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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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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
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September 13, 1984
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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.

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Sincerely,

Alan I. Penn

Alan I. Penn
Vice President

Encl.
AIP/alr

DUPE
~~8411060097~~

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY & LICENSING BOARD

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In the matter of: :

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

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(Long Island Lighting Company) :

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State Office Building

Veterans Memorial Highway

Hauppauge, New York

Thursday, September 13, 1984

Hearing in the above-entitled matter was convened at 9:00 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

APPEARANCES:

On behalf of the Applicant:

TIMOTHY S. ELLIS, III, ESQ.

DARLA B. TARLETZ, ESQ.

MILTON FARLEY, ESQ.

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700 East Main Street
Richmond, Virginia 23219

On behalf of the Nuclear Regulatory Commission Staff:

RICHARD J. GODDARD, ESQ.,
Office of the Executive Legal Director

On behalf of the Intervenor, New York State:

ADRIAN F. JOHNSON, ESQ.

On behalf of the Intervenor, Suffolk County:

ALAN ROY DYNNER, ESQ.

JOSEPH J. BRIGATI, ESQ.

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1900 M Street, N.W.

Washington, D.C. 20036

September 13, 1984. Whereupon,

DAVID O. HARRIS,

DUANE P. JOHNSON,

ROGER L. McCARTHY,

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:

JUDGE BRENNER: Good morning. Yesterday, Mr. Goddard, you had wanted to raise a matter with us, and I asked you to hold it until today. Do you still want to raise that matter?

MR. GODDARD: Yes, I do, Judge Brenner. It concerns the availability of one of the staff witnesses who will be testifying on the shot peening of the crank shafts, and the acceptability of the cylinder blocks. That's Dr. Spencer and Bush.

Because of prior commitments, Dr. Bush is going to be available for only a limited period of time prior to the 8th of October. The days that he would be available are the 20th, which is a week from today, next Thursday.

JUDGE BRENNER: You're going to tell me he is available one day here and one day there?

MR. GODDARD: No, he will be available the 20th through the 25th only because of prior commitments. However he may well be available after the 24th of October, if it looks as though we are going to be in hearing at that time.

Accordingly, the NRC staff would request that the NRC witnesses be impaneled during that period for purposes of cross examining Mr. Bush alone on the issues of shot peening, and adequacy of the cylinder blocks.

JUDGE BRENNER: Have you discussed this with the other parties?

MR. GODDARD: I have not had a chance to do so at this time. I will do that.

JUDGE BRENNER: Go ahead and do that. I don't want to take it up now.

MR. GODDARD: I just wanted to notify the Board of your problem.

MR. ELLIS: Judge Brenner, he has discussed it with us and we are happy to accommodate it.

JUDGE BRENNER: Wait a minute, Mr. Ellis:

give a chance to the Staff, please.

MR. ELLIS: Sure.

JUDGE BRENNER: Welcome back.

MR. ELLIS: Thank you.

JUDGE BRENNER: I see potential problems, Mr. Goddard, with taking subjects totally out of order, especially since it involves two subjects, not just one subject. I have already expressed concern in that regard.

The Staff's panel would be coming on last. When will he be available beyond that time? We know that he is not available until after the 22nd-24th of October, in that time frame. We do not know his exact schedule after that period of time.

MR. GODDARD: The Staff would not make this request if it did not feel there was any other way to accommodate it. We do feel of course, that this information is highly probative.

JUDGE BRENNER: Well, it blocks the total subject on one part of the contention. I can see the possibility of maybe taking something like the shot peening out of order as an isolated subject. But you're asking us to take two subjects out of order. It gets very difficult to keep the subject matter in mind as it is.

It was not my preference to proceed the way we are going in any event, but at least we have the subject matter together from the witnesses for one party in the sense that all parties can ask their cross-examination, and can get direct and follow-up on the subject.

This hearing has been scheduled for a long time. One thing I believe the Board can take credit for, and maybe in your view it's the only thing, is that we scheduled this hearing with great predictability.

We scheduled it back in June. We know there are a lot of people involved and a lot of schedules involved. The Board's schedule also has been involved. And we scheduled it back in June. Everyone knew then when the hearing was going to start.

As it turned out we unfortunately had to make a last-minute adjustment, and start later, because of the Staff's scheduling.

This has been known for a long time, and now you are telling me a witness who you're depending on is not available for approximately a month.

MR. GODDARD: That is correct, Judge

Brenner. The Staff will not apologize for failing to schedule Mr. Bush earlier. He was added to the NRC Staff's panel because of relatively unexpected new material introduced by Lilco with regard to the metallurgy of the blocks. He is also the witness who by virtue of his qualifications and expertise we have used for the preparation of the shot peening testimony.

At the time this hearing was scheduled and for some time thereafter we did not know that Dr. Bush would be a member of the NRC Staff panel.

JUDGE BRENNER: Well you want us to take him next week. I'm sorry, the week after next.

MR. GODDARD: Monday and Tuesday of the following week and possibly next Thursday on the issue of shot peening, since we expect we will be on the crankshafts at that time.

If there's some assurance, and I think we can find out further information on Dr. Bush's October and possibly November schedule.

JUDGE BRENNER: I don't want to talk about it any longer.

MR. GODDARD: Okay. It wasn't my favorite subject.

At this point I would just like to alert the Board to the serious possibility that this will be discussed with the parties and I will get back to you, Judge Brenner.

JUDGE BRENNER: He is available the week of the 24th; is that what you're saying?

MR. GODDARD: The 24th and 25th only. He is leaving for Europe on the 25th.

JUDGE BRENNER: I don't think it's going to be workable Mr. Goddard, my personal opinion. You better find out how important his opinions are. I think we can take care of shot peening along the lines you suggest, but I have great doubts as to anything beyond that.

But if you can present me with a concrete proposal agreed upon by the other parties, or at least with the other parties' views, we will consider it.

MR. GODDARD: Thank you Judge Brenner. That's all I have at this time.

JUDGE BRENNER: If there are no other preliminary matters -- did you have something Mr. Ellis?

MR. ELLIS: I think there was a matter or question pending; Mr. Youngling is prepared to address that.

JUDGE BRENNER: The pending question was whether someone on the panel could inform us as to the planned inspections of the pistons for the projected operational life of the diesels, if in fact there's any operational life. Mr. Youngling.

MR. YOUNGLING: Judge Ferguson, the TDI instruction manual in the maintenance section requires that at each refueling outage that we perform cold compression readings on the engines and assess firing pressures. Based on those readings, we would then make a decision to inspect the piston rings and cylinder liner, based on those results.

The DRQR program in Volume 9 Appendix 3 -- Appendix 2, I'm sorry, Maintenance Review, requires that a five-year inspection be performed on the pistons, mainly dealing with dimensional areas, dimensional checks.

The company feels very confident in the results of our analysis that the pistons have indefinite life. However, to address your concerns the company will, at the first refueling outage, inspect the piston boss areas on all 24 pistons, by eddy current and DP examination.

JUDGE FERGUSON: Was that the end of your answer?

MR. YOUNGLING: Yes, sir.

JUDGE FERGUSON: I want to thank you for that, Mr. Youngling. I think that's very helpful. I don't want to get too deeply into this subject, but I hope you understand my concern, that although many of us have great respect for many of the mathematical techniques that are used to predict events, it's always reassuring from an engineering point of view to be sure that the measurements track the data. At the appropriate time

Based on what I have just heard from Mr. Youngling, Dr. Swanger, you remember the testimony you read yesterday, the last statement that I was concerned about, do you feel that you want to say anything further that might clarify what you meant by "No further operational inspections are required"?

DR. SWANGER: Yes. That statement referred to the fact that there have already been two sets of inspections on the AE pistons in the Shoreham engines.

All of the pistons were given a thorough inspection prior to operation by eddy current, by dye penetrant, to demonstrate that there were no reportable indications in the highly stressed stud boss area.

In addition, after 100 hours of operation, at or above the 3500 kilowatt level, 10 of these pistons, 10 out of 24, were disassembled for post-operational inspections, and as we have explained earlier, we looked at all of the stud boss regions, in all of these pistons, the total of 80 highly-stressed areas, and 40 stud bosses, and found no operationally-induced flaws there.

This, of course, fits right in line with our prediction that nothing would happen in these pistons.

Thus we feel that we have demonstrated, through the application of very standard engineering fatigue principles, that these pistons are operating below their endurance limit and with no preexisting flaws, and with no potential for any flaws which might be there to propagate anyhow, that the discipline of fracture mechanics as applied to many engineering and transportation studies, conservatively, in this case, tells us that further routine periodic inspections in the stud boss area for cracking are not warranted.

JUDGE FERGUSON: Is what you -- you just seemed to indicate that all of the measurements that Mr. Youngling said he is going to take are really unnecessary? Is that what you're saying?

DR. SWANGER: The routine maintenance inspections that Mr. Youngling discussed are those recommended by TDI to assess a number of the performance attributes of the piston, other than cracking in the stud boss region. The measurement of the normal wear of the tin on the outside of the piston. The measurement of the side clearance of the piston rings to the piston. These are typical measurements that should be taken on a periodic basis, to assess the total performance of the piston, including the AE piston skirt, in the engine.

However, we feel confident that in the area of cracking of the stud bosses in the AE piston, that the conservative application of proven fracture mechanics techniques does recommend that no further inspections are required.

JUDGE FERGUSON: I'm really trying to get across a very simple-minded concept. Mr. Youngling did you say that during these routine inspections you would, in fact, do a thorough inspection of the piston, looking for cracks as well as signs of wear that Dr. Swanger just mentioned? Let me be very specific. Will you look for cracks during your routine inspections?

MR. YOUNGLING: During the inspection of any piece of apparatus, the inspector is always looking for unusual signs. Cracking would certainly be one of the signs that he would be looking at, yes.

JUDGE FERGUSON: So you will be sensitive to the fact that there may be cracks and you will be looking to see if there are, in fact, any cracks, is that correct?

MR. YOUNGLING: Judge Ferguson, we do not feel that there will be cracks, but we will be looking at it as a part of our normal routine practice.

JUDGE FERGUSON: Fine. That's, I think, a very good idea.

But, Dr. Swanger, is your testimony that that is a waste of time or it's unnecessary? Dr. Swanger, I'm asking about his testimony.

DR. SWANGER: I feel that it is very prudent and very very cautious and very very conservative to do these inspections. From my standpoint, with a reasonable degree of engineering certainty, I do feel that such inspections are unnecessary.

JUDGE FERGUSON: All right. Well the point I hope that we leave this with, and I don't want to spend any more time on it, is that we are not lead to a feeling of great comfort in our calculations such that we don't do things that normal engineering practice suggests we do. It is important to have confidence, I'm sure, in our calculations, but those calculations should always be verified by inspection. I did not want the record to indicate that somehow FaAA or Failure Analysis Associates had led Lilco to a feeling that the calculations say that there are no flaws there, there are no cracks.

We didn't see any when we were inspecting these pistons before, these skirts before, they went into the engine, and therefore you're wasting your time to look for such cracks.

Just one final point, and I want to leave this, and that is the testimony as I understand it has indicated, based on the analysis that was performed, if a crack is less than a half inch, it will not propagate. Is that the testimony?

DR. SWANGER: That's part of the testimony. As we also indicated with respect to one of our exhibits, if you give me the time to locate it.

The analysis did say that cracks one-half inch deep will not propagate.

But as we also just stopped our analysis at that point, we feel that we could have carried it even further than half an inch, and cracks larger than half an inch also will not propagate.

But we felt that half an inch was such a conservative number to choose, and I am referring to exhibit P-25 in Lilco's exhibits which indicates that the analysis was merely terminated at half an inch, as a very conservative place to terminate it.

But we feel that cracks even deeper than half an inch also will not propagate, were they to be there. We also feel that there's no way to instantaneously generate any kind of flaw, crack or defect half an inch deep.

JUDGE FERGUSON: That's been very helpful, Dr. Swanger. I have no further questions.

JUDGE BRENNER: Mr. Youngling, I have a followup. You said you were going to perform an inspection on the piston which you described at the first refueling outage. I thought that the TDI diesels were going to be removed from any service as emergency standby diesels for Shoreham at the first refueling outage.

MR. YOUNGLING: Judge Brenner, based on

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our total analysis of the diesel generators, looking at our overall effort, not only in these four components, but the remainder of the engines, Lilco is extremely confident that we will be able to qualify these engines.

Consequently, we are planning as good prudent management to insure that these engines are available not only for the first cycle, but future cycles. And the Colt diesel engines will be used to complement the TDI diesels. And the Shoreham plant will be one of the most unusual plants in the United States, in that we will have six qualified diesel generators to support plant operation.

JUDGE BRENNER: Actually it will only be unusual by that number, because there are other plants with smaller diesels and a larger number.

