, I say no.

If this question is related to standard design, diesel engines, I say yes.

Q. Well, if the side thrust in the AE piston turned out to be a 123 psi instead of 78 psi, in your judgment would the lubrication in the AE piston skirt be adequate to eliminate any possible adverse results from that side thrust load of 123 psi?

A. No.

DR. PISCHINGER: No concern absolutely.

JUDGE BRENNER: I guess someone will remember to ask Professor Christiansen the same question about Dr. Pischinger's figure, just in case

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we can't put the two together later. I will if nobody else does which is why I like to try a subject together with all party witnesses but we can't always do what we'd like to do in this life. Go ahead.

Q. Dr. Pischinger, if you will please turn to — if you're not already there, to page 59, in your question, answer to question 93, if, in fact, a temperature distorted the piston skirt so that it rubbed on the liner, wouldn't the friction of the skirt rubbing on the liner destroy the lubrication at that point?

DR. PISCHINGER: The piston in this operation cannot distort to such an amount, so I find your question theoretical.

Q. All right. Well, let me be more precise.

The first sentence of your answer is that with an adequately lubricated piston, side thrust will not create a dramatic temperature differential.

Isn't it true that given enough side thrust pressure there will be a significant temperature differential from one portion of the skirt to another?

DR. PISCHINGER: The friction work of a piston is so low, so small compared with all the

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other thermal effects that there will be no increased temperature. This has been measured in numerous pistons -- piston designs -- also, of similar size, and; therefore, again, I cannot see where this distortion should come from if the temperature distribution is quite uniform.

Q. All right. I'm trying to get at the point, Dr. Pischinger, in your answer where you say that an adequately lubricated piston side thrust will not create a dramatic temperature differential.

Is that statement true even if the side thrust is 400 pounds per square inch?

JUDGE BRENNER: Let me interrupt, Dr. Pischinger.

Mr. Dynner, within reason, it's your time, but you may have exceeded reason with that question.

How is that ever going to be material, even taking the highest number believed to be accurate by your witness? We're not talking about side thrust --

MR. DYNNER: Obviously what we're trying to get to is there is a relationship between side thrust and the effects of side thrust which are not always handled by adequate lubrication, and I think that the witness testified -- I asked him the

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question specifically as to generally, now I'm giving an illustration.

JUDGE BRENNER: It's just never going to be material in my view. The right question to ask him in that area you already asked, what if the pressures turn out out to be as high as Professor Christiansen believes, and you asked him that question. You got the answer. And then you asked the general question and he gave you the answer as to why he thought that was theoretical or words to that effect. And it's just not going to be --

MR. DYNNER: It's two entirely different answers. If his answer to the theoretical question is one which indicates that he does not have a grasp of the technical underpinnings of how side thrust affects it, then I think that that is a significant issue to bring out in cross-examination.

If he's saying -- even if you had a thousand pounds of side thrust, it still wouldn't affect the temperature of this skirt, that might be something this Board would be interested in. I don't know. Why would I be interested in it?

MR DYNNER: I think it would be --

JUDGE BRENNER: Are you going to put in evidence that the side thrust at the Shoreham

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pistons is a thousand pounds per square inch?

MR DYNNER: No.

JUDGE BRENNER: So why would I be interested in it? I want to be interested in things that are interesting.

MR. DYNNER: All right. We have testimony on the record which states that there is a relationship and that the side thrust at a certain point will create a temperature differential which will create the distortion, which will create the rubbing on the side which will create a destruction of lubrication which will lead to piston seizure. That's on the record and if Professor Pischinger is testifying that isn't the case at all from a technical and scientific matter that it can happen. I believe that's useful testimony on cross-examination.

We have other expert witnesses on the Staff and others that -- and I should think that the Board might be interested in whether everybody disagrees with that approach.

But I will move on if the Board doesn't think that's a pertinent question.

JUDGE BRENNER: I think you're way out there in terms of anything that's going to be

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important to the findings.

I understand how part of your argument would relate to a view of Dr. Pischinger's expertise, although I thought we were past that on Monday. Nevertheless, certainly the content of the substantive questions and answers can in turn be related back to some of the prerequisites for believing testimony by his expertise and so on, but -- and then I understand, like a good lawyer, you've made an argument that shows there is some arguable relevance. I'll give you that much.

The scale of what's relevant, way off in the distance of the solar system of relevance, well, you understand the difference in degrees between things that are remotely relevant and when you're on a time limit, a time limit I thought was reasonable if you had stayed with that which I thought was important and productive.

MR. DYNNER: I'll move on.

JUDGE BRENNER: Give me just one moment.

Q. I've made my point.

Judge Morris on his own saw that you were going to make the argument you made. He doesn't disagree with my comment as to its importance to the record, but it's your privilege to put it in the

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record if you want to, and I'll let you proceed with it and then we will change our mind when we look at it later.

Q. All right, Dr. Pischinger, taking your statement, the first line of your answer to question 93, would it make any difference to your conclusion if the side thrust were 400 psi or a thousand psi?

DR. PISCHINGER: In an internal combustion engine, the side thrust cannot exceed a certain percentage of the gas pressure, and, therefore, there are natural limitations to side thrust, so, again, I have to say this question is totally hypothetical.

If you want to build an engine which with ever increasing side thrust, then this engine could not run because of too short connecting rod or the piston would be no longer a piston but a disc. Within the design, within today's design limitations of a diesel engine, I am well aware of it, the side load, the side thrust which is within this limitation will not create any dramatic effect given proper lubrication, but maybe I could make you available some of my -- I shouldn't say that.

DR. SWANGER: As a co-sponsor to answer number 93, I do have some things that I would like

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to add --

JUDGE BRENNER: Even as a co-sponsor you still have to direct your comments to answer the question.

DR. SWANGER: Yes. Question was would -- as I recall, and Mr. Dynner can correct me, if the side thrust were 400 or a thousand psi, would that make a difference in the analysis.

MR DYNNER: In the first sentence of your answer, Dr. Swanger, that with an adequately lubricated piston side thrust will not create a dramatic temperature differential.

DR. SWANGER: Following up the answer that Professor Pischinger gave that there are natural limits to the side thrust, taking into account the geometry of the components in the TDI engine, the natural limit is that the side thrust cannot exceed 22 percent of the gas pressure.

22 percent of the maximum gas pressure of one thousand -- of one 1670 psi times the 227 square inches of piston.

DR. MC CARTHY: Which parenthetically don't occur at the same time, so they would be indeed the extreme end and completely unobtainable in conjunction with the real engine.

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DR. SWANGER: When we do that, we get a net — an upper limit of side thrust in pounds of 81 thousand pounds of force, which is about four times the number that Professor Christiansen computed.

FaAA did do independent computations of the side thrust taking into account the gas pressure, and we agree with Professor Christiansen that the true maximum side thrust total in pounds in the TDI engine is about 22 thousand pounds.

Dividing that number by just the projected area of the skirt, which is 17 inches in diameter, times 18 and a half inches in height or 314.5 square inches, dividing that number into 22 thousand pounds gives us a unit side thrust of 71 pounds per square inch.

Our number agrees very closely with Professor Pischinger's number, and since it uses a side thrust total load at the same magnitude that Professor Christiansen used, we feel that the error in Professor Christiansen's calculations must have been in the calculation of the projected area of the skirt or the use of that area in his further computation?

JUDGE BRENNER: You can look at that some more during the break.

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MR. DYNNER: Gentlemen, earlier we talked about the -- a bit about FaAA's current work on the circumferential rib as it relates to side thrust, and I recall that we had decided that the appropriate time to ask you without that would be during the discussion of the excessive side thrust.

Would you briefly describe the work that you're doing on the circumferential rib of the AE piston at FaAA as it relates to side thrust issues.

DR. HARRIS: In recent effort -- in recent days, Failure Analysis Associates has been involved in some additional experimentation regarding the strain levels in the ribs of AE skirts. This was done under top dead center loading.

