ORIGINAL

UNITED STATES
NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF:

SHOREHAM NUCLEAR POWER STATION
(Long Island Lighting Company)

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the matter of: :

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

(Long Island Lighting Company) :

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State Office Building,
Veterans Memorial Highway,
Hauppauge, New York.
Tuesday, October 2, 1984.

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

BEFORE:

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

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

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

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APPEARANCES:

On behalf of the Applicant:

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On behalf of the Nuclear Regulatory Commission Staff:

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DONALD HASSELL, Esq.

Office of the Executive Legal Director

On behalf of the Intervenor, Suffolk County:

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DOUGLAS J. SCHEIDT, Esq.,

Kirkpatrick, Lockhart, Hill, Christopher and Phillips,

1900 M Street, N. W.,

Washington, D. C. 20036

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C O N T E N T S

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P R O C E E D I N G S

JUDGE BRENNER: Good morning.

Whereupon,

ROBERT N. ANDERSON,

STANLEY G. CHRISTENSEN,

G. DENNIS ELEY,

DALE G. BRIDENBAUGH,

and

RICHARD B. HUBBARD

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

JUDGE BRENNER: I see we have the same parties present who were present yesterday, namely the Staff, the Applicant, and Suffolk County. Yesterday's transcript erroneously indicates an appearance on behalf of New York State. There was no such appearance yesterday, and there is no such appearance today so far.

We have two preliminary matters. One involves the subject of correspondence to the Board. We said we could consider the subject and perhaps get back to you.

We see no reason to change our established procedures in this case, and they are that copies of routine correspondence will be served on all the parties and the Board. However, the subject now before the Board only relates to the emergency diesel generators. We do not want

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correspondence on other subjects. We mentioned that at a previous conference of parties, I believe, as long ago as last February. Perhaps it was the July conference.

In any event we continue to receive some correspondence, particularly between the Staff and the Applicant on subjects that do not relate to the emergency diesel generators. The parties have got to be selective. Somebody has got to be in charge of deciding which Board receives which correspondence. We don't want it all.

In terms of discovery, of which there is little left in this case, our usual rule is the Board does not have to receive copies of discovery, particularly informal discovery materials.

Receiving information copies of correspondence, however, does not serve the give the Board formal notice of anything. We get a lot of correspondence. It gets lost in the shuffle sometimes. If parties have anything that they want to bring to the particular attention of the Board as support for any action which they desire the Board to take, or in support of their obligation to notify the Board of something, even though the bottom line conclusion of the notifying party is that no action need be taken, then a more formal legal pleading is required to be filed before us.

Changing subjects, the Board is considering setting a finding schedule on the subject of crankshafts to

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commence from the completion of the litigation of crankshafts which we expect will be the end of this week, and we will come back and discuss that later this week. But we raise it now for the parties to consider, and we will hear from the parties on it.

Finding schedules that we will set in this case will be those in accordance with the time set in the regulations.

In addition, we are going to set page limitations on findings, as we stated in one of our prehearing orders. And we will set a page limitation on crankshafts at least later this week, whether or not we order a separate schedule on crankshafts. We understand the parties will be working on the findings, or should be working on the findings, even if we do not schedule a filing on one subject in advance of other subjects.

We may have some page limitations in mind which we can discuss later this week. In any event we will hear from the parties on that subject also later this week, and we raise it now so the parties can consider what their page limitation would be.

The framework of the page limitation would be that the combined pages of findings accorded to each party will be equal. Therefore LILCO, since it has the right of reply, will have to have less pages for its initial filing

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than the other parties and will be allowed to make up the difference in its reply.

That is all we have. Do the parties have any preliminary matters?

MR. BRIGATI: No, Judge.

MR. STROUPE: No, your Honor.

MR. GODDARD: No, your Honor.

JUDGE BRENNER: All right.

We can return then to the subject of shot-peening.

Mr. Stroupe, can you give us your firm time estimates?

MR. STROUPE: I can give you an estimate. I believe I can complete shot-peening in somewhere around two hours this morning. I would hope I could.

JUDGE BRENNER: We must be on a clairvoyant wavelength because if it was going to be longer than two hours, we were going to have a discussion.

MR. STROUPE: If we were clairvoyant I didn't know about it.

JUDGE BRENNER: I know that.