I guess it would help me some time when it's convenient, not this week, for Lilco to give me a brief oral rendition of what findings Lilco is asking us to make with respect to the time frame question on the diesels, because there's testimony that relates to that, particularly the Staff's, and I thought it was an official proposal that Lilco was only relying on these diesels until the first refueling cycle.

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I don't know if that matters to any of our findings; let me say that at the outset. But it might. And if I could get that explanation in the near future in this proceeding, we will hear it.

MR. ELLIS: Yes, sir, we will do that.

JUDGE MORRIS: Gentleman, I have a few areas of inquiry.

First to Mr. Youngling. Coming back to the pressure measurements that you would make periodically, what was the frequency?

MR. YOUNGLING: The TDI manual specifies that we take those readings at each annual outage, or each refueling outage.

JUDGE MORRIS: Each refueling outage.

MR. YOUNGLING: Yes, and that will normally occur each 18 months.

JUDGE MORRIS: And these would be made with the Kiene instrument?

MR. YOUNGLING: Yes, they would be made with the Kiene gage. As I testified earlier, the Kiene gage is a satisfactory gauge for discerning trends. That's what we are looking for, is trends.

JUDGE MORRIS: And if you saw a change in the peak firing pressure outside of the TDI limits, you would then retune the engine, is that the --

MR. YOUNGLING: We would take the appropriate steps. It could be a tuning, or it could also require that we go into the engine and look at the rings or the valves, yes.

JUDGE MORRIS: Dr. Pischinger, I'd like to understand a little more about the behavior of the peak firing pressure as a function of time.

With the accurate measurements you can follow the pressure throughout the cycle, and you get, I presume, something like a sinusoidal wave, is that correct?

DR. PISCHINGER: The last word but one I couldn't --

JUDGE MORRIS: If you plotted the pressure versus time, it would be something like a sinusoidal wave?

DR. PISCHINGER: In a very rough sense. Of course if you analyze it, this is, as it is shown in Exhibit No. 5, it is -- well deviates a little from --

JUDGE MORRIS: Let's call it oscillatory.

DR. PISCHINGER: I beg your pardon.

JUDGE MORRIS: Oscillatory, so we won't try to define the shape.

DR. PISCHINGER: Yes, it will be a

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oscillatory function of time.

JUDGE MORRIS: For a single cylinder, looking at each peak, over a period of say a minute, what variation in the peaks would you anticipate?

DR. PISCHINGER: As measurements indicate, well in agreement with my experience, this will be -- I give you the percentage in just a moment.

JUDGE MORRIS: Fine.

DR. PISCHINGER: The scatter of the peak values will be in the range of about 7%.

JUDGE MORRIS: That's a total range of 7%?

DR. PISCHINGER: This is a total range.

JUDGE MORRIS: Yes.

DR. PISCHINGER: The band within the pressure of this, the peak pressures, will vary.

JUDGE MORRIS: And if you were to take an average peak pressure for that one minute, and then come back, say a month later, after continuous operation, what kind of differences would you expect at that time in the average peak pressure?

DR. PISCHINGER: This may depend on how much the engine was operated in this time. If you relate to running hours --

JUDGE MORRIS: Let's assume continuous steady state operation at 100% of let's call it

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qualified power level.

DR. PISCHINGER: And you said one month?

JUDGE MORRIS: Yes.

DR. PISCHINGER: According to my experience, if the engine stays untouched, that means nobody interferes by let's say resetting of the fuel pump, it will not vary -- it will -- within 1, 2 or 3% is maximum, the maximum this mean value will change.

JUDGE MORRIS: If over some long period of time you noticed some difference in the engine performance, what symptoms would indicate that the firing pressure was changing?

DR. PISCHINGER: I --

JUDGE MORRIS: For example, would it cause an increase in fuel consumption to maintain the same output? I'm just making this up as an example.

DR. PISCHINGER: I understand. Yes, you mean what symptoms -- symptoms left aside -- say, checking with pressure measurements.

JUDGE MORRIS: Correct.

DR. PISCHINGER: Yes. For instance, increase of fuel consumption at the same output, that will be, that could be an indication.

JUDGE MORRIS: So would it be your opinion that if the peak firing pressure changed substantially, let's say 10%, that that would be noticeable in the engine's operation?

DR. PISCHINGER: By measuring the fuel consumption, and control, close control of the load, this certainly would be measured.

JUDGE MORRIS: Yesterday Judge Ferguson was examining the peak firing pressures of different engines before and after replacement of the crankshaft. Would the increase in the diameter of the crank pin affect the firing pressure?

DR. PISCHINGER: No. Definitely not to a noticeable degree, if all other engine setting parameters stay exactly the same.

JUDGE MORRIS: Thank you.

Dr. McCarthy, I can't see you over there, because of the strange topography we have in this bench. You mentioned early in this proceeding the quality assurance that FaAA applied to this project; in our business we are usually focusing on quality assurance of hardware, that is to say structures, systems and components.

So I'd like to learn a little bit about how QA is applied to the activities of this project.

For example, is there a permanent quality assurance organization within FaAA?

Are there procedures that are applied more or less in a standard fashion to the many different types of assignments that you have? And I'll stop with those two questions. I have some more, but so we don't lose track, can you respond.

DR. McCARTHY: Yes, Judge Morris. The answer is yes, to all of your questions.

First of all, Appendix B of Code 10 CFR Part 50 spells out quality assurance procedures for work in -- relating to engineering of nuclear-related activities.

Our company has a designated quality assurance Manager who reports directly to me, who is Dr. Johnson. Dr. Swanger is an assistant quality assurance Manager in the company, also in that capacity reporting directly to me.

Our quality assurance procedures, and I have with me a copy of our quality assurance and operating procedures manuals, are a standard book that's maintained within the various sections of the company, is continuously updated when required in accordance with our operating procedures. They do spell out both the true procedure and the correct methods for assembling support packages to our technical work product, which includes such standard features as all calculations being independently checked by another engineer different from the one who performed the original inspection, the levels of management sign-off, and things of that nature.

JUDGE MORRIS: It wasn't clear to me whether those persons, for example Dr. Swanger who performed QA functions, are completely independent of those who do the initial work, or does that change with time, or how does that work?

DR. McCARTHY: I'm sorry. Perhaps I incorrectly characterized their role. Dr. Johnson or Dr. Swanger's responsibility to me in their quality assurance role is that the procedure is followed. They, especially with a firm of our size, could not hope to audit the technical product of the whole firm, nor is their expertise appropriate for that audit in all areas.

Their responsibility is to make sure that when a report is generated, let's say by someone in our instrumentation group, that someone independent also with appropriate instrument expertise, audits that report, and that the procedure is followed.

Who performs the audit has to be someone independent of the original performer of the work, who also has the appropriate expertise.

JUDGE MORRIS: So that would change with the nature of the particular jobs that you were performing?

DR. McCARTHY: Yes. And the reviewer is -- particular reviewer in a particular job is selected by a corporate officer, and indeed reviewers throughout the company can be -- the role of worker and reviewer, individuals on the Staff will do both roles on different jobs, and of course all our work has had, it's my understanding, an independent Lilco audit in addition to our own QA procedures.

JUDGE MORRIS: As an example, could you tell me how you would perform a QA function on a finite element analysis of, for example, a piston skirt?

DR. McCARTHY: Okay. In the particular finite element analysis that we discussed here today, of course Dr. Harris was the Task Manager who assembled with the help of Mr. Sire and Mr. Muir the analysis that's reported.

The reviewer on that program was Dr. Graham Fowler, PhD in applied mechanics from Cal Tech, with extensive finite element experience. His review is reflected in the sign-offs on the support package. He is not, however, here today.

Q. Do you accomplish something like a qualification of the computer programs?

DR. McCARTHY: Yes. As part of the procedure, there is a qualification requirement for computer programs, and also in assembling the support package backing up a report, the version and copy of the program actually used in analysis has to be appended as part of the support package. Programs, especially commercially-used finite element programs, will occasionally be updated and expanded by their supplier, but we also track which particular version was used for which particular analysis.

JUDGE MORRIS: Dr. Pischinger, did you want to say something?

DR. PISCHINGER: No, I just wanted to follow.

JUDGE MORRIS: So, with respect to qualification of computer programs, I believe you have responded, along with the program goes the boundary conditions or the assumptions which have to be stated to solve the problem. What quality assurance is made on the correctness or adequacy of those boundary conditions?

DR. McCARTHY: The reviewer not only, of course, must have the appropriate expertise to evaluate assumptions made in boundary conditions, but in addition to the printout, which will have the inputs to the computer program, it is required that the engineering assumptions involved be stated so that the reviewer can make an evaluation of both the assumptions made for input, as well as the numerical input itself.

JUDGE MORRIS: Thank you. That's all I have at this time.

JUDGE BRENNER: Gentlemen, I wanted to try and clarify some basic terms that are used in your testimony and in the exhibits. Some of these have been alluded to earlier, but I want to try to get it clarified and also get it all in one place.

Can you explain to me what is denominated by the use of the positive and negative signs in relation to the values for stress and strain? If it helps you to refer to some of your exhibits, such as 16 or 17, you can do that. You might want to explain it in context of what you mean by minimum stress or strain and maximum stress or strain.

DR. HARRIS: In order to simplify the

discussion of stress, let's concentrate on normal stress and for the moment, hopefully for the whole morning, not consider shear stresses.

All of the tabulations in our reports have to do with normal stresses, and a normal stress is much like a pressure. It's just a force per unit area. And has, therefore, the units such as pounds per square inch.

A positive value of a normal stress for mechanical engineers pertains to the situation where you are; you're pulling on a body, when you put it in tension you have positive normal stress. If you put it in compression, that is if you're pushing on it, then you would have negative normal stress.

As I mentioned briefly, the shear stresses are also another important component of the problem. So that stress is actually, has six components to it. It's a fairly complex thing. But hopefully the discussion I just gave on normal stress will be sufficient for the current discussion.

JUDGE BRENNER: I can ask a follow-up and maybe that will help clarify it, unless you want to add something to that, Dr. Swanger.

DR. SWANGER: I believe your question also asks for clarification of minimum stresses and

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maximum stresses.

JUDGE BRENNER: Yes, and my follow-up was going to be either Dr. Swanger or Dr. Harris the other day stated that all the minimum stresses were negative, and I was wondering whether you meant that totally or just with respect to a particular exhibit that you had in mind. And it was in the context of Dr. Swanger warning us not to confuse that with the algebraic use of positive and negative.

DR. SWANGER: Minimum stresses and maximum stresses only have meaning due to their comparative nature. In looking at a set of stresses, that stress which would be the algebraically lowest stress would be the minimum stress. That stress which would be the algebraically largest stress would be the maximum stress.

In general, depending on the problem being solved, both minimum stresses and maximum stresses could be either negative or positive. But we believe that in the stud boss region of the AE piston, the minimum stresses are always negative.

JUDGE BRENNER: And the maximum stresses could be negative or positive, correct?

DR. HARRIS: Yes, Judge Brenner, that is correct.

JUDGE BRENNER: Let's take one example. If you look at exhibit P-17, that's your table where you present the cyclic stresses. Now am I correct that in order to get the cyclic stress you have to subtract the minimum stress from the maximum stress?

MR. ELLIS: Which number again, please, Judge Brenner?

JUDGE BRENNER: P-17.

MR. ELLIS: Thank you.

JUDGE BRENNER: Let's take an example in that exhibit. Could you, using let's say the 11-inch, I'm sorry, the 11 mil gap under the steady state condition example, could you tell me what the cyclic stress would be under the finite element analysis for that example?

DR. HARRIS: Referring to the stress levels under the column that has FE at the top, referring to finite elements, under steady state conditions with an 11 mil gap, the maximum stress would be 1.57 ksi. The minimum stress would be minus 42.2 ksi.

This means that the maximum stress is tensile, and the minimum stress is compressive.

The cyclic stress would be the maximum stress, minus the minimum stress, which is, using the numbers I provided you, the cyclic stress is 43.97 ksi.

There's a closely-related stress parameter that is also of interest called Sigma Sub A for the cyclic stress amplitude. That is equal to one-half of the value that I just cited.

JUDGE BRENNER: Thank you.

You discussed in some of your exhibits a comparison in what you have labeled steady state conditions in contrast to isothermal conditions. For example, the triangle presentation in exhibit P-23 does that, and your testimony does that also.

Am I correct that when you say steady state conditions you mean the conditions in an operating diesel, is that right?

DR. HARRIS: Yes, Judge Brenner.

JUDGE BRENNER: And when you say isothermal conditions you mean the conditions in your experiments, is that correct?