We've also done some finite element calculations, stress in the ribs in the AE skirt under side loading.

We have found that the stresses in the circumferential rib between the wrist pin boss in the AE skirt are lower when a maximum side load of 22,500 pounds is applied than the corresponding stresses at top dead center when the full pressure loading is applied. This leads to the conclusion the maximum stresses that are -- that the AE circumferential rib is subjected to and controlled

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by the peak firing pressures rather than any side thrust and is further evidence of the lack of influence of side thrust on cyclic stresses in the AE skirt.

We're now convinced that this is also a conclusion that can be applied to the ribs themselves.

Additionally, some recent inspections have been performed on the circumferential rib, the AF skirts that were removed from the diesel engines at Shoreham. As far as I can recall, I have been informed that there were no relevant indications in the region of any of the AF skirts that were inspected at Shoreham.

JUDGE BRENNER: Excuse me, there was a term that I didn't understand. You said this was evidence of a lack of influence of side thrust on some type of stresses.

DR. HARRIS: Cyclic stresses.

JUDGE BRENNER: Cyclic, all right.

MR. DYNNER: The cyclic stress you're referring to is the stress with which might cause cracks to initiate in the boss area that you had studied earlier; isn't that true?

DR. HARRIS: No. My answer was addressed

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to the ribs themselves, which would have to do with the crack initiation in the ribs.

Q. But the County has not alleged that there's cracking in the ribs, have they?

DR. HARRIS: Not that I am aware of. However, you were asking about our studies in regards to AE ribs.

JUDGE BRENNER: Again, Mr. Dynner, I was going to jump in, but I didn't want to.

MR. DYNNER: It took only a second.

JUDGE BRENNER: Not on that question. I was going to to jump in when you asked your opening question. It was a very broad question, and then you wanted to know why he gave you the answer given that question.

I think you could have been more precise when you started to ask about the work on the circumferential rib. Just take that into account in your future questions.

BY MR. DYNNER:

Q. Gentlemen, Dr. Pischinger, and Dr. Swanger, turning for a moment to page 60 of your testimony, you point out in that testimony that modern materials have a higher tensile strength than those which may have been available in the source

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authority that was listed in the County's testimony.

What would be the effect of materials in the piston skirt having a higher tensile strength on the issue of side thrust leading to distortion of piston skirt, if any?

DR. SWANGER: The change in materials going from cast iron with the modulus of elasticity of about 15 million pounds per square inch to nodular iron with a modulus of elasticity of approximately 23 to 24 million pounds per square inch would by itself increase the stiffness of the piston and its resistance to distortion.

Q. Just to clarify, Dr. Swanger, I was speaking about thermal distortion.

Would your answer be the same with respect to the effects of thermal distortion?

DR. PISCHINGER: Higher strength material gives the possibility to use minor -- or smaller dimensions for the walls of any part of the piston skirt, and smaller dimensions mean lower temperature differences as is well-known.

The piston is cooled from the inside with splashed oil. The piston is cooled from the outside with -- by contact with a cooled cylinder liner of the oil film, and the thinner the wall the more --

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the less temperature differences between the inside of the piston and the outside of the piston skirt, but, of course, this temperature difference is in this design of piston, this two part design was -- with oil cooling of the crown and which by that preventing of a lot of in-flow from the combustion chamber into the crown for such piston temperature difference as has been already mentioned yesterday, I think, is very small in the skirt, and with higher strength materials this can even be further degree in proof.

MR. DYNNER: Dr. Swanger, I'm sorry, thank you, Dr. Pischinger. My question was directed to your testimony, is it true -- your testimony was true with respect to thermal distortion.

DR. SWANGER: It would be true for thermal distortion for the reasons that Professor Pischinger gave.

MR. DYNNER: Thank you.

(There is a discussion off the record)

JUDGE BRENNER: We're going to go back on the record now.

BY MR. DYNNER:

Q. Dr. Pischinger, let me go back just for one second.

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The two engine skirts and the engines you referred to, the MANL 32-36 engine: what is that piston skirt made out of?

DR. PISCHINGER: If I recall right, it is aluminum alloy.

Q. And the MWND-5, is that aluminum also?

DR. PISCHINGER: Aluminum piston skirt. It has no affect on the calculation, of course.

DR. SWANGER: Judge Brenner, the one minute break we had was enough to absolutely resolve the difference between our calculations and Professor Christiansen's calculations, if you would like to know the origin of discrepancy.

JUDGE BRENNER: Is that okay with you, Mr. Dynner?

MR DYNNER: I'd be delighted to know it.

DR. SWANGER: Referring to County Exhibit 18, on the first page of that exhibit, point number five, it is written: "Effective thrust area on skirt equals skirt height times cylinder bore divided by the square root of two."

In my experience, eight years with the engine parts division of Imperial Clevite Manufacturing sleeve bearings for such engines, I have dealt extensively with the concept of unital

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pressures, and the standard definition for unital pressures would be strictly a height times a diameter. The factor of square root of two is non-standard in this type of calculation.

FaAA's calculations and Professor Pischinger's calculations are done with the standard definition of unital pressures, not with what we feel is the non-standard definition in the County's exhibit. That factor accounts for the difference in the numbers reported.

DR. PISCHINGER: May I add that figures given for the other comparable engines or engines in comparison are, of course, all calculated according to the same definition. That means still are comparable, that means that steel engine with at least 36 higher side thrusts are in operation.

JUDGE BRENNER: So it would be -- I want to make sure that we've got all the terms equated, Dr. Swanger, what you had calculated would be multiplied. The way you would caluclate it would be to multiply the skirt height times the cylinder bore.

DR. SWANGER: Yes. That would give you the projected area of the skirt. Its diameter times its height and that is the standard technique for computing unital pressures.

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BY MR. DYNNER:

Q. Is there some textural authority that you can give us for your stating is the standard technique?

DR. SWANGER: Since we just discovered this discrepancy in a one minute break, I can't give you the textural reference now, but I'm sure if you look in ASME Wear Control Handbook, for instance, in --

JUDGE BRENNER: I'm sorry, what was the title?

DR. SWANGER: ASME, American Society of Mechanical Engineers. Also --

JUDGE BRENNER: Yes. I knew that much. But we're --

DR. SWANGER: Wear Control Handbook. Also publications in the Society of Automotive Engineers Literature about calculation of journal bearing pressures would all use the same unit pressure definition.

JUDGE BRENNER: Do you want to -- did you include Dr. Pischinger in your question, too, as to whether he had a textural reference?

MR DYNNER: Yes. Do you have a textural reference -- I've included any one of them.

DR. PISCHINGER: So numerous that I have

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really difficulty now in naming them. Of course, it's German literature, but there are a lot of textbooks which the unital pressure on -- bearing whatsoever slightly on the surface is the projected -- the force divided by the projected area.

Q. Dr. Swanger, doesn't your statement assume that the bearing -- that the journal sits in a bearing and contacts the surface over 180 degrees?

DR. SWANGER: As Professor Pischinger had said, knowing the exact distribution of pressure around the skirt, it's a very difficult problem in elastohydrodynamics to solve; therefore, for rule of thumb or design guideline calculations such as this, simplifications have to be used.

The one that is in use in the diesel engine industry is to divide unital -- is to define unital pressures as projected areas, diameters times lengths with no other correction factor.

MR. DYNNER: Judge Brenner, if you're ready, we have --

JUDGE BRENNER: I'm ready.

MR. DYNNER: We have unfortunately only a limited number of photographs. We have two copies of the photograph, we tried to get extra copies, but, unfortunately, the photographic store has not

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cooperated and I don't know where the extra copies are now but they will be furnished later.

We would like to distribute at least one copy, show the copies to counsel and the staff, and have a chance to ask the witnesses a couple of questions.