You can assume that you may not be permitted to question beyond two hours from the time we allow you to begin, so save your unimportant questions for a time period beyond two hours. We can visit the subject again if it

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becomes necessary as we approach the two-hour time limit, but operate on that assumption.

Can you give us an estimate, which I recognize may be less firm, for the remaining portion of the crankshaft subject?

MR. STROUPE: Judge Brenner, I would hope that I could complete crankshafts in general in a day to a day and a half.

JUDGE BRENNER: A day and a half is too long.

MR. STROUPE: Well, I was close, wasn't I?

JUDGE BRENNER: I will just give you that comment now, and we don't have to pursue it further at this point.

MR. STROUPE: I would hope that I could complete crankshafts in a day.

JUDGE BRENNER: We expect to finish the issue this week.

MR. STROUPE: So do I.

JUDGE BRENNER: We won't finish in this week if you take a day and a half.

MR. STROUPE: I will do my best, Judge Brenner, to try to complete it in a day.

JUDGE BRENNER: All right. Instead of talking about it, we will let to get to it right now.

MR. STROUPE: Thank you, Judge Brenner.

JUDGE BRENNER: Proceed, please.

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CROSS-EXAMINATION (Continued)

BY MR. STROUPE:

Q Professor Christensen, do you have a bachelor of science degree from a college or university?

A (Witness Christensen) I do, yes.

Q What college or university is that?

A That is from the Connecticut State Board in Connecticut. It is an organization which controls the universities in Connecticut and each year, up to a certain level of education, you can present your credentials to them. They go through your credentials and if there is anything they consider lacking, you are allowed to take those subjects.

This is what I did. They told me that my background in technical education from Britain was way ahead of a bachelor's degree in the United States, and that they could not present me with anything more.

I had to take papers in the English language and in the humanities in order to get that bachelor degree.

Q Is this the only bachelor's degree that you have?

A It is the only bachelor degree that has that name. I have other qualifications from Britain. That is the Extra First Class Engineer's Certificate which is a government examination which classifies me as a first class honors passed. And in that respect I think I would be up to

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any master's degree in the United States.

Q Well, Professor Christensen, you do not have a bachelor of science degree awarded by a college or university in the United Kingdom, do you, sir?

A I do not. I went for other diplomas in the professional field rather than from the colleges.

Q Professor Christensen, do you have any metallurgical training and/or experience?

A I do, yes.

Q And what is the nature of that metallurgical training or experience?

A Mainly in the areas of ferrous metals, the brasses and the bronzes, steel ship's plates, and the general areas of metallurgy as would be required for a competent marine engineer.

Q Have you ever taken a course in metallurgy?

A Yes, I have.

Q And where did you take the course?

A I took that at Poplar Technical College.

Q Was it only one course?

A That was only one course, but we must remember that when we are dealing in marine engineering, so much of our work is associated with metalogy that a lot of metalogy is taught in other subjects.

Q Have you had any training or experience,

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Professor Christensen, in shot-peening?

A Not as such, only what I have read up in technical papers.

Q Professor Christensen, have you had any training or experience in non-destructive examination?

A Yes, I have.

Q What is the nature of that training and/or experience?

A Mainly in Lloyd's Registry of Shipping. I attended courses on X-ray photography for high pressure boiler drums and similar areas where there is very high stress in welded areas. That was in the main.

I also received instruction in the use of magnetic particle detection methods, and I have often been involved, although I had no training in it because it does not require a lot of training if you are mechanically inclined in the first place, mainly in the area of sonic testing for the thicknesses of ships' plates -- I should say ultrasonic testing for the thickness of ships' plates without taking -- drilling holes and having to fill the holes again.

Q This X-ray testing or training that you received at Lloyd's, would that have been in the 1940s when you were employed by Lloyd's?

A In the 1940s I was not employed at Lloyd's. I

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was employed at Lloyd's right at the end of 1940 through 1950.

I received that training at the Kodak organization at Harrow just outside of London, one of the suburbs of London.

Q Again was that in 1949 or '50?

A I think it was in the early '50s. I cannot recall now.

Q Have you had any non-destructive examination training since that point in time?

A No, only the fact that I had been using these things. We had some of our own non-destructive testing equipment when I was with Sugarline in London.

Q Are you a qualified examiner in mag particle, ultrasonic or eddy current examination?

A I have no U. S. qualifications in those subjects, but as a -- what we would refer to as a licensed professional engineer in Great Britain, I would be allowed to perform those tests if I wanted to. If I felt I would be happier with somebody else doing it, a man who is doing it all the time, then naturally I would call one of those people in, but I am well able to judge the results of such testing.