DR. HARRIS: I mean the conditions in my experiments and also the conditions in an operating engine when it's first started from a cold, from a non-operating condition. As when you start an engine that has been in the stand-by condition, it will be under isothermal conditions. When you first start the engine it takes a while for the temperatures in the piston crown, and elsewhere in the engine, to reach the steady state condition, so there's a transition period in there, and the isothermal condition and steady state conditions provide the two extremes of the beginning and the end of this transient or time-varying condition.

JUDGE BRENNER: All right. I will keep the distinction you have in mind by those labels. The reason I asked is that, now to make sure I have got that correct, you also testified that in your opinion, under normal operating conditions that you relate to under steady state conditions, the temperature of the piston skirts were, I believe, expressed as relatively isothermal.

DR. HARRIS: Yes, I believe that's correct. Or it's a characterization that I quoted.

JUDGE BRENNER: We have discussed several times again this morning your testimony with respect to the fact that you can state that cracks up to a half inch, in your opinion, would not propagate. And I understand Dr. Swanger's explanation that that was conveniently as far as you went.

Does the length of that crack matter at all to your analysis or conclusions? You have always discussed it only in terms of the depth of the crack. In other words, if you had a longer shallower crack, might we expect different propagation than a shorter crack?

DR. HARRIS: Everything else being equal the crack growth rate would depend on the surface length of the crack in addition to only its depth.

As I recall, the fracture mechanics analysis in the AE piston skirt took the conservative approach of assuming that the surface length of the crack was infinite, very, very, very very long relative to its depth.

JUDGE BRENNER: All right. You anticipated my next question.

Dr. McCarthy, you discussed the concept, I guess I could call it the knee effect, if you would, in relation to your answer 87 in your testimony, and by responding to Mr. Dynner's questions it was your testimony that the situation with the crankshafts supported your testimony, and I didn't understand the bases for your point, and I want to come back to it now. For the sake of the record that discussion with Mr. Dynner was approximately transcript page 22,354, and thereafter, although I don't know that we have to refer to it in terms of reading it now.

As I understand the testimony in your direct testimony, it is that once you get over the particular beginning of the knee in the case of the piston, you believe that to be 1.35 million cycles, approximately, that you would expect that 93% of anything that would fail up to 10 million cycles would have failed by that 1.35 million cycle point. Am I correct?

DR. McCARTHY: No. If I left that impression, my explanation was not then clear.

The knee occurs on ferritic materials at 10 to the 7 cycles. Which means that anything that makes it to 10 to the 7th should run forever, for ferritic materials. That's the infinite life point. If it's run at that rate for the remainder of its cycles.

In other words, if it lasts 10 million cycles it will exhibit infinite life.

Now, if you have a part that makes it to 1.3 million cycles, the stress level of that part can only be 7% above the endurance limit at a maximum, or you should have observed failures. In other words, 1.3 million, a part designed to last only 1.3 million cycles can only have a stress 7%

above the endurance limit

Now the key factor in that, of course, is we have a large number of parts whose statistical variation of stress and strength would be, one would expect the scatter to be substantially greater than 7%, and as we observed in the crankshafts, all three of them developed cracks or failures, because they were in this range of one million to 10 million, and indeed one broke, and the other two had substantial crack growth. Whereas when we looked at 10 pistons, 40 bosses and 80 fillets, we saw not a single indication.

And therefore, since we went to 1.35 million cycles on the ten pistons, which means their stress level could at most have been 7% above the endurance limit, and we got no indications, we have concluded, in fact, that the stress level is substantially below the endurance limit, because not even the weakest material in the most highly stressed stud boss developed a single indication after 100 hours.

JUDGE BRENNER: Sorry, you have have lost me again and I'm sure it's my fault. If you tested them, the pistons, that is, to the 1.35 million cycles, correct?

DR. McCARTHY: Yes.

JUDGE BRENNER: The crankshafts, prior to the time any defects was noted in them, were past 1.3 million cycles, I believe somebody testified that the 102 crankshaft was about 3.4 million cycles.

DR. McCARTHY: 3.4 or 4 million, I don't know whether that 3.4 reflects the preoperational testing of TDI or not.

JUDGE BRENNER: Somewhere between the one and 10 million.

DR. McCARTHY: Yes, right.

JUDGE BRENNER: And you're asking us to say that that's of course the fact that if you look at the pistons at 1.35 million cycles, we can assume that they will not fail beyond that.

DR. McCARTHY: That is correct, because had you opened up, just like what happened when we opened up 3 blocks, we saw, in fact, one of the parts had failed, and the other two had cracks. In other words we looked at three and they all had extremely large relative indications that they were above their endurance limit, all three, the one that failed, of course, told us that. And the other two, even though they hadn't failed yet, had clearly very large indications, cracks that were visible to the naked eye.

JUDGE BRENNER: You just said blocks; maybe it's true for the blocks too. But didn't you mean the crankshafts?

DR. McCARTHY: The -- we had three crankshafts, one of which had failed, two of which had very large crack-like indications, that could be seen with the naked eye. All three crankshafts were operating above their -- of the old type -- were operating above their endurance limit, and in the range from one million to 10 million cycles developed cracks.

Now, let's take -- let's go look at our pistons, if they're operating in that same range, that is above their endurance limit, and we look at not three samples, indeed not 30 samples, but in fact 40 bosses and 80 fillets, we see not a single indication. And the crankshafts have taught us that all the parts operating in that range are, if they're above their endurance limit are either going to fail or develop cracks. In fact none of the pistons developed relevant indications or cracks.

JUDGE BRENNER: Well, here's my problem. I take it people assume that the crankshafts were not operating above their endurance limits until they learned otherwise.

And would have argued that since the crankshafts made it past one million cycles, which is about the point of your testing of the pistons, that therefore that proves the fact that they won't fail after that. In fact, they did fail at around three or four million cycles.

DR. McCARTHY: We would not have accepted the argument that the crankshaft, that the fact that the crankshafts made it 1.3 million cycles, they were not going to fail.

Now had someone opened up the blocks at that point, pulled the crankshafts, very accurately inspected them with eddy current and dye penetrant and found no indications in any of the fillets, we would have been much more moved by the experience of three crankshafts.

If you had done 80 crankshafts, ran them to 1.3, 5 million cycles, pulled them from 80 blocks, inspected them all with dye penetrant and found the relevant indications, you would have made it, your crankshafts would have survived.

In point of fact had we run 80 crankshafts to 1.35 million cycles you would have found many relevant large indications on that fleet of 80 crankshafts.

JUDGE BRENNER: And citing the experience with just the three crankshafts, in support of your view, in answer 37 of your testimony, are you implying that if the crankshafts had been inspected at the one million or 1.35 million cycles, that the indications would have been apparent? Is that a necessary element in your reliance on the crankshaft experience for support?

DR. McCARTHY: If you had 80 of them you definitely would have found some of them cracking. I'm just -- the question on the three, I just have to consult with my panel here on the crack growth rate to answer that question.

JUDGE BRENNER: Maybe this will help, Dr. McCarthy. My question isn't whether you can tell me that those three cracks and in one case failure of the crankshaft in fact would have been available at one million or 1.35 million cycles. I'm asking you whether it was a necessary element of your testimony on which you relied on the crankshaft experience that that be the case. I think you are telling me no.

DR. McCARTHY: Let me understand the

waga

question. I'm sorry.

JUDGE BRENNER: Let me back up.

Mr. Dynner asked you wasn't the crankshaft experience inconsistent with your testimony in answer 87, and you said no. In fact the experience with those three crankshafts, you weren't talking about 80, you were talking about those three, supported strongly your testimony.

I am trying to understand a little better why it supports your testimony strongly, since the crankshaft failures, and problems, were not noted at the one million cycle range, but rather were not apparent until the three or four million cycle range. And if I in my own simplistic way apply that to piston experience, I would say, well, I don't care that you haven't seen any problems at one million cycles. If the crankshaft experience is relevant, maybe there will be failures at 3 to 4 million cycles.

DR. McCARTHY: The answer to your question is yes. But there are a couple of things that don't make the analogy between crankshafts and pistons exact. And that is the crack growth rate. That's one other parameter you have to consider to know that, for instance, 1.35 million cycles is sufficient on, let's say pistons, which it is, whereas on crankshafts you might have needed 2.5 million because of the different in the crack growth rate.

When Mr. Dynner mentioned the crankshaft experience, I thought that was an excellent illustrative example of how, if you park an operating stress level above the knee of the curve or the infinite life, even though you make it into a million cycles, all of the parts that you have parked in there, if they're operating in that, above their endurance limit, will exhibit either indications or failure before they get to 10 million cycles.

The piston crack growth rate is faster than the crankshafts, and there --

(Discussion off the record among the witnesses.)

DR. McCARTHY: As one of my engineers observed, we predict no crack. If the pistons were operating in a range, a stress level, where they were -- let me start again. Cracks do not propagate in the piston. So there isn't a piston crack growth rate to discuss here. But in the crankshafts, had they been inspected at the same point in their operational service as the pistons were, and this is the key, not that they operated successfully, but they were inspected before failure, with the techniques to find incipient cracks, you would have expected to find these cracks before the failure of the crankshaft, before the failure of any one of them. And in fact after one failed, two others were found with cracks.

Given our analysis of the piston, we are highly confident that were the pistons operating above their endurance limit at 1.35 million cycles, we would have found many relevant indications were cracks initiating and growing in the pistons. And I think the analogy between the crankshafts and the pistons relative to are they operating above their endurance limit is a good one. That was the reason for my answer to Mr. Dynner's question.

JUDGE MORRIS: Just so the record is clear, Dr. McCarthy, could you define for us right here what endurance limit means?

DR. McCARTHY: Endurance limit is the stress level in a part, cyclic stress level below which the part will endure, though cyclic stress levels, forever, that is, exhibit infinite life.

DR. SWANGER: I can also refer you to

Lilco's exhibit P-28, which is a selection from the iron castings handbook. On the second page of that exhibit is a definition of the endurance limit. It states, discussing fatigue performance it says, "As the maximum stress is reduced, the number of cycles necessary to produce a failure becomes much larger. The highest stress at which the number of cycles for failure approaches infinity, generally in excess of 10 million cycles, is called the endurance limit."

JUDGE MORRIS: Thank you.

JUDGE BRENNER: All right, getting back to the theme of some basic terms.

This morning you gave us the definition of stress. While we are at it could you give us the definition of strain?

DR. HARRIS: Strain, like stress, is a fairly complex concept of solid mechanics. There are shear strains and normal strains. And for our purposes we can concentrate on normal strains.

Strains has to do with how much a body deforms when subjected to a stress. If you put a body in tension, that is you pull on it, it will get longer, and that will be a tensile strain, which is taken to be a positive strain.

And the strain itself is defined as the

change in length of the body divided by its initial length. It's especially illustrative to think in terms of what is called uniaxial tension, where you have a slender bar on which you can pull and push on the bar. If you pull on the bar, the change in length of the bar divided by its initial length is the strain, the normal strain.

Since it's a change in length divided by the length, the units are dimensionless, but quite often you see strains given in inches per inch or millimeters per millimeter, which is really dimensionless.

JUDGE BRENNER: Right. In fact one of your exhibits gives the units; at least was it micro inches per inch?

DR. HARRIS: Sometimes micro inches per inch, so you get numbers you feel more comfortable with, because in fairly stiff bodies, like bodies composed of iron and steel, as you know from every-day experience, you pull on a piece of steel it doesn't get much longer. You need very sensitive instrumentation in order to detect this.

If you push on the slender body, it will get shorter, and this is, you're applying a compressive stress, and you get a compressive normal strain. And compressive normal strains are negative as the change in the Delta L by mathematical convention is negative.

JUDGE BRENNER: Thank you.

JUDGE BRENNER: Thank you, gentlemen, we can go to Lilco for its redirect.

REDIRECT EXAMINATION BY MR. ELLIS:

Q. Dr. McCarthy, in response to some of Mr. Dynner's questions you were asked about --

JUDGE BRENNER: Mr. Ellis, I'm sorry, the fan is going overhead. I'm having difficulty hearing.

MR. ELLIS: Is this better?

Q. Dr. McCarthy, in response to Mr. Dynner's questions about whether you have designed a diesel engine, I'd like to refer you, if I may, to your resume, which is an attachment to the Lilco testimony. Do you have that in front of you?

DR. McCARTHY: Yes. Yes.

MR. ELLIS: For the benefit of the Board, this is the first page in the attachments.

Q. Dr. McCarthy, again, would you tell the Board, please, the ways in which -- tell us whether your background is reflected in your resume there as relates to experience or familiarity with the design or manufacture of diesel engines such as those at Shoreham?

DR. McCARTHY: Well, yes. As I indicated in my previous examination, I performed failure analyses in the past that dealt with large medium speed diesel engines in nuclear backup service. I have also worked on large medium speed diesel engines in non-nuclear backup service.

The major service which I, and personally the firm as a whole, is called upon to deliver, is failure analysis, to determine why a particular part failed.