The photographs in question, just for the Board's information are in the first place a photograph taken by Mr. Bacchi of Ocean Fleets and during the June 1984 inspection of the AE cylinder -- of the AE piston skirts at Shoreham. It is a picture of the scuffing on EDG 103 piston skirt which is referred to in the County's direct testimony.

And the other photograph is of a piston removed from EDG 103 during the same time, which shows the scoring that is alluded to.

We do not have these photographs available in time to attach them to the direct testimony, but I think that they would aid and assist the Board in understanding that testimony as well as in eliciting some cross-examination testimony from this panel about what these marks mean.

JUDGE BRENNER: All right. Well, I'll

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let you get them marked for identification, we're going to have to work out the logistics of looking at it here, and we'll let you go with it subject to your representation that you're going to be able to tie them up as being what you represented them to be, presumably, through your witnesses.

When they get on the stand it may be you don't have to do that because it may be these witnesses can do that for you, but if they can't, you'll have to remember to close the loop in order for us to use any of this.

We have only two copies.

MR. DYNNER: I'm sorry.

JUDGE BRENNER: Why don't you let us look at it for a moment and then we'll give it back to you, somebody else.

You have two photos.

MR. DYNNER: Yes. I want to give you the other one, we're going to try to keep these separate, we're going to mark them for identification. It might be less confusing to do them one at a time.

JUDGE BRENNER: Can you get it for the reporter tomorrow, the additional copies?

MR DYNNER: We've got people trying to

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bring them up by car somewhere. We had a foul-up.

JUDGE BRENNER: See if you can get them as soon as possible so we can use them in as close in time when we use it.

MR. DYNNER: The first -- I have to read it, Joe.

JUDGE BRENNER: I'll do it. It refers -- the first photo, Suffolk County Exhibit 71 for identification has been labeled by the County, a photo of a piston removed from EDG 103 taken by Anesh Bakshi at June 1984 at SNPS.

JUDGE BRENNER: Unfortunately, as Judge Morris points out, you've entitled both photographs, we didn't get to the second one yet, exactly the same. Can we call the first one something and the second one something else?

What was the point of the first one, again? One was scoring and one was scuffing.

MR. DYNNER: Yes. I think the first one is scuffing. Mr. Brigati will help you out there.

JUDGE BRENNER: Add to the title scuffing after SNPS.

(Exhibit Diesel-71 is marked for identification.)

JUDGE BRENNER: I hope we can get all the important descriptive things, both the question and

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the answer in words on the transcript rather than reliance on the photos and follow it as we're doing it now since we don't have a photo in front of us, although we have looked at the photo prior to the question.

Whenever you're ready, Mr. Dynner.

Thank you.

BY MR. DYNNER:

Q. Gentlemen, have you had a chance to examine the photograph of the County Diesel Exhibit 71 which purports to show scuffing of a piston skirt, you any of you seen an AE piston skirt removed from EDG 103 that had this appearance which, if I can describe it vaguely, is an U-shaped pattern within the sort of V or U-shaped pattern, there is a darker color material than what appears to be the lighter colored material in the other portions of the skirt.

Do any of you recognize this piston skirt?

JUDGE BRENNER: Mr. Brigati, while they're doing that, you can show this -- you can show it to the staff.

So that the question is -- reminds me of some other cases that I've been at but the question is have you ever seen this piston?

MR. DYNNER: Yes. That was the

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question.

JUDGE BRENNER: All right.

DR. PISCHINGER: One entrance remark, the picture is out of focus which makes it very difficult to sayanything definite.

JUDGE BRENNER: That was my -- it was my opinion that the picture appeared to be out of focus also. As to the second part, you'll have to testify to that, whether you can tell anything or not.

MR. YOUNGLING: Judge Brenner, none of us have looked at the pistons in the 103 engine after they were removed --

DR. PISCHINGER: Of the present.

MR. YOUNGLING: After they were removed to replace the engine block; however, the pistons were all inspected as part of the DROR program during that repair process and found to be acceptable.

Perhaps Dr. Pischinger could comment on the photo, if he feels he can.

JUDGE MORRIS: Before he does, you said they were inspected, Mr. Youngling, by whom?

MR. SEAMAN: The pistons were inspected by DROR personnel, quality control personnel associated with the Owners Group.

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JUDGE BRENNER: Well, some of them may or may not have been local people. DrQR is a conglomerate or conglomeration. Did any LILCO people look at it?

MR. YOUNGLING: Yes. Test Engineers in the start-up organization who were supervising rebuilding the engine looked at them, in addition there were TDI personnel on site supervising the rebuilding effort who also looked at them.

JUDGE BRENNER: I wasn't very clear. I'm sorry. I understand that anybody would have used them in the work may have seen them. I meant people looking at them for the purposes of inspecting it. were there any LILCO personnel --

MR. YOUNGLING: Standard practice when you take an engine apart.

JUDGE BRENNER: Dr. Pischinger, you were invited by one of your colleagues on the panel to comment further, if you thought you could.

DR. PISCHINGER: Yes. Of course. I am willing to say something, but, of course, with very much precaution of the out-of-focus picture.

May I say this, it reminds me, I know an expert who had been shown a cross-section of a sausage as a metallographic structure and he

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identified it as nodular cast iron.

JUDGE BRENNER: Your point is well taken as stated. Stated by you much better than my poor attempt to remind Mr. Dynner that he was having to tie up the pedigree of that photograph with his own witnesses if the witnesses here could not and he'll keep that in mind.

We'll also not try to qualify his expert witness as an expert.

DR. PISCHINGER: But, of course, I will do my best with all precautions.

You have to be aware, it looks to me as if the tin plating of this piston partially is worn in the black or dark colored area.

This would be not so unusual, because with all this tin plated pistons, the tin plate is used for break-in purposes, during breaking to give further safety, and it usually wears after short or longer time depending on the thickness of the layer, and the break-in condition obtained; so the only thing I can say, there is a difference in color, one color, let's say, silver shining in the photograph seems to be tin layer which is still there or at least partial layer and the darker colored area seems to be a tin layer which is already worn that

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the normal way.

As far as I can see by this focus, there is no sign of scuffing nor scoring.

Q. When you testified, Dr. Pischinger, it would be worn in the normal way, worn after how many hours of operation, that certainly would be a consideration, wouldn't it?

DR. PISCHINGER: Certainly. It depends upon the -- again, as I say, on the thickness of the tin layer of the way of operation of the hours, of the lubrication oil, a lot of influences are there.

It is not unusual after severe operation -- severe I mean parts of over load, that means higher than the usual one hundred percent load that tin layer is worn out earlier than if you have continuous operation at lower load, below the highest load.

Q. Can anyone on the panel tell me how many hours the EDG 103 ran with the new AE pistons in them before the engine was disassembled for the inspection in June?

JUDGE BRENNER: That's the question. Just before that, I want to make sure I'm hearing you correctly, Dr. Pischinger.

Are you saying tin layer rather than thin

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layer?

DR. PISCHINGER: Tin, the metal tin.

JUDGE BRENNER: That's what it sounded like. I just wanted to make sure.

DR. PISCHINGER: Not a thin but a tin. Maybe a thin tin layer.

JUDGE BRENNER: Mr. Dynner's other question is pending.

MR. YOUNGLING: Diesel engine 103, operated approximately 530 hours prior to the time that the pistons were removed in June, and I should also point out that after the block rebuild, these pistons were put back in the engine and have operated successfully for an additional 250 hours approximately.

Q. Mr. Youngling, of the 530 hours, you say the AE pistons were run prior to this inspection in EDG 103. Can you tell me how many of those hours were at or above a hundred percent load?

MR. YOUNGLING: Between 100 and 125 hours.

Q. Dr. Pischinger, in your experience, would you think that the type of markings shown in this photograph on this piston skirt would be expected on a skirt that was run for about 530 hours, 100 to 125 hours of which were at full or above full load of 3,500 kw?

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DR. PISCHINGER: That's not unusual.