You cannot answer questions with regard to why failure occurred without analyzing the design aspects, material aspects, the service, the use, or of misuse, and analyze the contributions of those various factors to determine why failure occurred.

My background has been involved in analyzing design contribution to engine failure for large medium speed diesels, as well as many other major propulsion engine energy conversion or generation systems, both for engines and turbines and large industrial equipment of numerous types.

Q. Is your academic training also involved with experience in mechanical design related to diesel engines such as those at Shoreham?

DR. McCARTHY: Yes. First of all my Doctorate is in mechanical design, and in studying for that Doctorate at MIT some of my course work involved design and control of large rotating machinery explicitly as the course title, and the whole term of study with regard to those courses. This not only involved study of the design techniques for large rotating machinery, but the design analysis with the most current and powerful analytical techniques to be called upon by a sophisticated manufacturer or user of such equipment for design analysis input.

You cannot bring merely the conventional and accepted and long ago learned techniques and methods of analysis to the problem. An individual called in as an outside consultant must bring what is the state of the art in the design analysis area to provide indeed an economically viable service.

My testing and professional work has been dedicated to that, especially with regard to mechanical design and machine and mechanism design during my entire career.

Q. Dr. McCarthy as President of FaAA do you consider that FaAA with the expertise it assembled with respect to Shoreham was expert in matters involving the manufacture and design of diesel engine components, such as pistons?

DR. McCARTHY: Yes. As I think that's become apparent during the last few days of testimony: all the members of my Staff bring substantial experience gained not only within Failure Analysis, but outside of Failure Analysis in the design and development of measures and mechanisms and parts that are either directly applicable or very closely alllied to the design problems and analyses questions that are involved in large medium speed diesel engines.

The design analysis that occurred on the Shoreham diesels reflects the input and direct participation of more than 40 very senior scientists on the Staff, a fraction of which have been part of this panel, and more members of which will become and will appear as members of follow-on panels.

These individuals' collective expertise. and the collective expertise of Failure Analysis, has made us the largest and I believe certainly the most widely recognized engineering firm in the nation devoted primarily to the analysis and prevention of engineering failures.

Q. Dr. Pischinger, you testified as to your experience in design. Have you had experience in assembling design teams to consider either the design or the review of a design for diesel engines or diesel components?

DR. PISCHINGER: Certainly I have been involved through my professional life until now, a lot of years, nearly 30 years, in dealing with teams working in design.

But maybe I should define a little again what this design of the diesel engine -- the diesel engine process is already an old process, and the principle hasn't changed since its invention. What changed, the designs. So in principle all diesel designs are redesigns. It's a steady state redesigning involving the modern and the achievement, new achievements of different sizes.

And so today's design has to involve the sciences which are known today. And of course has to rely on experience with failure evaluation of previous diesel engines, of running diesel engines, and in this sense I may stress that this panel in an ideal -- ideally -- very very good sense combines the input for such a design for redesign of diesel engine components, for instance such as a piston.

because we have present a very powerful failure analysis.

We have present material scientists and all these people not the first time in touch with component design, or even diesel design.

We have maintenance experience. We have experience for very thorough evaluation of testing and failures. And this is just what is needed to make a design.

I want to express that in the public most people think a design, a man who is designing, or lady, is just drawing lines out of his experience. This is not true, and this is especially not true today.

The design is bringing together all the experience of the different, of the input from the different special knowledge, and to combine it for defining the shape of a part.

And our experience in the work done in combination with the Shoreham problem that those people working in this group, each for himself, but to a larger extent all together, represent a very very strong power in designing engine component, especially a diesel engine component.

Q. When you say --

JUDGE BRENNER: Mr. Ellis, I'll give you the same suggestion I have given to Mr. Dynner along the way. I think you'd better focus your questions, to the extent you can, in order to get more focused, shorter answers.

MR. ELLIS: Thank you, judge.

Q. When you said "these people" in your answers, were you referring to the panel?

DR. PISCHINGER: To the people on the panel, yes.

MR. ELLIS: Thank you.

Q. Dr. Swanger, you indicated that you were a director of product development for a diesel component manufacturer. Would you tell us, please, what your responsibilities were, how they relate to experience that is relevant to Shoreham.

DR. SWANGER: Yes. As Director of Product Development for the engine parts division of Imperial Clevite I had reporting to me managers of mechanical engineering, metallurgical engineering and product analysis.

Reporting to those managers were metallurgical engineers, mechanical engineers, electrochemists and supporting technicians, for a total Staff of approximately 30 people.

I was personally involved in a number of the technical aspects of the design and development work on pistons, cylinder liners and engine sleeve bearings that went on in this group, as well as being responsible for the administrative aspects.

Q. I think you testified in response to Mr. Dynner's questions about your experience in design of pistons and other -- strike that. In relation -- you testified in response to Mr. Dynner about your experience in design of diesel engine components at Cooper Bessemer. Would you tell us what other design experience you had.

DR. SWANGER: Yes. In addition to that one specific example of a large cast iron piston I discussed, I was involved in the design evolution of other pistons for other diesel engines, with which I worked closely with people, employing finite element analysis, for stress analysis, and also employing thermal analysis for temperature profiles, and using these inputs to help select the materials and the processes necessary to generate those materials.

In addition, I worked extensively on the design of engine bearings, which have, as one of their key features, the thin electroplated Babbitt layer. And in the work on electroplating of the bearings. I developed an expertise on the theory and application of the plating of thin layers of metals on to components.

JUDGE BRENNER: Excuse me, did you say Babbitt layer?

DR. SWANGER: Yes. B-a-b-b-i-t-t. It's a lead or tin-based alloy used for good lubrication and resistance to wear and scuffing.

Q. Dr. Swanger, let me refer you to your resume as well, which I believe is attached as number 6 to the Lilco testimony. Do you have that in front of you?

DR. SWANGER: Yes, I do.

Q. Was your work at Stanford in attaining the PhD and MS degrees also pertinent to your experience at Shoreham?

DR. SWANGER: Certainly it is. This is in the area of materials science and engineering, which is the application of materials, such as nodular iron, for withstanding operation under states of stress or temperatures as defined by the the condition under which those parts operate.

Q. Dr. Harris and Dr. Swanger, I think in his questions, Mr. Dynner asked a number of times about percentage differences between experimental and finite element analysis results. Did these percent differences affect your conclusions? The fact that there are two percentage differences, I think it was 28% and 33%.

DR. SWANGER: No, the conclusions are not sensitive to that small difference of 33% or 28%.

The conclusion that the pistons at Shoreham will not have any potential for crack propagation stands with either one of those.

Q. Did the experimental results change at all in these two figures, 33% and 28%?

DR. SWANGER: The comparison was to one set of experiments, values of which never changed.

The 33% or 28% refers to the degree of conservatism in the finite element analysis relative to the experimental analysis.

I believe that Dr. Harris can tell us about the evolution of the finite element model and as it became more accurate how it closely approached the experimental results

DR. HARRIS: I would like to reiterate Dr. Swanger's statement that the experimental results did not change. What did change, and what was responsible for the changes in the percentages of accuracy that were quoted, were the finite element results.

As we started out on our finite element analysis in pistons, we were using more simplified boundary conditions. Those more simplified boundary conditions led to less accurate stress levels.

As we became aware of the influence of the simplified boundary conditions we decided to continue refining the finite element analysis, to make the boundary conditions more representative of reality.

As we refined the finite element analysis and as we refined the statement of the boundary conditions, the stresses continuously decreased, and became more and more closer to the experimental observations.

At one point -- at various points we were quoting different percentage accuracies.

However, since the final QA report has appeared, the quoted agreement between the finite element and the experiments has not changed.

Another recent development was the rigid versus the soft wrist pin. That's another percentage change in stresses that has cropped up in our discussions. I believe the important points are that the experimental results have not changed.

That's been our you might say bedrock result. And in no case has our conclusion regarding the initiation and propagation of cracks or the lack of propagation of cracks in the piston skirts changed.

The bottom line is independent of those intermediate results that were obtained in the process of coming to our final set of results.

MR. ELLIS: And the final results, is that the May report? Are you referring to the May report?

DR. HARRIS: The May report as was supplemented by the thermal distortion report in June.

Q. Would you expect that there would be refinements in finite element analysis between the preliminary and the final report, so that the extent to which there is agreement with the experimental results would change from preliminary to final report?

DR. HARRIS: Yes, I certainly would expect that. In fact that was the primary motivation for continuing our finite element analysis of pistons. The motivation was to improve the statement of the boundary conditions, and improve the agreement with the experimental observations.

Q. Dr. Swanger and Dr. McCarthy, I believe yesterday there was some discussion with Judge Ferguson, concerning measurement of peak firing pressure. Do you have some data before you that you were looking at during the period of time that you were answering those questions? Let me show you a sheet and see if this is the data you were referring to. If it is, Judge Brenner, I'd like to have it marked and give copies to the Board and the parties.

DR. McCARTHY: On the back sheet of this handout is the data I showed to Judge Ferguson yesterday, and the front sheet is a digitized -- is the digital data that is the source of the composite pressure curve referenced earlier in the testimony, I believe, by several of us. P-5.

Q. Is this the data that was obtained in the testing of one of the engines with the Piezo electric transducer?

DR. SWANGER: Yes, this is data that was taken with the Piezo electric transducer in the air start valve of 103, taken at peak load, 3500 kilowatts.

Q. Were these sheets prepared by FaAA from data prepared by FaAA?

A. These sheets were prepared by FaAA, from data obtained by both Stone and Webster and FaAA during the DG 103 crankshaft torsional test.

MR. ELLIS: Judge Brenner, we'd like to have this marked as a Lilco exhibit, and I am going to offer it into the record.

JUDGE BRENNER: Is there a title at the top? I have something that's practically obliterated at the top of the first page. I can't read it. Maybe the witnesses can help us. Dr. McCarthy, do you know what it's supposed to say? .

DR. McCARTHY: Yes, what the title says. is pressure in psi at one degree increments beginning at top -- at center.

For the purpose of the Board's reading of this numerical sheet, you will note that there are 9 columns and a total of 80 rows down the page. If you can think of the first column on the left hand side as column one over to column 9, and the rows starting at the upper left hand corner as row 1 through row 80. 9 times 80 is 720, for two revolution of the crank, which is what's required to get from one firing to one firing. If you take data at one degree increments you get 720 data points; 9 times 80 is 720.

The way the table is read is starting at the upper left hand entry, which is row one, column one, you read across the page to get consecutive data points, and then start down at row 2, column one, and read across, and so on.

So it reads like a conventional printed page, not down the column and then the top of the next column.

JUDGE BRENNER: Give me a handy title for exhibit purposes of these two pages, Mr. Ellis.

MR. ELLIS: Yes, sir. I think it can be entitled average peak firing pressure measurements on diesel generator 103.

JUDGE BRENNER: All right, why don't we mark it as Lilco Diesel exhibit P-35 for identification so far. Is it okay to give it a numerical designation, 35.

MR. ELLIS: Yes, sir, that's right.

JUDGE BRENNER: The motion is also to move it into evidence. Do you have any objection?

MR. DYNNER: No, but we would, perhaps, like just to check on whether this is in fact the average peak firing pressures as the statement implies.

MR. ELLIS: I think that's a good question. Perhaps I'll just ask the witness to give their label to that. Rather than for me to give my label. I think Mr. Dynner is correct.

Q. Dr. McCarthy, would you give us an appropriate label for this exhibit P-35?.

DR. McCARTHY: P-35 is the curve digitized sheet.

JUDGE BRENNER: Both of them?

MR. ELLIS: Both together.

(Curve digitized data sheet and attachment marked Lilco Diesel Exhibit P-35.)

DR. McCARTHY: Right. The complete title of the digitized sheet, actually the top was cut off is Lilco 13 by 12 test data from air start valve and in cylinder 7 at 100% load.

These digitized values are average values at this cylinder operating point for a large number of cycles. And that's the sheet of digitized data. In other words, for the pressure observed at any given crank angle, in a large number of cycles.

DR. MC CARTHY: At 100% load, the digitized data represents a composite.

The other sheet, which is a graph, versus time, is true peak firing pressure. In other words, the link that looks like a squiggly line, sort of like an EKG or changing voltage level, each little kink in the curve is one peak firing pressure measured on one cycle. You notice the time axis has increments of 50, 100, 150, 200, and 250. Those are seconds. And of course the engine is operating at 450 rpm.

So there's a number of cycles between each of those major divisions.

The upper voltage level, the 1.14, it looks like on your copy it's 1688. That should be 1638. The Xerox --

JUDGE BRENNER: Why don't you read the rest of that term. I was going to ask you the other two terms that are also difficult to read.

DR. McCARTHY: There's 1638 psi peak to peak. That's the upper left hand corner opposite the 1.14.

The lower value --

JUDGE BRENNER: It's a difficult exhibit to read, Mr. Ellis.

MR. ELLIS: Yes, sir. I wish I could have made it better, but we were forced to work with what we had.

JUDGE BRENNER: I think you could have made it better.

DR. McCARTHY: The bottom pressure is

1523. The one over at the right-hand side through the mean line there is 1574.

Now all these pressures, the 1638, the 1523, and the 1574, one has to add the turbocharger boost, which is approximately 30 psi.

Therefore, the 1.14 line is in fact 1668 psi.

Q. Is the data in fact data at a hundred percent?

DR. McCARTHY: Yes.

MR. ELLIS: Judge Brenner, we can and will do better, and will give the record and get the parties better exhibits as soon as we get hold of the original.

JUDGE BRENNER: It's not going to be today, I take it.

MR. ELLIS: No sir, it can't -- I don't think it can be today, because we are --

JUDGE BRENNER: All right.

It's admitted into evidence as Lilco exhibit P-35, consisting of two pages. We can call it simply Lilco EDG 103 cylinder 7 pressure data. Is that generic enough to cover both sheets?

MR. ELLIS: Yes, sir, it is.

MR. DYNNER: I can do this later, but it

might be appropriate to do it now.

Mr. Ellis might want to clarify whether or not this digitalized data is in fact the data that we spoke about during the cross-examination as relating to exhibit P-5.

MR. ELLIS: Yes, this is part of the data which we gave you, I believe, yesterday or whatever we gave you in response to try to accommodate your request for data.

JUDGE BRENNER: All right.

(Discussion off the record.)

Q. Dr. Swanger and Dr. McCarthy, at cross-examination you were asked a number of questions about the firing pressure of 1670 psig that was employed by FaAA in connection with some of its analysis on the piston. What is the significance of this data with respect to that number?

DR. SWANGER: The significance of this data is twofold.

One is that this data, along with its graphic representation in Lilco's exhibit P-5, shows that the peak firing pressure does indeed occur very close to the top dead center position at 7 degrees after top dead center

The other significance of this data is taking the second sheet of Lilco's exhibit P-35, shows that in excess of 800 individual cycles of the engine, taken with the accurate quartz Piezo electric transducer, that the highest peak firing pressure obtained during these experiments at 100% was 1668 psi, including the correction for the inlet manifold pressure.

This is very close to the 1670 psi that was used in the piston analysis center.

Q. Dr. Swanger, there was also testimony during your cross-examination concerning the examination of two pistons from the Kodiak engine. Was the examination of two pistons rather than the entire 16 pistons adequate in your opinion?

DR. SWANGER: Because the Kodiak engine had experienced 6000 hours of operation at a peak firing pressure of at least on an average 1200 psi and a brake mean effective pressure of about 185 psi, that is about 80% of load, we feel that this large number of cycles, approaching 10 to the 8th cycles on these pistons, made it perfectly appropriate only to look at two of the pistons.

The inspections of both of these pistons showed that there were absolutely no

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operationally-induced indications in them.

Q. Dr. Swanger, with respect to tin plating and the questions you were asked on that subject, is it your opinion, or do you have an opinion whether polishing and tin plating of two pistons from the R5 discussed in P-29 was done before or after operation of those pistons in that engine?

DR. SWANGER: Yes. I think there had been some confusion about that point, and consideration of the evidence will clear this up.

The examination of the pistons clearly showed that they had been operated in a engine after the tin plating operation, and that no tin plating had been done after the pistons came out of the engine.

Also, as you recall, there was some leakage current or is there any current, which deposited tin on the inside of the piston, and in fact deposited some tin over the areas of the stud boss region, which were of interest.

Since that tin was still there, that clearly demonstrates that if polishing operation took place before the tin plating, hence that polishing operation took place prior to insertion of these pistons into the R5 engine and prior to the

622 hours of operation at a peak firing pressure of 2000 psi.

Q. Thank you.

Dr. Swanger, one more question on the previous subject.

You testified about 1670 peak firing pressures. Just so that the record is clear, the 2200 psig that was used in some of FaAA's analysis, is that an assumed number, or was that a number that had some basis in experimental data?

DR. SWANGER: The highest value of experimental data that we have is 2000 psi. Both in the R5 engine tests and in the strain gauge test. The 2,200 was an extreme assumed pressure to demonstrate the conservatism of FaAA's analysis.

Q. The 2000 psi from the R5 engine, is that a firing pressure that you would expect in the Shoreham engines?

DR. SWANGER: The Shoreham engines are incapable of reaching a peak firing pressure as high as 2000 psi.

MR. ELLIS: Yes, Dr. Pischinger, did you want to add something? That should be a question.

DR. PISCHINGER: Based on the measurements on the engines in Shoreham, it is quite impossible with the load given, if the load range is observed, that you arrive at 2000 psi.

Q. And would it then follow, of course, a fortiori, that 2200 would not be possible in the Shoreham engines?

DR. SWANGER: That is correct. 2000 psi is an upper bound and certainly no number above it, that upper bound could be achieved.

Q. But the pistons themselves, are they suitable for service at 2000 or 2200 psi?

DR. SWANGER: The pistons have demonstrated by testing in the R5 engine that they are suitable for service at 2000 psi. This is further confirmed by our analysis which demonstrates that based on the fracture mechanics considerations they are suitable for service at 2,200 psi.

JUDGE BRENNER: Mr. Ellis, I am going to take the morning break about this time. If you want to ask a few more questions and break, we can. I leave it up to you.

MR. ELLIS: If we could take the break I may be able to come back and wrap it all up. Very quickly.

JUDGE BRENNER: All right. We will take a break in a moment.

Let me mention something we can add to the crankshaft testimony by Lilco, so that Lilco can consider this. I believe I asked during the conference call last week whether Lilco intended to put all of its crankshaft testimony on together. And I believe the indication on that that call was yes. If that's still the answer I'd like to ask Lilco to reconsider.

MR. ELLIS: I think the answer was yes. But we did not mean to include shot peening in that.

JUDGE BRENNER: All right. Even subtracting shot peening, that helps, because that cuts the panel down from 12 to 6.

MR. ELLIS: That's right, Judge.

JUDGE BRENNER: You have your other concern with Dr. Pischinger, and I don't understand why, if you continue to have that concern, you don't put the rather slim volume, at least in terms of number of pages, of testimony sponsored by Dr. Pischinger and Mr. Youngling, on separately, and first. We have been hearing every other day about a scheduling problem and that seems to me an easy solution.

MR. ELLIS: Well, let's discuss that on the break.

JUDGE BRENNER: That's the only reason I'm raising it.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: So you can consider that. If we did that, we could go through all the parties' questions on each piece of testimony.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: If you don't want to do that, fine, but don't talk to me about scheduling problems later on.

MR. ELLIS: I think we have got that message.

JUDGE BRENNER: Maybe there's some relationship in the subject matter so that you don't want to make that division, although the exact testimony was able to be prepared with that division in mind which might undercut that.

MR. ELLIS: I think, without discussing -- I think there's such a connection and I think we do want a panel of six.

JUDGE BRENNER: I'll let you do that. If that's what you want to do.

MR. ELLIS: Thank you, judge.

JUDGE BRENNER: Let's break until 11 o'clock.

(Brief recess.)

BY MR. ELLIS:

Q. Dr. Swanger, you were asked a number of questions yesterday concerning the thickness or concerning the tin plating on the AE pistons. Do you have an opinion regarding the thickness of the tin plating on the AE pistons at Shoreham?

A. Yes, I do have such an opinion. My opinion is based on inspection of the AE pistons at Shoreham after running the engine, as well as inspection of other pistons, which I will relate.

My opinion is that I saw no performance or operational problems with the tin, and therefore conclude that the tin on the Shoreham pistons is not applied in a layer that is too thick. But there was no evidence of tin migration on the AE pistons after 100 hours of operation at or above full load.

Also, I believe that the tin plating process as done by DeLaval is the same for all of the A series pistons, and therefore my opinion is based on my inspection of more than just the AE pistons. My opinion is that the uniformity of the application of tin on a large population of AE pistons and other pistons that I have inspected has shown me no performance problems. That includes inspection of 32 pistons at the Catawba Nuclear Station after operation, seeing no tin migration, no performance problems associated with tin, an. by inspection of 32 pistons at the Grand Gulf Nuclear Station.

And again these were AE pistons after approximately 200 hours of operation, with no operational or performance problems related to the tin.

It's on this broad population of AE pistons that have run in engines and nuclear service that I have personally inspected that I conclude that there's not a problem with the tin plating on an AE skirts at Shoreham.

Q. Dr. Swanger or others, in cross-examination and in examination by the Board you have used the term isothermal. What do you mean by isothermal in the context of the analysis of the AE pistons at Shoreham?

DR. SWANGER: We have used the term isothermal in two distinct instances.

The first of these instances is in the finite element analysis. There we used the term isothermal to apply to the entire piston assembly, that is the piston and the crown, and the important portion of the analysis there is that the crown is at the same rate of speed as the skirt, and furthermore that the crown itself has no thermal gradients in it and hence no thermal distortion. As one use of the isothermal, which is a conservative assumption, that maximizes cyclic stresses in the AE skirts.

The other use of the term isothermal is when we restrict it just to the AE skirt in operation in the engine.

In that context we referred to isothermal as the fact that even in an operating engine at full rated output, it is our opinion that the skirt itself is essentially isothermal. That is, it is not subject to any thermal distortions.

JUDGE BRENNER: Do you have anything further, Mr. Ellis?

MR. ELLIS: Yes, I was waiting for -- that completes Lilco's redirect examination.

JUDGE BRENNER: Mr. Dynner, do you have any questions?

MR. DYNNER: Yes, Judge Brenner. I have a few questions.

BY MR. DYNNER:

Q. Dr. Swanger, tin plating, that is the thickness of the tin plating on an AE piston, can be accurately measured by use of eddy current measurements, can't it?

A. Yes it can. As was demonstrated on the examination of the R5 piston, with a calibration of tin on nodular iron, which was done microscopically and metallographically by FaAA, an accurate measurement of tin thickness can be done by eddy current.

Q. And did FaAA or Lilco or the owner's group measure the thickness of the tin plating by eddy current measurements on the AE pistons that were installed at Shoreham?

DR. SWANGER: Since our inspection showed that there were no operational or performance problems associated with the tin on the pistons, we felt it was unnecessary, and therefore did no measurements of the tin thickness.

Q. As I understand your testimony, in answer to one of Mr. Goddard's questions, given the maximum variations on the thickness of tin plating for the AE skirt, one could have as little as one mil on one side of the piston theoretically and as many as 8 mil thickness on the other side, is that correct?

DR. SWANGER: I don't think that that

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accurately reflects my testimony.

What I was discussing was the maximum theoretical amount of tin which could be applied around a piston, just based on the examination of the dimensional tolerences as shown on the print.

However, in actual practice, as I had discussed at length, tin plating is very easy to put on in a uniform, circumferentially and longitudinally uniform, layer on the piston.

The variation in the tolerance on both, before plating and after plating, is four hundred thousandths of an inch in both cases. And that just demonstrates that the tolerance on the diameter is unchanged by the plating process. Therefore, this requires that a very uniform and precise layer of tin be applied.

Q. Perhaps you misunderstood my question, because my question was a theoretical one and not what the actual might be. Once you -- if you ever measured by eddy current. My question is given the tolerances, couldn't you have one mil on one side of the piston skirt, and as many as 7 or 8 mils on the other?

MR. ELLIS: Judge Brenner I may need to have the question read back, because I am not sure

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there's any foundation for what the tolerances in fact are.

JUDGE BRENNER: Well we had testimony the other day, Mr. Ellis, that relates to this. The question is whether or not you could theoretically have as much as one mil of tin on the inside and 7 mils of tin on the outside of the piston skirt.

JUDGE MORRIS: No.

MR. DYNNER: No, I think we are assuming that as per the design that the tin plating is only on the outside of the skirt. The question is on one side of the skirt could you have one mil and on the other side, opposite it, could you have as many as 7 or 8 mils thickness.

MR. ELLIS: And my concern was that he said within the tolerances, and I am not sure there was a foundation laid as to the tolerances.

JUDGE BRENNER: That we have on record. We can, I'm sure we will get it as part of the answer now. If not, we will allow you to get it right now.

MR. ELLIS: Thank you.

DR. SWANGER: The amount of tin build-up that could in theory, just based on the dimensional, the diametrical dimensions of the pistons, be applied to the entire outside surface on an diametrical basis is just 7 mils. Therefore if you take this abstract hypothesis that in spite of the high flowing power of a tin bath, due to its high conductivity, and in spite of the fact that electrodes are easily placed around the tin, that somehow you could get one mil on one side, you could only get 6 mils on the other side.