May I, perhaps for understanding it, those engine people who are only familiar with coated pistons of other types where the coating is of a dark color, they are usually surprised by the pictures because if this dark colored layer wears, then there is no big difference in color, and it doesn't look so interesting.

In this case, you have the difference of the colors of tin and the cast iron surface which in the first moment gives you an opinion of what have we here, but all source of wear, within several hundred hours of operation part of it being full load.

Q. Gentlemen, you have responded in part on page 61 in your answers 96 and 97 to the County's direct testimony about their interpretation of the scuffing on this particular piston. I just want to be sure that I understood. Is it correct that none of you gentlemen individually inspected the scuffed piston to which the County has referred and which this photograph represents, as will be established later on?

MR. YOUNGLING: As Dr. Pischinger has testified, this is not a scuffed piston, and, yes,

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you're accurate that we have testified that we did not personally inspect them in June.

Q. All right. Did you inspect this -- any of the pistons which, according to your own exhibit 32 -- if you'll turn to Exhibit P-32 for a moment, you will see the last seven pages of that cover inspection reports on EDG 103 and relate to what is called here scuffing of pistons five, seven and eight on EDG 103 during inspections that took place apparently in March of 1984.

Now, were these piston skirts that are identified as five, seven and eight that were inspected and then dealt with in the -- these DRQR reports or reports that made part of the DRQR report, would any of these -- the piston skirts that were made available from the disassembled EDG 103 for the County to inspect in June of 1984?

JUDGE BRENNER: While they're considering their answer, it's 3:30, we're going to break after this answer. I hope you are over in the time we have set for you.

What did you have left to get to?

MR DYNNER: The few quick questions on the other photograph and I suppose maybe twenty minutes on the balance of the cross-examination plan.

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JUDGE BRENNER: For the life of me, I don't understand with why you decided to waste your first half hour this afternoon on looking at those articles.

There are other engines that the witnesses -- the articles at least with which the witnesses were not familiar and then wait until your time is up to ask particular questions about the Shoreham pistons. That's the problem you have.

MR. DYNNER: Judge Brenner, we're going to forget this other picture.

JUDGE BRENNER: They're still preparing the answer. This may be a good time to break. We'll give you fifteen more minutes after the break. You can include the other picture or not. It's up to you. It's going to be your fifteen minutes.

MR. DYNNER: I think I've heard this before in other contexts and I will do my best to try to speed things up as much as I can.

JUDGE BRENNER: I think you may know it's uncharactheristic of us to -- I don't think you've merited the other fifteen minutes. I want you to know that in the past there for one or two times where we gave you additional time where we thought it was merited. I don't think it was merited here

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because while you may still have a few things to get to we'd like to hear, you went through other things first which weren't necessary to go through to get there.

I also took some of your time in my questions of that article, just to, I thought, emphasize to you the problems with using articles like that when witnesses are not familiar with them, and I take that into account, too. I probably could have refrained from doing that, protected your time for that ten minutes. We'll come back at 3:50.

(Recess)

JUDGE BRENNER: All right.

Mr. Dynner, you may complete your cross-examination now. It's 3:50. Keep an eye on the clock and come to a logical conclusion before five.

BY MR. DYNNER:

Q. Yes. There was a pending question, gentlemen, as you'll recall, whether any of the piston skirts that are shown on Engine 103 in Exhibit P-32 are the same as the skirt with these marks which was inspected in June by the County. Do you have an answer to that question?

MR. YOUNGLING: Yes, Mr. Dynner.

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As part of DRQR program, TER number Q-500, a visual inspection of all eight of the pistons was performed during the block replacements outage. That would have included this piston.

The results of that inspection showed, and I'm reading from the document, no unusual scuffing or scratching was observed on the outboard portions of the piston and piston skirts.

Q. Is that document in the group of documents in Exhibit-32?

MR. YOUNGLING: Yes, it is. You should go from the back of the exhibit, and if you go forward, one, two pages.

Q. Mr. Youngling, can you identify for me who made the decision that this -- that the markings on these -- on the pistons shown in the photograph that we've given you to look at has no unusual scuffing or scratching on it?

MR. YOUNGLING: These inspections were performed by members of the DRQR program in the quality assurance arm of that program.

MR. FARLEY: Mr. Dynner, I think there's a failure of communication. Either you're waiting for an answer or the panel is waiting for a question.

MR. DYNNER: I'm sorry. I was waiting

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for you to identify the individuals who made this decision.

MR. YOUNGLING: I'm sorry, Mr. Dynner.

MR. DYNNER: Thank you, Mr. Farley.

MR. YOUNGLING: If you look at the exhibit on the bottom, there are sign-offs of the signature of the individual who prepared the inspection report, and a review by signature.

These were both Stone and Webster employees working in the DROR effort.

Q. So it's your testimony, Mr. Youngling, that the subject piston shown in the photograph is, in fact, not covered by one of the inspection reports in the earlier pages which referred to pistons five, seven and eight; is that correct?

MR. YOUNGLING: No, that isn't correct.

Since I don't know what piston that is, I can't make a determination as to whether it was in number five, seven or eight cylinder.

JUDGE BRENNER: So the sign-offs here that you're talking about are the ones on the second to the last page.

MR. YOUNGLING: Yes, judge.

JUDGE BRENNER: Sign-offs on the last page of Exhibit 2, is that part of the same

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inspection report?

MR. YOUNGLING: Yes, it is. It's a follow on document to take care of the second paragraph of the -- the concerns in the second paragraph of the previous page dealing with the carbon problem.

JUDGE BRENNER: Those sign-offs have LILCO people as well as S & W people according to the printed boxes. I don't know if the signatures are --

MR. YOUNGLING: Yes, there are Stone Webster people on there. There are start-up personnel, and there are LILCO quality assurance personnel.

If you'd like, I can identify the LILCO employees.

JUDGE BRENNER: I don't need it. It's up to Mr. Dynner.

Q. Mr. Youngling, I just want to be sure that I understand your testimony, because in the first couple of pages on EDG 103, there is a document called Q 159 followed by LDR number 2198 that do identify scuffing on piston skirts for numbers five, seven and eight pistons, and attached to that, on the back, there is a document that

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appears to be from DeLaval dealing with those pistons, number five, seven and eight, that appear to have scuffing. I just want to be sure that you're certain, if you can be, that the piston skirt shown in the photograph is not, in fact, either five, seven or eight.

MR. YOUNGLING: Mr. Dynner, I am certain what I testified to.

TER-159 was an inspection performed after the pre-operational program, but the approximately 100 hours on the pistons at greater than or equal to 3,500 kw.

At that time the engine was taken down and disassembled.

Three of the pistons were looked at under the program, TERO 159 was generated.

Then in May -- I'm sorry, in April of 1984 -- as part of the repair of the engine to replace the engine block, we dismantled the engine again and pulled out all eight of the pistons and performed the inspection covered by TERO 500.

Now, since I don't know what piston this is, I cannot identify whether it is five, seven or eight. So I can't tell if it relates to the TER 159.

MR. FARLEY: And this, for the record, is

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County Exhibit 71 for identification.

Q. Gentlemen, if you turn for a minute to page 69, if the answer to question 110, it stated that in 1983 the Shoreham EDG's had Koppers piston rings and were experiencing an excessive amount of carbon buildup on the piston crown as a result of a recommendation of the DROR program, those rings have been replaced; however, with Muskegan piston rings.

When were those Muskegan piston rings installed approximately?

JUDGE BRENNER: Mr. Dynner, if your interest is in relation to some other time, maybe they can answer that, rather than find a particular date. Or was it a particular date that you had to have?

MR DYNNER: An approximate day, if I could.

JUDGE BRENNER: What I mean is the only significance would be whether it was before or after something else. Why don't you ask them the question in that way.

MR. DYNNER: Maybe they have the answer. Do you have the answer?