However, there's an additional tolerance specified on the print, that says that 5 key diameters of the piston must all be concentric to each other within one thousandth of an inch.

This additional tolerance on the print for concentricity of 5 key diameters prevents a variation in thickness of tin around the piston of more, in my opinion, about half a thousandth of an inch.

MR. DYNNER: Was that dimension, in fact, measured with respect to all of the AE pistons installed at Shoreham?

MR. YOUNGLING: Mr. Dynner, those measurements were made by our PQC inspection of the pistons at the TDI facility prior to shipment to Shoreham.

JUDGE BRENNER: Is PQC procurement

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quality control?

MR. YOUNGLING: Yes, an arm of Stone & Webster Corporation.

JUDGE BRENNER: As long as I interrupted, Dr. Swanger, what did you mean by "on the print"? Is that the design drawing for the plating process? You referred sometimes in your answer to the phrase "on the print."

DR. SWANGER: Yes, I'm looking at a print for the skirt, two-piece piston 03-341-0 4-AE. It has a complete dimensional specification of the piston, both before and after tin plating.

Q. Mr. Youngling, these measurements, are they documented somewhere?

MR. YOUNGLING: These measurements are part of the total documentation package associated with the release inspections on the pistons prior to shipment.

Q. Was that examination a visual inspection or was it measured in some more accurate way?

MR. YOUNGLING: No, that was a dimensional check.

Q. Now Mr. Youngling, Judge Ferguson asked you some questions about firing pressures. In one of your responses you mentioned the possibility that some of the differences between the cylinder pressures shown before the crankshaft replacement and after the crankshaft replacement in exhibit P-9 might have been affected by the difference in the season.

Could you explain briefly how the seasonal differences would have an impact on pressure readings for the firing pressure of the cylinders.

MR. YOUNGLING: Mr. Dynner, one of the primary effects due to the seasonal differences is the air temperature. And the effect of the air temperature will and can result in a difference in the firing pressures measured, albeit not necessarily a major contributor.

Q. Do the higher temperatures result --

MR. YOUNGLING: Excuse me. Perhaps Dr. Pischinger can add to that.

DR. PISCHINGER: Well, usually, to put it in general terms, in such engines the temperature level varies to a small degree with the ambient temperature, and of course each temperature level has an influence on the ignition lag. And the ignition lag, which is the time between start of injection and start of combustion to initiate the compression stroke, influences to a small degree the peak pressure.

Q. Does a higher ambient temperature usually result in a higher peak pressure or a lower peak pressure?

DR. PISCHINGER: According to this explanation, too little -- a higher ambient temperature shortens the ignition lag, and makes combustion start little earlier, which leads to a little higher pressure.

Q. Could you quantify --

MR. ELLIS Excuse me, may I have the last of that answer read back, please.

MR. ELLIS: Thank you.

Q. Can you, Dr. Pischinger, quantify the effects for us, in some way, that is to say if you have a difference, a higher ambient temperature of let us say 20 degrees, is there some way of quantifying how much, what effect that would have in degrees, or in pounds per square inch on the peak pressure?

DR. PISCHINGER: A modification is only possible if a lot of boundary conditions are known, which I think we do not have at the moment, starting with the number of the fuel with the injection rate, of the injection pump, actual measured injection rate, so I cannot answer this question, but I personally think that the influence is very small in this case. In principle, it's an influence, but in this case, it is a very small influence.

Mr. Youngling described that such influences have been observed, and there's a background for it, but in this case it will not account for let's say variation in peak pressure compared before replacement of the crankshaft and after replacement of the crankshaft.

Q. One more question on this. I just wanted to try to see if you could quantify, when you say it will be a very small influence, are you saying less than 1%? Less than 2%? Given the difference between the coldest winter day and the hottest summer day?

DR. PISCHINGER: Everybody who is familiar with diesel combustion process will back me up when I say such a quantification is not possible.

Q. Now, Mr. Youngling, in answer to another of Judge Ferguson's series of questions concerning inspections of the AE piston skirts, I think you mentioned that there would be, even prior to the first refueling outage, some inspections in order to determine whether there were cracks developing in the AE skirts; would you tell us precisely what methods of inspections you were referring to.

MR. YOUNGLING: First Mr. Dynner I did not say that there would be inspections prior to the first refueling outage to check for cracks.

Q. Perhaps my use of the word inspection may have led to some confusion.

It might have been more accurate, and please tell me if I'm correct. I had thought that maybe the words that you used to Judge Ferguson, was that you be would be looking for cracks. He asked you would you be looking for cracks up to this period, and I think you answered in the affirmative.

MR. YOUNGLING: I believe I testified that during the inspections which were to be accomplished in accordance with the TDI owners group manual and in accordance with the DRQR program at the intervals specified in those documents.

When we had to do other inspections as part of those inspections, we would be performing general overviews of the piston as appropriate, and we would be looking for various signs of abnormal conditions, including cracking.

Q. All right. Now would you tell me in

these overviews how precisely would you go about looking for cracks on the AE pistons?

I'm asking you Mr. Youngling, because you're from Lilco, I think Dr. Swanger might be able to give his views afterwards.

MR. YOUNGLING: Mr. Dynner, I have committed for the company that as part of the inspection of the pistons at the first refueling outage we would inspect the piston boss areas by eddy current.

Q. I am going to interrupt you, because my question was obviously before the first refueling outage.

JUDGE BRENNER: I'm confused as to what you are asking for Mr. Dynner. We have the testimony already this morning, and we are going to get it as to the inspections after the refueling outage and that was not my question. He also testified as to the Kiene gage measurements prior to that. You are not asking about that either.

MR. DYNNER: No sir. I'm asking, and I'll clarify the question, if there was confusion.

JUDGE BRENNER: You're concerned about the time.

MR. DYNNER: Yes, I understand.

JUDGE BRENNER: So the sooner you communicate with each other, the better.

MR. DYNNER: I'll do my best. That's why I interrupted him. I didn't mean to be impolite, but I didn't want you to go in on an area --

JUDGE BRENNER: Go ahead.

Q. Before the inspections, after the first refueling outage, you're going to -- I think you said that in the process of your normal maintenance and overview, you're going to be looking for cracks on the AE pistons, is that correct?

MR. YOUNGLING: As part of the inspections required by the TDI Owner's Manual, and the DRQR program at the intervals specified in those documents, we will be performing overview assessments.

At those intervals.

Q. Now are any of those --

MR. YOUNGLING: Now --

MR. DYNNER: Go ahead.

MR. YOUNGLING: Now in the TDI manual, the first time I have to look at those pistons is at the first refueling outage coming up. In accordance with the DRQR program, the first time I have to look at those pistons is at the 5-year inspection point. Consequently, we will look at the first refueling outage.

Q. But, therefore, you will not be looking for cracks in the AE pistons prior to the first refueling outage, isn't that true?

MR. YOUNGLING: We have already looked at the pistons as part of the DRQR inspections done after 100 hours of operations.

Q. So your answer is between what you have already done, and the first refueling outage, you will not be looking for cracks in the AE pistons, isn't that true? May I have your answer without Dr. Swanger advising you?

MR. YOUNGLING: We will not be looking for cracks between those two inspections points, nor do we have to look for cracks during those inspection points.

MR. DYNNER: Fine.

Q. Now when I said fine, I meant in the context of getting my answer.

JUDGE BRENNER: Since he interjected, I think I'll tell you, you got that answer 10 minutes ago.

DR. PISCHINGER: Expressing confidence in piston.

JUDGE BRENNER: I have enough trouble with the lawyers in this case. Give me a break.

Q. Now Dr. McCarthy, Judge Brenner asked you some questions about the discussion concerning the crankshafts.

Dr. McCarthy, do you know precisely when the cracks initiated in the crankshafts in the Shoreham EDG's

DR. McCARTHY: Not to get hung up on the philosophical question of when precisely any crack initiates. There were no inspections done of the Shoreham crankshaft prior, for cracks, after they were put in operation, but prior to the failure of the first crankshaft.

Q. So you don't know when those cracks first initiated, correct?

DR. McCARTHY: No. Some estimates of the initiation period could be made. I have not made them, but they could be made from a calculation of the crack propagation rates, which can be predicted reasonably well.

Q. I'd like to turn for a moment to the new exhibit P-35

Now it's true, gentleman, isn't it, that the data shown on exhibit P-35 is data reflecting the firing pressures of cylinder number 7 on EDG 103, isn't that correct.

DR. McCARTHY: That's correct, 103 at a hundred percent level.

Q. Cylinder number 7, correct?

DR. McCARTHY: Yes, sir.

Q. Now if you will turn for a moment, please, to exhibit P-9, will you turn to page showing the Kiene gage, what was testified to be the Kiene gage engine cylinder pressure log for EDG 103 post-crankshaft replacement. The 8th page into the exhibit.

You will see there that the pressure taken for cylinder number 7 at, in this case, 3,595 kw, was 130 psi less than the pressure, for example, taken in cylinder number 6, which was 1,680, and number 3, which was also 1,680.

So there's a variation of 130 psi.

Now given this variation, it's true, isn't it, that had you taken the reading for exhibit P-35 on another cylinder in engine 103, you might have gotten a peak firing pressure not of roughly 1680, but in fact a peak firing pressure 100 or more psi higher, depending on the cylinder that you chose.

DR. SWANGER: The data shown on the page

in exhibit P-9 that you have reference to, was taken on April 10, 1984, approximately 4 months after the time of the torsional test that we described.

As you will recall, we discussed that at the time of the torsional test, we had two additional quartz Piezo electric transducers which were fitted to the bleed ports or the test cocks on the cylinder heads, and that these two quartz Piezo electric transducers were moved to test all 8 cylinders.

We did this specifically for the purpose to demonstrate that at the time of torsional test cylinder number 7 was representative of all the cylinders, and was not reading low relative to the other cylinders.

Q. And those are the measurements I have been asking for. Do you know what those measurements are now?

DR. SWANGER: No, we do not have those with us now.

Q. When you say representative, do you have any idea whether -- can you represent now that the variation between cylinder number 7 and any of the other cylinders on the engine at that particular time was within a certain range of psi?

JUDGE BRENNER: While they're conferring, Mr. Dynner, we are going to adjourn promptly on time due to flight schedules, so how much more do you have?

MR. DYNNER: That's it.

JUDGE BRENNER: Does the Staff have any follow-up?.

MR. GODDARD: Yes, just briefly.

JUDGE BRENNER: How much, how briefly?

MR. GODDARD: 5 to 10 minutes

(Discussion off the record.)

JUDGE BRENNER: My apologies. I thought it was 12:45. It's 11:45. Time flies when you're having fun.

JUDGE BRENNER: All my statements about the crankshaft witnesses and so on was based on the loss of an hour in my mind.

MR. ELLIS: We haven't sent anybody home.

JUDGE BRENNER: You must have been wondering what I was talking about, and were too polite to tell me. Don't hesitate to tell me; and I can adjust to my own mistakes. Sorry.

JUDGE BRENNER: We are still waiting for the answer. If you don't know, that's the answer.

DR. SWANGER: We can't give you any

quantitative number now. We would have to check our records and get that information for you.

MR. DYNNER: We will just renew our request for all of that data, and I assume it will be forthcoming at some point.

Q. Now, gentleman, it's true, isn't it, that the information shown on P-9 in the engine cylinder pressure log that I have referred to for EDG 103 was taken by from the test cocks of the cylinders, isn't that correct?

MR. YOUNGLING: Yes, it was taken at the test cocks using a Kiene gage which had been calibrated.

Q. And the test measurements at the test cocks tend to result in lower pressure, cylinder pressure readings than the measurements that were taken with the Piezo electric transducer within the cylinder itself, isn't that true?

MR. YOUNGLING: No, that's not true. We, I believe we testified earlier that it was higher. And I think Dr. Pischinger can give you a further explanation.

DR. PISCHINGER: I think as is also -- already on the records one of the previous days I explained that by the existence of a rather long connecting pipe between the combustion chamber and the point where the Kiene gage is positioned, it is possible that by the phenomenon of pressure increase, by reflection, you can get a higher reading at the Kiene gage.

In any case, the Kiene gage is an apparatus which gives you the maximum of the maximum values of different cycles.

So there's sufficient reason for regarding the Kiene gage reading as being rather too high.

Q. And when you say rather too high, or the possibility is it would be somewhat higher, can you quantify that? Are we talking about 1% difference or more than 1%, in your experience?

A. If you ask on my experience, it can be, it can be a lot. It depends on the geometry and the curve of the combustion pressure versus time. But in this case I do not, and cannot, give you a completely reliable figure.

MR. DYNNER: Thank you.

JUDGE BRENNER: Mr. Goddard.

CROSS-EXAMINATION BY MR. GODDARD:

Q. Thank you, Judge Brenner.

Dr. Pischinger, what, in your opinion,

would be the upper limit on an acceptable thickness for tin plating on the AE piston skirt?

DR. PISCHINGER: Units. Just a moment. Units. Well it comes out by 2 thousandths of an inch.

Q. 2 mils you indicated?

DR. PISCHINGER: 2 mils, yes.

Q. Yesterday did you hear, did Dr. Swanger testify that if tin plating was applied to an AE piston skirt, of minimum dimension or minimum diameter, prior to plating, that as much as 3.5 mils on the radius could be applied, and that the pistons would still meet the outer diameter check?

DR. PISCHINGER: I have in my remembrance that this was a little hypothetical, or theoretical calculation, simply based on the diameter comparison within the tolerances.

If, today, it was a — if, or he said, that if you take into account concentricity of the diameter this variation in thickness will decrease and will not be 3 mils.

Q. That is not the way I heard his testimony, but I'll accept your answer for now.

Dr. Pischinger, it isn't just theoretical if you state that you can take a minimum diameter piston which meets tolerances prior to plating and then measure it to the maximum tolerance after plating. It is quite conceivable that you could have the 3.5 mil plating equally around that piston, is it not?

DR. PISCHINGER: Yes --

MR. ELLIS I object to the form of the question, because he says is it conceivable. Anything is conceivable, and I don't think -- at least my Professor said even a square circle is conceivable to him. He had powers that I don't have. But I don't agree that that form of questioning is appropriate.

JUDGE BRENNER: Why don't you rephrase it.

Q. Dr. Pischinger, based upon the facts which I just presented to you, the dimensions with regard to the tolerances, could not, in fact, an AE piston be plated to a thickness 3.5 mils, and still pass pre-plating and post-plating inspection checks for diameter.

DR. PISCHINGER: I would again check with the drawing.

Well it is true, if you only relate on this measurement and assume these widely range tolerances to coincide, this could be possible.

Q. Without actually measuring the thickness of the plating itself then, it is possible you could get a three point 5 mil thickness plating of an AE piston during this process, is that correct?

DR. PISCHINGER: I agree with you, but I may add that if you get into a situation where the thickness is too high, one would certainly see the smearing effect in operation, and it was testified yesterday, and I personally have, in addition I personally have seen quite a lot of these AE pistons, and I couldn't watch any of this smearing.

So by that I feel quite confident that at least the pistons which are in the engine wouldn't be affected by such an event.

DR. SWANGER: Furthermore, in assessing the likelihood or even the possibility that as much as three and a half mils of tin could be put on, you have to consider the plating process, as well, and that the pistons would have to be in the plating bath with the plating current applied for at least two and a third times as long as the specified amount of time necessary to put the proper amount of tin on.

It is unlikely, in my experience, with electroplating, where automatic timers and automatic controls of currents are commonly used, for such an occurrence to exist.

Q. Dr. Swanger, you don't know where these pistons were plated, do you?

DR. SWANGER: We know that the tin plating is subcontracted out as we testified to yesterday, and we had a lengthy discussion as to the principles of electroplating and how we can make use of the knowledge of general principles to draw reasonable conclusions about what happens in a commercial operation.

JUDGE BRENNER I didn't hear your answer to the question, Dr. Swanger.

DR. SWANGER: That's true. We don't know where they were plated. We know that they were plated by an outside vendor to TDI.

Q. And your reasonable conclusions are all based on the assumptions that they were using techniques and procedures in line with what you are familiar with in your experience, is that not also true?

DR. SWANGER: The primary basis for my conclusion is inspection of pistons, which have actually operated in engines, with no future performance, whether these pistons feature -- with no indications there's excess tin on it. I think that that is the bottom line conclusion, that the pistons, the AE piston skirts at Shoreham are operating properly, given the amount of tin that they do have, and that discussion of whether or not it's measured is secondary to the observation that they have been performing properly.

MR. YOUNGLING: Mr. Goddard, we'd like to just caucus for a moment.

DR. SWANGER: In addition, earlier this morning I mentioned the large number of pistons that I personally have inspected after operation in nuclear plants. And that adds to the strength of my conviction that there is no problem with tin plating on AE pistons.

In addition to that, the TDI owner's group through its component tracking system has access to a much broader data base, and that data base also shows that there are no problems associated with tin plating of any style of piston in TDI engines.

Q. Based upon operational histories to date, is that correct?

JUDGE BRENNER: I guess it's not based upon future operational histories. So I don't understand your question.

MR. GODDARD: Very well, Judge Brenner.

Q. Your conclusions as bolstered by experience, which you have observed may be sound, but does this give you any basis for predicting future results, given the possibility of smearing, the possibility of plating of 3.5 mil thickness?

MR. ELLIS: Judge, I'd like to register a general objection to this line of questioning. I think it's immaterial. There's never been any problem with any TDI piston and tin plating. Here we are talking about hypothetically. Anything is possible in the world, but I haven't seen any basis for pursuing it.

JUDGE BRENNER: I have a contention in front of me that says in part the analysis does not adequately consider tin plated design of the pistons could lead to scoring, causes excessive gas load and thereby causing failure of proper operation. Now it may be, when we are through with our findings we'll find you demonstrating that this tin plating problem, I'm sorry, that this alleged tin plating problem, A, doesn't exist, and B, if it existed would have nothing to do with scoring, but I can't draw that conclusion right now. So your argument hasn't established, in my mind, at least, that the questions are irrelevant to that contention.

And there's some Staff testimony that presumably we will get back to, not back to, we will get to, and you'll have the opportunity to cross-examine the Staff on the subject, and then I can put it all together and make a ruling. But I can't do that right now. So the objection is overruled.

MR. ELLIS: Yes. I know. I think my objection really was to the hypothetical nature. But as you pointed out, the entire contention may be that. May I have the question read back for the panel, please. I think there's a pending question.

JUDGE BRENNER: Yes, there is. Mr. Goddard, can you repeat it.

MR. GODDARD: Not after this dialogue, Judge. I prefer to have the question read back.

JUDGE BRENNER: All right.

(The question is read by the reporter.)

DR. PISCHINGER: I think that the experience, the operational experience with the AE piston skirts, tin plated, if -- as -- if they are, give enough evidence that this very piston skirt will safely operate also in the future as before they have been examined they have experienced full load, and even overload, and they have especially during the break-in period, which used to be very critical, in these cases.

MR. GODDARD: Thank you, Dr. Pischinger.

Q. Just a clarifying question to you. When you said these pistons, do you mean the pistons already installed in the EDG's at Shoreham?

DR. PISCHINGER: Yes.

MR. GODDARD: Thank you.

Q. Mr. Youngling, what if any plans does Lilco have to QA for the thickness of tin plating on future AE pistons which may be used in the diesel generators at Shoreham station?

MR. YOUNGLING: Based on the experience that we have had at Shoreham, and on the recommendations presently in place from the TDI owner's group, we would have no planned future actions any different than what we have put in place now for the purchase of any AE pistons in the future relative to the assessment of the tin plating.

Q. Mr. Youngling, you say other than what you have in place now. Do I interpret that to mean you have no plans presently in place as well to measure the actual thickness of the tin plating on the AE pistons to be purchased in the future?

MR. YOUNGLING: The present requirements are that the documentation is reviewed to insure that TDI has, in fact, performed the tin plating, as indicated on their routing sheets.

Q. When you say performed the tin plating as indicated on the routing sheets, do those routing sheets give any indication of the thickness of tin plating applied or merely that tin plating was in fact performed on the skirts prior to shipment?

MR. YOUNGLING: It indicates that the tin plating was performed prior to shipment.

Q. Perhaps I asked a compound question. I'll just clarify it. Is there any indication on those routing sheets as to the thickness of the plating that was applied?

MR. YOUNGLING: No, there's no indication as to the thickness. However, our experience has shown, based on not only the experience at Shoreham, but within the overall TDI engines, that there is not a problem with the performance of the tin plating.

MR. GODDARD: Thank you. I have no further questions.

JUDGE MORRIS: Dr. Pischinger.

DR. PISCHINGER: Yes.

JUDGE MORRIS: Let me give you a hypothetical situation and then ask a question.

The hypothetical situation would be that excessive tin was on at least part of the piston skirt at the time of start-up of the engine, and the break-in period

Can you describe to me whether the excessive tin would cause a problem during the early period, would not cause a problem for some period of time, or can you say anything about how the problem might arise?

DR. PISCHINGER: If one assumes a higher thickness of the tin plating, excessive, as you say, and the piston diameter is still within the tolerances, you usually get this already mentioned smearing appearance, which usually do not affect the operation of the piston, but of of course you can see this appearance, if you remove the piston

I personally do not know of any case where such a smearing has resulted in a catastrophic piston failure, but it is generally regarded unfavorably, and it could give rise to quicker wear of the moving parts.

Of course, as you stated, this is, in that respect, also the hypothetical, as it depends on the amount of excess of tin. And there's certainly anyway a limit which I myself cannot give at the moment, where this excessive tin plating could lead to troubles with the piston rings.

JUDGE MORRIS: Did you say with the piston rings?

DR. PISCHINGER: Could be, yes, could be referred to the piston ring zone.

JUDGE MORRIS: Would it be possible to produce the kind of scoring that the County alludes to, which might lead to blow-by?

DR. PISCHINGER: I personally think that 3 mils of tin plating, which if -- which would be hypothetically possible, if only the diameter, the diameters are measured, would not lead to such a damage, or effect.

JUDGE MORRIS: Dr. Swanger, do you have an opinion on that?

DR. SWANGER: I have an opinion on that, as well as on the earlier hypothetical question that you had asked, Judge Morris.

I think that there's a valid analogy between the behavior of the tin layer on the piston, and behavior of the thin Babbitt layer on bearings that I had discussed earlier, as part of my experience and expertise.

It has been my experience that when engines have been disassembled in the early part of their life, and this is large medium speed diesel engines, for inspection of the bearings with a Babbitt layer, that if the Babbitt were applied too thick that smearing of the Babbitt would occur very early in the life of the engine. Perhaps on the first few revolutions, when the accommodation of the various moving parts, which is the purpose of break-in, is occurring.

I think that an analogous situation would occur with the pistons if hypothetically they had too much or excessive tin, that the tin migration or the smearing would occur early in the operation, and that this redistribution of the tin would actually accommodate the geometry of the piston to the liner, and then minimize further smearing of the tin later in its life.

As to the second question, about the possibility of this amount of tin leading to excessive blow-by, it is my opinion that the blow-by is primarily controlled by the four compression rings in the crown of the piston, and that a long, multi-step process would have to be hypothesized in which any problem with the tin could then lead to a problem with the compression rings, eventually getting to the point where you could hypothesize blow-by.

Given the unlikeliness of any step in this long chain of steps, I think that 3 mils of tin would not lead to excessive blow-by in the engine.

JUDGE MORRIS: Dr. Pischinger, did you have something else to add?

DR. PISCHINGER: I only want to stress, or to add, I think I didn't do this, that according to my experience, if there is tin migration or smearing, it is in the beginning of break-in, and first load appearance, and then it decreases, according to wear.

JUDGE MORRIS: I won't say fine, as Mr. Dynner was careful to say. Thank you very much. I am not commenting on your answers.

JUDGE BRENNER: I thought you were going to comment on his wanting to stress things.

Any redirect, Mr. Ellis, further redirect?

MR. ELLIS: Yes, I have a couple, Judge Brenner.

REDIRECT EXAMINATION BY MR. ELLIS:

Q. Dr. Pischinger and Dr. Swanger, in the testimony that you have given about smearing, did you observe any smearing on the AE pistons at Shoreham after they had been in operation?

DR. SWANGER: I'll go first and say that, no, I did not observe any smearing of tin on any AE pistons at Shoreham or on any other of a large number of AE or AF or other TDI pistons that I have examined at other locations.

Q. Dr. Pischinger, did you observe any smearing on the pistons at Shoreham?

DR. PISCHINGER: No, I didn't observe any smearing on pistons at Shoreham. I think I stated this already. And neither did those people which reported to me upon being asked see any smearing effect on the pistons.

MR. ELLIS: Mr. Youngling --

DR. PISCHINGER: Yes. Mr. Youngling reminded me I should say those persons who worked for me did give me this information.

Q. Mr. Youngling, Mr. Dynner asked you a number of questions following up on the inspections to be done on the pistons.

Let me see if I can put that into perspective.

You have already testified the pistons were examined by eddy current and liquid penetrant before they were installed and no cracks or indications, relevant indications were found.

And then the engines were run for 100 hours 1.35 --

MR. DYNNER Is this a summary of prior testimony?

MR. ELLIS: It's a question; I am going to put it into perspective. 1.5 million cycles and inspected again by liquid penetrant.

MR. DYNNER: I object. This is a characterization of prior testimony, either he said it or didn't. And I don't think a summary is called for at this point.