MR. YOUNGLING: Yes. We replaced the piston rings on each of the engines at different

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times, and as I remember, the last engine was done by March of 1984.

Q. Was an analysis made to find out the source of the carbon that had become built up on the piston crown?

MR. YOUNGLING: As part of the DROR program and the LILCO effort to review the engines, we saw this carbon buildup, and both FaAA and Dr. Pischinger, looked at the buildup and resulted in the recommendations that we talk about in our answer to the question 110 in our testimony. I'll ask Dr. Pischinger to comment on his observations.

DR. PISCHINGER: Well, carbon buildup is not unusual for -- it's usual in an engine of such type.

What we were concerned with was that carbon buildup behind the piston rings and near the piston rings on the crown was a little more than usual, which at least could lead to engine wear in a shorter time than usual, and we, therefore, recommended to use in combination with the recommended and now used Muskegan piston rings which have a shape unsymmetrical bell-shaped face on the first ring, which used in combination with this rings, a high detergent oil which is, in general,

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beneficial in reducing such coat buildup.

This detergent oils which are widely used also in marine engines help to dissolve this carbon products.

It is not usual to analyze such carbon products in this region, because it's completely clear where it's coming from, it's formed partially out of soot stemming from the combustion, from the combustion chamber together with products or -- coke products of the lubrication oil, and knowledge of any composition is of no help in assessing of what to do.

In combination with this high detergent oil, it was decided to use fuel injection tip with 135 degrees which means sprays are not so much directed to the cylinder walls, is a good experience with thes injectors, that it also reduces carbon buildup.

There is experience at the Catawba nuclear power station with the engine that a higher grade detergent oil really sufficiently works and prevents this carbon buildup.

Q. You said that the carbon production -- production of carbon buildup was associated with the higher temperatures, with the high temperatures; is

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that correct?

DR. PISCHINGER: No. I said -- I couldn't remember. Did I say that?

Q. Is it associated with high temperatures in the piston crown or skirt?

DR. PISCHINGER: The usual environment in a piston crown is such that has always carbon formed with diesel engines.

Q. Were all three of these changes made at approximately the same time, that is to say, the changeover in the piston rings and the use of the higher detergent oil in the new fuel injection tips?

MR. YOUNGLING: No, Mr. Dynner.

Of the three recommendations, the Muskegan ring recommendation has been fully implemented. The change over to the 135 degree tips has been fully implemented, and we are beginning now to change the oil out of the engine and replace it with the higher detergent oil.

Q. When were the tips changed, approximately?

MR. YOUNGLING: That was accomplished by March of 1984 also.

DR. PISCHINGER: May I add something?

MR DYNNER: Certainly.

DR. PISCHINGER: Of course, one could

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question why not do these changes all at the same time. Of course, this problem is --

MR. DYNNER: Actually I don't have that impression.

DR. PISCHINGER: It's not urgent.

JUDGE BRENNER: He's not concerned with that.

DR. PISCHINGER: Because it's a long range wear problem and you could pursue it in connection with the usual inspection of the engines.

JUDGE BRENNER: It's almost 4:10, Mr. Dynner, why don't you ask your last question.

MR. DYNNER: Yes, one more. I have to think about that for one second.

JUDGE BRENNER: Is that a coincidence I asked you to do it just when you had one more?

MR. DYNNER: Oh, no. You know me better than that.

BY MR. DYNNER:

Q. Did any of you examine the possibility that the carbon and/or coat buildup that was noted in the piston crown might have been associated with the clearance between the piston and the liner?

DR. PISCHINGER: Just to make this question clear, what part of the piston do you mean?

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Because clearance varies over the whole --

Q. Yes. The piston crown in the liner which you may know, if you read depositions of Mr. Lowry testified to at one point was a problem which causes a similar situation.

DR. PISCHINGER: We are aware that such engine as with TDI engines, when using a marine diesel fuel, that means a heavy oil fuel, heavy fuel oil, where the coke buildup is still more of a problem, it could be convenient to have a large clearance on the piston crown.

We do not think that this is necessary for Shoreham where number two grade diesel fuel, that means a very good diesel fuel is used.

JUDGE BRENNER: Okay. Interesting that you chose your last question a question that at this moment I don't see as being within the contention, but maybe in the final analysis will show me otherwise.

MR. GODDARD: I believe this question is best addressed to Dr. Johnson.

Would you please refer to LILCO Exhibit P-29.

Within that, I'd like you to turn to Page 2 of Donald Johnson's trip report on Kodiak, Page 2.

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the final paragraph thereof.

JUDGE BRENNER: Which trip report?

MR. GODDARD: I'm sorry, February 17th. Page 2 of the Exhibit 12.

BY MR. GODDARD:

Q. The final paragraph thereof references a three quarter inch indication which was found by penetrant which did not appear to be a crack like indication upon inspection with eddy current.

Could you tell us what the results of your investigation of that indication indicated it to be?

DR. JOHNSON: First of all, that indication was not down in the boss area. It was up in the area of the rib. We brought that piston back to Palo Alto, investigated it in the laboratory, that area, very carefully.

That penetrant indication was not reproduceable, that is, we never were able to get a penetrant indication on that area when we returned it.

I believe that it's due to the fact that it's awkward geometry to be working up at Kodiak. It was cold where they were working, about 38 degrees -- 38 to 45 degrees. It was cold.

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And I think they simply did not wipe off all the penetrant in the process of doing the initial penetrant inspection.

Q. Did you at any time have occasion to discuss that indication with Donald Johnson?

DR. JOHNSON: Yes, we discussed it.

Q. Did he concur in your evaluation there was, in fact, a failure to properly remove the penetrant?

DR. JOHNSON: Yes, he did.

Q. Thank you.

The remainder of the staff's questions concern the issue of tin plating will be directed primarily to you, Dr. Pischinger, and Dr. Swanger.

Do you know whether the electroplating process which resulted in the tin plating of the AE skirts for Shoreham station were done by TDI facility in Oakland?

DR. SWANGER: We don't know that.

Q. Is there anyone else on the panel that can answer that question as to the source of that plating?

DR. HARRIS: In my discussions with TDI personnel, my impression is that the tin plating is not done at the TDI plant in Oakland but is done

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somewhere outside. I've never been informed as to who outside does the tin plating.

Q. Thank you, Dr. Harris.

Dr. Pischinger, the NRC testimony at page 54 indicates that a plating thickness for a piston skirt in an engine of this type, meaning a medium size diesel operating on a good grade number two diesel fuel would be a thickness of one to one and a half mils is acceptable.

Do you concur in that evaluation?

DR. PISCHINGER: Roughly, I would say within this range.

If it's a lot more tin on it, you get this tin migration which is not so favorable.

Q. You used the term migration. Would it be fair to call that smear or balling up of the tin?

DR. PISCHINGER: Yes. But with this thickness of thin tin plating, which is done here in this piston, this is a very favorable procedure. It's not the cheapest procedure to treat the piston, but it's very good.

DR. SWANGER: I might add in our visual inspections of the pistons, we have never seen evidence of the tin migration or tin smearing that was referenced.

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Q. How was the thickness of the application of the tin plating controlled in the electroplating process?

DR. SWANGER: I don't know the specifics of how the subcontractor at TDI controls it, but if you wish, I can address the general principles for controlling tin plating thickness.

Q. Electroplating is a fairly common industrial application; is it not?

DR. SWANGER: Yes, it is.

Q. Fine. Proceed to do that.

DR. SWANGER: Tin plating involves the electro dissolution of tin from tin anodes in an aqueous electroplating bath and the cathodic electro deposition of that tin on to the article being plated.

The thickness of plating will be directly proportional to the current density over the surface of the item being plated. Where the current density is higher for a given amount of time, the thickness of tin being deposited will also be higher.

In areas where you don't want any tin at all, they can be masked off with an insulator such as tape or wax, bringing the essential zero density at that point with no deposition; therefore, control of

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the electric -- of the current density is what controls the thickness.

The methods of controlling the current density are primarily geometric and chemical. The geometric methods are to place anodes around the part being plated such that every portion of the part being plated is about equidistant from a source of the tin, from the anodes, for instance.

The chemical means of controlling the thickness is referred to as the throwing power of an electroplating bath and is basically proportional to the conductivity of the aqueous electroplating bath itself. The higher the conductivity of the bath, the more even the iso potentials within the bath are, so the more even the current density is.

With tin, especially, it is easy to get highly loaded high conductivity baths and tin is known as being one of the plating metals with the highest throwing power, meaning that electroplated tin is about the most uniform metal which can be deposited by electroplating.

Q. Thank you.

If I understood you correctly, please correct me if I did not, the descriptions you gave would indicate how you would expect to get an even

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or equal thickness of deposition of the tin; is that correct.

DR. SWANGER: Going past the point where I discussed masking, which is intended to keep tin off of the part, yes, the principles that I talked about could be used to put down an even layer of tin. A high conductivity bath and an even spacing of electrodes would all be aimed at achieving a uniform thickness of tin on an electroplated part.

Q. Right. Dr. Swanger, as opposed to the uniformity of the thickness of the plating, how would you determine, during the plating process, when you have achieved the desired thickness on a uniform basis; in other words, I'm concerned with the uniformity question as much as I am with the overall thickness, the addition to the OD of the piston skirt.

DR. SWANGER: In my experience, the best way to do that is to monitor the overall plating current being used and to calibrate that against measurements of current versus time.

If you have the correct integrated value of the current times the time, you will have through Coulomb's law deposited the proper amount of tin on the part.

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Q. Thank you.

I take it from your description of how you would apply the tin in a uniform manner that this would then operate the control concentricity of the application?

DR. SWANGER: Directing the discussion now to the tin plating of AE piston skirts, yes. This is how one would achieve a concentric layer of tin on the OD of the piston skirt.

Q. Thank you.

If these processes such as you've described for monitoring the application were not followed during the electroplating process itself, I would assume that in an easy way or an accurate way to determine the thickness of the application would be by measurement of the other outer diameter of the piston before and after the application of the plating process; is that correct.

DR. SWANGER: In the case of pistons where the diameter changed from unplated to plated is three thousandths of an inch on a 17 inch nominal diameter part that is possible in theory, but I think it's a — it's not the way that would be most efficient for maintaining it.

One of the facts of life of tin plating

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is that tin is expensive. It costs about seven or eight dollars a pound, and electro platers take special care not to put too much of this valuable material on their parts.

Q. Especially if the part is the size of an AE piston skirt.

DR. SWANGER: Yes.

Q. Mr. Youngling, to the best of your knowledge, did LILCO in their recent inspections of these pistons take any steps to measure the thickness of the tin plating on those pistons?

MR. YOUNGLING: No, we did not take any steps to measure the thickness of the tin plating; however, as part of our inspection of the pistons prior to release for shipment from TDI, we performed measurements of the pistons including measurements of the OD of the pistons to insure that they conformed to the design specifications.

DR. PISCHINGER: May I add, shortly —

Q. Please, Dr. Pischinger.

DR. PISCHINGER: In addition, it should be noted that no tin migration or how do you call it, smearing problem, is known, number one.

Number two, to my experience, a little too thin tin plating is usually no problem.

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Q. You say a little too thin tin plating is no problem. Meaning that you would not, in fact, have to do any tin plating at all; is that correct?

DR. PISCHINGER: Yes. These pistons usually run with no tin plating, tin plating being some additional comfort.

Q. Mr. Youngling, in the process of the recent inspections, do you know whether LILCO reviewed any process documents which dealt with the tin plating of these piston skirts?

MR. YOUNGLING: As part of the inspection done by LILCO prior to releasing the pistons from the factory, one of the attributes that Stone and Webster inspectors had to look at was a review of the routing sheets which are used by TDI in the manufacture of the piston.

I don't have those documents here, but as part of those routing sheets, as long as there was a sign-off for the tin plating, there would have been a review that the tin plating had been done.

In addition, the inspector had to perform a visual inspection of the piston in conformance with the design documents, and he would have noticed if the tin plating had not been done.

Q. Well, visually, I guess we all would have

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noted if the tin plating had not been done. As Dr. Pischinger put it out you've got a dark colored nodular iron cuffed with a very light colored tin, so if it hadn't been done it would be somewhat readily apparent.

What I'm asking is whether there were any process documents reviewed by LILCO upon taking receipt of these pistons which indicates the appropriate thickness of the plating.

MR. YOUNGLING: We've reviewed some information here on the routing sheets and there is a check-off point that the tin plating had to be put in place. It's indicated as being bought out, meaning it's done outside on a subcontractor basis.

That is the degree of documentation that we have reviewed to insure that it was done properly.

In addition, I'm sure that TDI has specifications as part of their drawings to insure that the proper thickness is specified.

Q. Does that complete your answer?

MR. YOUNGLING: Yes, it does.

Q. You indicated that upon receipt you mentioned the outer diameter of the pistons and found them to be in conformance; however, as Dr. Swanger testified, measuring for the existence of

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one to one-and-a-half mils on each radius of a 17 inch piston does not really comport with real world tin plating, I believe.

In regard to those inspections, was that the only inspection done by LILCO which might evidence the thickness of the tin plating?

DR. SWANGER: If I may, I might just clarify my comment.

In order to know the thickness of the tin plating, you'd also have to know the preexisting as machined diameter of the piston.

There's certainly going to be a manufacturing tolerance on that, and something this size is probably one to two mils and that would add that much to the uncertainty of a -- an imputed thickness of tin.

Without knowledge of what that preexisting diameter is, that's why I said it was difficult to determine the tin plating thickness by direct measurement of the OD.

Q. Thank you.

Then in view of what you just said, it would be impossible to draw any conclusions to the thickness of the tin plating by virtue of the receipt inspection measuring the ODs; is that

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correct?

DR. SWANGER: No, I don't think that's true either. Because there is a specification for the machine OD of the piston prior to plating and by computing the stack-up of the tolerances, you can draw a conclusion as to the limits of what the tin plating thickness would be.

Q. Dr. Swanger, do you know what the tolerance is on the manufacturing OD of the piston prior to plating?

DR. PISCHINGER: Yes, we can tell you. Just a moment.

JUDGE BRENNER: While they're looking, give me just one moment, Mr. Goddard.

DR. SWANGER: In answer to your question, yes, I do know what the tolerance is on the diameter before plating.

Q. And that is?

DR. SWANGER: It's a range of four thousandths of an inch.

Q. Then the measurement of the OD after plating could, in fact, indicate a tin thickness of eight mils possible: is that correct?

DR. SWANGER: Assuming a minimum size manufactured piston and a maximum size after plating,

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the drawing indicates that it is possible to have three-and-a-half mils of tin thickness on the piston.

Q. That's three-and-a-half on the radius, seven on the diameter.

DR. SWANGER: That's correct. I testified to the thickness of it.

Q. I just wanted to make sure that we're together on that.

DR. SWANGER: I can point out the danger of this kind of thinking by looking at the other extreme in tolerances.

It's possible to have a negative one thousandths of an inch of tin on the diameter.

Q. I think not.

JUDGE BRENNER: At some point, Mr. Goddard, I'm going to ask you it might -- in how many mils difference in terms of materiality is the issue before us?

One thing, I assume all these answers were without regard to the measuring capability of the measuring equipment and on and on and on.

MR. GODDARD: That is correct. We are concerned about thicknesses, let's say, substantially in excess of the one to one and a half mil range based on the application and the greater

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fuel for this type engine.

JUDGE BRENNER: Well, I don't know what you mean by substantially in excess, and we're talking here about one and a half mils, three mils, four mils.