JUDGE BRENNER: Objection sustained. Why don't you back up and ask a question. It's also an overly leading problem here at this time in the proceeding.

MR. ELLIS: I am going to get to the question. I thought it would help to put it into perspective.

JUDGE BRENNER: Get to the question now.

MR. ELLIS: I'll get to the question now. I do think perspective would help.

JUDGE BRENNER: Mr. Ellis, please.

MR. ELLIS: I will get to the question.

My questioning has been the shortest. I have questioned for 30 minutes instead of 5 days.

JUDGE BRENNER: I didn't question the length. It was an objection to that particular question, that's all.

Q. Mr. Youngling, you testified that Lilco has committed today to again inspect the pistons at the first refueling outage by liquid penetrant, magnetic particle testing, eddy current testing. How many hours of surveillance testing do you expect the engines to undergo between now and then?

MR. YOUNGLING: Between now and then, the engines will undergo approximately 120 hours of surveillance testing.

JUDGE BRENNER: Is that for each engine?

MR. YOUNGLING: Yes, Judge.

Q. Am I correct that a hypothesized LOOP/LOCA event for 7 days would be approximately 108 hours of engine running?

MR. YOUNGLING: Yes, it would.

Q. How much total time would you expect, even assuming such an event that the engines would have on them between now and the first refueling outage at which time Lilco has committed to reinspect the pistons?

MR. YOUNGLING: At a maximum the engines would have, assuming a 7 day LOOP/LOCA, 288 hours.

MR. ELLIS: Thank you. No further questions.

JUDGE BRENNER: I was going to say, I think we have come to the end, but Mr. Dynner says he has just a little question.

RECROSS-EXAMINATION BY MR. DYNNER:

Q. Gentleman, there's only one area I want to get into. You testified that with respect to the fact that you thought there were no problems evidenced with the tin plating and the AE pistons. Would you please turn to Lilco's exhibit P-32, and about the 9th page in, you can start there. You see it's a page at the bottom of this particular page there's a number A-1.

MR. YOUNGLING: A-2, if that helps you to find this particular page. And the following page is A-1.

MR. YOUNGLING: Yes, sir.

MR. DYNNER: Now the total of this, what this document is, is somewhat obliterated. Perhaps you could help me Mr. Youngling. At the top it says Stone andWebster Engineering Corporation. To the left my copy is obliterated slightly. Do you know what that is referring to, something it looks like report.

MR. YOUNGLING: Yes. The words in the upper left hand corner should be quality control inspection report.

Q. All right. And the date of these two documents for these inspection reports is in the right hand corner February 11, 1984, is that correct?

MR. YOUNGLING: Yes, it is.

Q. And this refers to EDG 102, at the Shoreham plant, doesn't it?

MR. YOUNGLING: Yes, it does.

JUDGE BRENNER: Why don't you get to your substantive question.

MR. DYNNER: Yes.

Q. Now, my question is, does the information shown in the drawings on here, where it indicates in places scored, in other places it states tin flaking, and then on the next page there's a notation that the tin surface appears to be melted, and other places it indicates where.

Are those indications in this inspection report indications that the tin plating is perfectly normal?

MR. YOUNGLING: Mr. Dynner, these inspection reports were associated with the review of the pistons in the DG 102 engine after the 100 hours of operation at greater than or equal to 3500 kw as part of the DRQR program.

The inspection findings were reviewed in accordance with the appropriate procedures, and the wear reported in the inspection reports was deemed acceptable by the vendor, TDI, as documented by their March 1, 1984 letter from Mr. D.I. Schmitz, to Mr. John Kammeyer.

In addition, as part of that inspection process, Dr. Pischinger had to travel from Germany to look at the pistons and other components in the engine and he also looked at these pistons and he should comment on his observation.

DR. PISCHINGER: Yes, I can remember these pistons I saw had no smearing effect which could be caused by too, too thick tin plating. What could be seen, what was seen is some marks, that means linear indications, and some wear, and it was also as well these pistons which had this already mentioned carbon, carbon deposits in the piston and ring grooves.

So I can state this is really no indication of too thick tin layer.

And I think also they were marks which

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had been, they were notes which had been taken by the inspector show that this is true.

Q. Did you record any of your results on documents of your inspection of these particular pistons, Dr. Pischinger? Do you understand the question? Did you write down the results of your inspection when you looked at these pistons?

DR. PISCHINGER: I think it is written down here, but I did not do this writing down.

Q. Did you personally write anything down about the inspections?

DR. PISCHINGER: No, no.

Q. Could you tell me when you looked at the piston that's shown on the page designated A-1.

MR. YOUNGLING: Yes, sir, what did you --

DR. PISCHINGER: What -- please.

Q. A-1.

MR. YOUNGLING: Yes, sir.

DR. PISCHINGER: Yes.

Q. The bottom right hand corner, it's that page I'm speaking about.

What did you conclude about the area that is noted here as tin surface appears to be melted. Was that perfectly normal?

DR. PISCHINGER: This is an area outside

of the running area of the piston above the wrist pin, which has particular no loading contact, and I am not concerned on marks in this region.

Q. Did anyone make any conclusions regarding the area of the tin surface that's noted here as appearing to be melted, as to the cause of that?

MR. YOUNGLING: Mr. Dynner, if you trace the documentation through, we will see that a LDR number.

DR. SEAMAN: 75 was written to discuss the problems for the, or the observations, not the problems, and that was a disposition, and I quote, in accordance with the attached TDI memo --

MR. DYNNER Mr. Youngling, is this one of the documents in this exhibit?

MR. YOUNGLING: Yes it is. I am trying to determine the number, the page number. I'll count the pages. Have you been able to locate the TDI memo?

JUDGE BRENNER: Yes.

MR. YOUNGLING: Let's go forward from there, 7 pages. I'm sorry, I have a problem.

JUDGE BRENNER: This is a difficult exhibit to work with, as we previously discovered.

MR. YOUNGLING: Let me take a few moments.

JUDGE BRENNER: I didn't mean to interrupt your answer, but I observed that I thought you were reading from a document that if it was one we already have in evidence --

MR. YOUNGLING: Yes, it is, but it's improper.

JUDGE BRENNER: Well, can you answer the question directly, I think as to whether the observation was looked into and determined.

MR. YOUNGLING: Yes, it was, Judge Brenner. As part of the program we consulted with TDI personnel, and the observations were judged as normal component wear, and were judged to be acceptable.

The pistons were cleaned and returned to service and have continued in service, and operated satisfactorily.

JUDGE BRENNER: I don't want to get in the way of your questions, Mr. Dynner.

Q. So it's your testimony that you relied on DeLaval to make that judgment, is that true?

MR. YOUNGLING: No sir, DeLaval provided us input. In addition we had the input from the owner's group, as well as the inspections by Dr. Pischinger, and by Dr. Swanger.

Q. Well, Dr. Pischinger just testified that he didn't make any conclusions concerning the melted tin surface. So who was the one --

MR. ELLIS I object to that characterization.

JUDGE BRENNER: That's a mischaracterization.

MR. DYNNER: I'm sorry.

JUDGE BRENNER: Why don't you ask Dr. Pischinger whether he --

Q. Dr. Pischinger, did you make any conclusions concerning the cause of the tin surface that appeared to be melted as shown on this page that's designated A-1.

MR. YOUNGLING: A-3, the right hand corner of the page.

DR. PISCHINGER: Well, I want to state again, this is in a not-loaded part of the piston surface, so with regard to smearing if any smearing effect should have been noticed it should have been that loaded parts of the piston.

Q. Well, Dr. Pischinger, when you inspected this particular piston, did you see it done --

MR. ELLIS I'm sorry, I don't believe the witness is done. I may be mistaken.

JUDGE BRENNER: In an effort to get some more quickly focused answers, if it's okay with me, I am going to let Mr. Dynner do it. He asked a question, he waited a long time. We have gotten that part of the answer; presumably Mr. Dynner is going to come back to focus on what he wanted to. I am going to let him do it.

Q. Dr. Pischinger, let me just make it very easy. When you examined this particular piston personally, did you personally observe this tin surface area that appeared to be melted?

DR. PISCHINGER: Well, I concentrated on and my main emphasis of my observation in the parts of the piston which are highest loaded, and I can at the moment not recall this part to such an extent that I can try to find a cause for this indication in this part.

Q. All right --

DR. PISCHINGER: But the only conclusion I know I have in mind that I found that at that time, whenever seeing it, not as critical. Otherwise I would -- otherwise I would have taken action, I would have taken action.

Q. All right, now Mr. Youngling, do you know whether anybody else came to any conclusions as to

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the cause of this area of the tin plating that is noted as appearing to be melted, if you know? I don't understand why the question calls for a conference. I just asked Mr. Youngling if he knows something.

JUDGE BRENNER: I agree with Mr. Dynner. Do you know, Mr. Youngling?

MR. YOUNGLING: No, but perhaps one of my colleagues can respond for me.

JUDGE BRENNER: Do you want to ask somebody else? Anybody?

MR. DYNNER: Anybody, does anybody know whether anybody came to any conclusions as to the cause of the tin plating that appeared to be melted as noted on this document?

JUDGE BRENNER: And if you don't know in the next few minutes we will find out next Monday whether you know it.

DR. SWANGER: As far as we know, no analysis was made for the cause of this cosmetic effect on this piston. At the time it was judged to be in a non-critical area of the piston, therefore a detailed scientific analysis of a purely cosmetic defect was unwarranted.

Q. And it's your testimony that you could tell without doing any analysis that it was just cosmetic, is that correct?

DR. SWANGER: We could certainly tell, based on knowledge of the design and operating principles of diesel engines and where that indication was on the piston that it was in a non-critical area, and just by visual observation, and rubbing fingers over it to make sure that it was less than a thousandth of an inch in dimensions, it's purely cosmetic.

Q. Did you personally see this area that had been melted. You personally, not Mr. Youngling, did you personally see it, run your fingers over it?

DR. SWANGER: I looked at an awful lot of parts of the Shoreham diesels during this time period when I spent weeks and months at a time at the Shoreham site assisting in all of these operations. A lot of the things that were significant did stick in my mind. This one is insignificant, but in spite of that I do think that I have a recollection of seeing this area on this piston.

JUDGE BRENNER: I don't understand what you meant by the term "cosmetic." Did you mean to imply a preexisting indication, or what?

DR. SWANGER: That it's just a visual contrast indication, that I don't think that it had any functional significance.

JUDGE BRENNER: Well if this was in such a benign area from the point of view of stresses, why would it have occurred in that area?

DR. SWANGER: I think you were probably on the right track, when you said it was probably preexisting.

JUDGE BRENNER: I didn't say that, but go ahead.

DR. SWANGER: Well, I think that you were thinking along the right lines, and that as part of the electroplating process, it is possible that in withdrawing parts from the solution tanks, the solutions can run down the side of a piston and leave marks such as this on a plated part. That's possible that that's what this was.

JUDGE BRENNER: So what you are telling me is that whoever wrote the observation in that report within exhibit P-32, on that page, A-1.

MR. YOUNGLING: A-3. In noting that tin surface appears to be melted, was in error?

DR. PISCHINGER: I think he stated it appeared to be melted, and he didn't say it was melted. I think, I do not know how precise this, or how this, or how it is expressed precisely, but I would translate it that if it appears to be melted, that it had an appearance as if it had been melted. But it didn't confirm that it was really melted.

JUDGE BRENNER: In other words, a preexisting cosmetic blemish, if you will, resulting from the electroplating process probe being withdrawn appeared to be melted to somebody who was expert enough to be performing these inspections.

MR. YOUNGLING: The primary role of the inspectors is to go out and look at the machinery and to note their observation. It's entirely possible that he may have chosen those words to characterize the observation. The most important --

MR. DYNNER That wasn't precisely my point. I'm really asking Dr. Swanger, whether the kind of preexisting cosmetic effect from the electroplating process would, in his opinion, appear to be a melting to somebody who was looking at it?

DR. SWANGER: I think that somebody without broad expertise and experience in electroplating might interpret such a cosmetic area as a minor etching or something like this, could to them appear to be melted.

JUDGE BRENNER: Does that complete your questions?

MR. DYNNER: Yes, sir.

JUDGE BRENNER: The Board has no further questions. Are there any involved on the Staff, just to the last questions asked, series of questions? .

MR. GODDARD: No questions from the Staff.

JUDGE BRENNER: Any redirect?

MR. ELLIS: No redirect.

JUDGE BRENNER: If I get the cast of witnesses correct in my mind, I might not have, I think only Dr. Harris gets to leave permanently and each of the rest ofyou will be here again. Am I right? So I will bid bon voyage to Dr. Harris, and thank you for your time. And to the others I'll say goodbye until we meet again, which will be for some of us at 10:30 Monday morning in this courtroom.

(Hearing recessed.)

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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 13, 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

Official Reporter

Reporter's Affiliation