MR. GODDARD The staff would be concerned if it were in the three, three-and-a-half mil range as indicated which would be the maximum possible under the manufacturing tolerances as testified to by Dr. Swanger.

JUDGE BRENNER: All right. If that's the case, I guess that's why you've asked your questions.

DR. PISCHINGER: May I --

JUDGE BRENNER: Let's -- no, there is not a pending question, I don't believe.

MR. GODDARD: The staff has no further questions for this panel.

JUDGE FERGUSON: I'd like to ask the panel a few questions at this time. Before I do, let me ask whether or not you have benefit of Tuesday's transcript, do you have that available?

BY JUDGE FERGUSON:

Q. What I'd like to focus on first is some concerns I've had about our discussion of crack initiation and propagation, so we're going to

re-visit that for a short while, and the exhibit that I want to use in that discussion is Exhibit P-9: so if you could have that in front of you, it would be helpful.

I want to ask just briefly about the concern that I have regarding the engine cylinder pressure logs.

Those engine cylinder pressure logs are divided into two general categories. One is pre-crank shaft failure category and one a post-crank shaft replacement category.

Is the panel following?

DR. PISCHINGER: Yes.

Q. Now, I'd like to very briefly look at the first set of logs that have to do with the pre-crank shaft failure.

I see they're logs for EDG 101, 102 and 103, and just looking at the numbers in those logs, and these are pressure values, I believe, we can sort of eyeball those numbers on EDG 101 to get an average, perhaps, of around 1550 for the pressure, and they're all about that number, and if we do the same kind of quick averaging for EDG 102, it's slightly higher, maybe 1625 or so, and then when we look at 103, again, a rough eyeball average might be

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a cylinder pressure of maybe 1525 or 30.

Keeping those numbers in mind, and turning forward to the post-crank shaft replacement logs, we note immediately that for 101, the average is somewhat higher.

If we look at the log for 102, it may be slightly higher than what we found in the pre-crank shaft replacement logs.

And that same comment as to 103.

Now, the first question that I'd like to ask is what is it -- or what can we ascribe the differences between, say, the average of the cylinder pressures pre-crank shaft failure to post-crank shaft replacement.

MR. YOUNGLING: Judge Ferguson, let me point out to you one possible difference.

If you look at the procedures that implement these testing requirements, these are base -- what we call base line data.

What we're trying to do is prior to releasing the engine to plant staff of permanent operation, we just take the engine to approximate full load condition and take a set of base line data so they know for approximately full load, so there is a possibility of a difference in load of a couple

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of, maybe, 25 kw, so forth.

In fact, if you look at the post-crank shaft data, you'll see for 101 it was 3,500, 102, 3528 and 103 3595 kilowatts.

In addition, the post -- I'm sorry, the pre-crank shaft data was taken in August time frame, the summer conditions, while the data after crankshaft replacement was taken in the April and March time frame, different temperature situations.

But the last contributor and which is probably the most significant contributor was the fact that after the crankshaft failure, we disassembled the entire machine and had to reset the engine up, retime the engine.

And as a result of that retiming, it is entirely possible that you would see the differences in the firing pressures.

And perhaps Dr. Pischinger could add some more to that.

DR. PISCHINGER: Of course, in disassembling the engine including the crankshaft, the whole gear to the injection pumps have to be re-adjusted, and though it is necessary as has been told that injection has to be retimed, and in my experience, this sometimes happened, when you have

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an engine that had time factory set timing and after a certain time you reset according to the handbook, you get a difference, and I think this is what happened here.

Q. It's easier to use perhaps a different setting of timing.

DR. PISCHINGER: Yes. I think this is a probable cause.

Q. Let's stick with EDG 101 for the time being, and this is the group that have to do with the post-crank shaft replacement.

Do you have that in front of you? This is the one that we spent a good deal of time on before, but I think there's one or two things that we should discuss briefly to help clarify the record.

As we look at EDG, the report on EDG 101, we see that the numbers in that particular table range from a low, perhaps, of 1640 to a high of 1720.

Would you think that that range, different pressures and in those instances might be due to the causes that you just described?

MR. YOUNGLING: The spread of the numbers that you're seeing there is quite typical of our balancing of the engine.

We have a requirement in the TDI

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manual that we have to have no more than 200 psi between the maximum values.

We generally have been able to time -- to set the engines up to around a hundred pounds difference. Sometimes it's 120, sometimes it's 80, but generally we run in the hundred pound range, about half of the TDI limit. That's just the amount to balance the engine out.

We're certainly well within the TDI specification for balance.

Q. There's nothing peculiar about 101 that would make a difference say, from 102; is that correct? It just seems to me you did a much better job on 102 than you did on 101.

MR. YOUNGLING: Just like taking three cars to the same mechanic. One comes out running a little differently than the other.

Basically, we have three engines that are within specification, a few pounds difference, but still in satisfactory specification.

Also, when you set these engines up, the way you balance them is by inserting shims under the fuel pumps, and the shim stock is only of so much thickness, and you can only buy a certain amount of balance, so that's the kind of procedure and these

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are the kind of results that you get.

I think we do pretty well, actually.

Q. Okay. Well, let me proceed.

The reason I was focusing on those numbers is that in the failure analysis that was done, apparently these numbers were used as a guide, I think the number 1670 psi was testified, to as sort of being an average of a group of numbers: isn't that correct?

DR. MC CARTHY: Close. An average peak pressure that was conservative, that is, a value that the actual numbers fell below, as I indicated in my testimony, that we had not measured that.

In fact, here is a plot of peak pressure for 200 seconds --

Q. The record can't see that.

DR. MC CARTHY: This is, we will put it in the record then, this is just a plot --

JUDGE BRENNER: Why don't you try to describe it. Let your counsel decide whether he wants to put it in.

DR. MC CARTHY: When this question came up, I got a telecopy of our original data from our engine test where what I've got plotted is peak pressures for 250 seconds of running time, four

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minutes for every peak pressure of every combustion cycle was plotted, and what we saw was that the pressures running at full load ranged from about 1550 psi gage to the single highest point reading we got was below 1668 psi gage with an average for the 200 and 240 seconds about 1604 psi gage.

We took a number of cycles and, of course, this is a large number of data points, none of which got up to the 1670.

Now, these are done with a quartz transducer that's highly accurate. A Kiene gage is accurate to a percent, and so using the 1670, which was a value we didn't actually measure as high up, we called a conservative average peak value for fatigue damage purposes.

Q. The group of data that you just described are all lower than the group that we're looking at; is that correct?

DR. MC CARTHY: No. As I indicated, they range from 1550 to a high of 1668, which falls in the range of the Kiene gage, but the key Kiene gage measurements -- but, remember, the Kiene gage has a check valve to keep its high reading, and doesn't do the same operation.

Q. Okay.

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One of the points in asking this line of -- introducing this line of questions is that there was a number -- you say 1670, was that number that you used in the failure analysis?

DR. MC CARTHY: That is correct.

Q. Let's stick with that number.

DR. MC CARTHY: I'm sorry. That is not -- we used that in the piston analysis on -- for the earlier crankshaft analysis before we had measured data of our own, we used a value of 1680 supplied to us by TDI, but we actually measured the pressure and we used 1670 for the pistons. 1680 is a peak pressure for bending in the crankshaft analysis.

The peak pressure only affects the bending stresses at the crank shaft, not the torsional stresses.

Q. Let me get to really the thing that I'm interested in. And that is if you, in fact, measure pressures as indicated in this exhibit that we just described that are higher than the number that you have used in your failure analysis, what effect have you in your analysis looked -- have you in your analysis looked at the effect of the extreme values?

Is the question clear?

DR. MC CARTHY: I believe, your Honor, I

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understand your question in that let's take as a point of argument, and let's say the peak pressure were 1720 for a supposition to answer your question, which is the highest value of measure here, we did did take the fracture mechanics analysis, in fact, beyond 1720 to 2,000 to see if that not only would -- the sensitivity of our analysis of the piston have to our assumption of peak pressure under normal operating conditions, but, of course, the additional effect the overload conditions that the engine is sometimes required to run at and that has to be considered as well.

As we've testified to previously, our analysis and testing indicates that the cracks -- a crack would not grow even if the average peak pressure were 2,000 psi, and, therefore, our analysis -- our conclusions are completely insensitive to a pressure difference of this small an amount.

DR. HARRIS: If I could just interject here for a moment to expand somewhat on Dr. McCarthy's testimony, we took the analysis up to 2,200 psig, not 2,000. Very minute point.

Q. All right. That's been helpful to me.

Let me ask you now to turn to Page 22227.

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This question is going to be directed to Dr. McCarthy and Dr. Swanger. Do you have that in front of you now?

I'm going to read the question that was asked.

And just to save me the reading of the lengthy answer, Dr. McCarthy, I'd like for you to read your answer, if you would be kind enough to do it and then, Dr. Swanger, I'm going to ask you after I ask Dr. McCarthy a question to read your shorter answer.

I'm reading the question now. "Dr. Harris and Dr. McCarthy, on page 44 in the response to question 69 you referred to the use of engineering fracture mechanics in modern design and analysis in structures such as aircraft, spacecraft, pipelines and turbines, et cetera.

You mean to suggest that fracture mechanics are used in the design of these various structures in order to insure that if there are defects or crack like indications that they won't propagate to dangerous levels?"

Dr. McCarthy, would you be good enough to read your answer out loud so that all of us can hear that answer.

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DR. MC CARTHY: "In a nutshell, yes. A lot of the work we do at Failure Analysis is just making those analysis for people of critical flaw size and what kind of critical flaw can exist in your structure" and I guess it should say to correct that, not just -- there are two things that you could do. One is a critical flaw size to know your structure will not fail in an overload and then there's a second question. "Does a critical flaw size determine how much you have to go back and look at your" -- it should be structure "because not only do we deal with the analysis of when a crack will initiate but indeed how fast it will propagate and at what size you will begin to affect the critical nature of your structure, in effect, the engine, the aircraft engine problem here referenced there was not an assumption of flaw size problem as much as a problem to analyze, the rate at which cracks could grow in," I guess it should be "in the field and how often such parts have to be inspected so that you can catch any growing crack at the appropriate time. You don't have to postulate an initial flaw. These are expensive parts that are extensively inspected" that should be "but come out with no real measurable flaws but, in fact, operate in the initiation range

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and, in fact, a crack" should be "will initiate and grow and this was to establish their inspection interval."

JUDGE FERGUSON: You see my motive for having you read that, but Dr. Swanger, would you read your answer and then I'll ask my question.

DR. SWANGER: "I might put this -- might put this into the context of AE pistons at Shoreham and that is that our analysis says that no cracks are possible to propagate in these pistons; therefore, they do not need any reinspection." It should be "An initial inspection upon manufacture is sufficient to show that there are no cracks and we have demonstrated through fracture mechanics that no further operational inspections are required.

Q. That's the point I'd like to focus on very, very briefly, if I may.

My understanding of these words you had just recently read is that an initial inspection of the piston is made after it has been manufactured, and I'm going on to assume that the manufactured part is installed. Let me go back. The manufactured part is inspected and installed. Does this last statement indicate that you're recommending that no further operational inspections are required at all

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at any time.

DR. SWANGER: We, of course, would recommend that LILCO follow the recommendations of TDI as far as routine inspections of the piston.

Q. Do you know what they are?

DR. SWANGER: I don't know what they are right now.

Q. Is there anyone on the panel that briefly can tell me whether or not there's a routine reinspection after they have been installed?

DR. MC CARTHY: With regard to cracks in the stud boss area, though, the recommendation is exactly as Dr. Swanger stated.

After an initial inspection at the time of manufacture and the finding of no critical flaws, that is, flaws of a size bigger than we predict will grow, there's no need to inspect the stud boss region for cracks with eddy current or dye penetrant at later phases in the operation, at least for the operating stresses that we've used in our finite element model and have testified about.

Q. That's the point I really wanted to get to.

I envision at some date after the machine had run many cycles and unless you tell me that

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there is some routine reinspection, I'm not so -- I'm not convinced at the moment that that initial inspection together with your analysis will verify that nothing, in fact, could happen.

I understand all of the testimony about your predictions, if there are no cracks, none will initiate or grow. I understand that. But it seems to me that -- I'd like to know whether or not there are any routine inspections planned.

Now, if you have it before you, I'd like to have it today, but if not, maybe this is a convenient time to break and we'll pick up with this tomorrow.

MR. YOUNGLING: Judge Ferguson, we don't have the DROR matrix which was developed. It's out in our anteroom. Perhaps we could come back to you tomorrow morning.

Q. Tomorrow simply tell me what the routine inspection is.

MR. YOUNGLING: Yes, we will.

JUDGE BRENNER: We're prepared to recess and come back at nine o'clock tomorrow morning.

Did you want to say something, Mr. Farley?

MR. FARLEY: Please, Judge Brenner.

The Board will have mailed to it a letter that was delivered today to Mr. Denton, and also

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delivered to Mr. Berlinger and a copy was afforded to counsel for the County.

It deals with a proposal that's been under discussion regarding the crankshafts and the cam gallery area of the block, and in the interest of professional candor, I would like to hand a copy of this letter to each member of the Board.

JUDGE BRENNER: Okay. That's the first I've heard about it. We'll take the letter and read it.

MR. DYNNER: If I would just add, Judge Brenner, we were given a copy of this letter at the lunch break.

It involves some proposals by LILCO that are based upon just a very cursory review of the letter that seem to appear to be a significant revision of the FSAR to derate the diesel engines and also contains discussions about or some discussion about discussions that were apparently going on between the staff and LILCO concerning additional testing of the engines.

I just will say as a preliminary matter that it seems to us that these matters discussed in this letter could have potentially a very significant bearing upon these hearings and as the

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Board reads the letter, it will quickly become apparent that it involves things such as load factors for the engines upon which both our testimony and LILCO testimony involving the crankshafts were based as well as other related matters, so I'm not going to go any further except to say that I think that this material may have a significant bearing on the hearings.

JUDGE BRENNER: Well, I haven't read it and I don't know what's in the letter. There have been discussions of different load factors going back quite some months, and back then I said if anybody -- had any argument that there was something material in there, presuming they would present it to us.

We sit here in an adjudicatory proceeding. I'm not worried about the routine correspondence or even non routine correspondence that goes on between the staff and LILCO.

We'll get copies so we're apprised of the situations, but we don't make any fact findings based on that type of material and nobody brought anything to us in the proceedings with respect to the different load factors, that there's -- that there have been any contention that loads assumed

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for use in the analysis of what the diesels would have to run at in an emergency situation are incorrect and that's where that stood.

Now if there's anything new or different in there, presumably, we'll hear about it from somebody.

MR. FARLEY: I just felt obligated to bring it to your attention as soon as it had gone out.

JUDGE BRENNER: But I assume at some point you're going to discuss among the parties, if anybody is going to bring something before us and you can tell me -- if LILCO can point out whether they think it's material or not material to anything before us and the other parties can do the same.

MR. FARLEY: Our present plan now, your Honor, is to proceed with the crank shafts on the file testimony.

JUDGE BRENNER: We'll recess until nine o'clock tomorrow morning.

(Whereupon, at 5:05 p.m., the hearing was adjourned, to reconvene at 9:00 a.m., Thursday, September 13, 1984)

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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:

SHOREHAM NUCLEAR POWER STATION

Long Island Lighting Company

DOCKET NO.: 50-322-OL

PLACE: Hauppauge, New York

DATE: September 11, 1984

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission.

(Sigt)

(TYPED) HELEN DOHOGNE

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Official Reporter

Reporter's Affiliation