Q Dr. Anderson, I direct this question to you.

Have you had any training or experience in

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non-destructive examination?

A (Witness Anderson) Not per se, no. My interests have allowed me to do a little bit of research in the area.

I also am putting together a course with the professionals in the Bay area to give an extension course at San Jose State, but I have not taken a formal course in it, no.

Q The experience that you indicated involved what sort of non-destructive examination method?

A Principally X-ray, field emission imaging, and ultrasonics.

Q I take it I would be safe in assuming from your answer that you are not a qualified non-destructive examination inspector in any mag particle or liquid penetrant eddy current or ultrasonic?

A No. That would be a technician that would have such qualifications. I don't.

Q Dr. Anderson, what sort of training and/or experience do you have in stress analysis?

A For example, fracture mechanics and areas like that? We teach it at the university. I have not taught the course but I have read the book that we use in it.

I have, in some of my consulting, been required to evaluate -- consulting other than this particular instance -- to evaluate the work of others and in

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particular, we are very blessed at the University in having a very sophisticated CAT system, one of the best in the country.

The CAT system is a computer that IBM has given us which allows us to do finite element analysis in the package so that once we have drawn and characterized the three-dimensional model on the CAT, it can automatically in the package do a finite analysis and I am taking the formal course in that, the post-CAT course.

Q Would that include only finite element analysis as a methodology?

A For the CAT? Yes, it would.

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Q Could you tell me, Dr. Anderson, the name of the text or the book that you referred to?

A We have gone in and out. One of the beauties of teaching is you keep changing the books so the students are always a little off-balance. Hertzberg was the basic text and then we tried others but we tend to go back to Hertzberg.

Q Dr. Anderson, would you agree with me that shot-peening is a work hardening process?

A Yes, I would agree with you.

Q What is meant by work hardening, if you know?

A Essentially we cold work the surface and produce residual stresses which increase the strength of the material.

Q Dr. Anderson, would you please turn to page 133 of the shot-peening testimony, which you are sponsoring. I believe it is still 133. I'm using my version.

A It is in my version, too.

Q Yes, it's page 133.

Do you have a copy of that in front of you?

A Yes, I do.

Q The last sentence of the second answer under crankshaft shot-peening says:

"Shot-peening, however, cannot increase the ultimate tensile strength or the yield

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stress of the fillet material."

Do you agree with that statement?

A Yes, I do. The shot-peening is a surface effect and the fillet is essentially a bulk. In other words, it is not just a surface, it is a continuation of the material. And, therefore, though I characterized the surface as having increased its strength, below the surface it does not

Q Well, would it not be true, Dr. Anderson, that the surface of the fillet radii would be the yield strength or stress of that surface that fillet radii would be increased by shot-peening?

A I believe I said that, yes, sir.

Q Dr. Anderson, do you have an opinion as to the depth to which that increase in strength attributable to shot-peening reaches or lies in the fillet radii area?

A No, I do not. It's a function of several parameters, time, intensity, so that I could not give you an actual parameter. In my own work for NASA it appears that the surface effects are somewhere on the order of a micron.

Q In your own experience with work you're doing for NASA, what sort of material are you talking about?

A Oh, I'm talking about fibrous materials where I am essentially trying to alter the surface. I'm essentially trying to do an equivalent damage to the surface and see if I can improve their properties. These are associated with

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ceramic materials.

Q What would the diameter of one of those fibers be?

A These materials are essentially the materials we used in the space shuttle. And the total diameters are 10 microns to 11 microns. And they're rotated in a field so that we can treat all sides of them.

Q Could you tell me, Dr. Anderson, what a micron is in inches, what the equivalency is?

A Yes. Well, in inches, a micron is normally a millionth of a meter, so there are a thousand to the millimeter.

A Thank you.

Getting back to the replacement crankshafts -- an issue in this proceeding -- I believe you indicated to me that to be able to give me the effective depth of the increase in strength attributable to shot-peening you would have to know the time, the intensity, and some other factors. Don't you, in fact, have access to those figures?

A I'm not sure. Were we referring to trying to estimate it or were we trying to measure it? One technique for actually physically measuring it would be by x-ray diffraction using Bragg's law, where we would be able to get some idea of the distortion to the crystal system.

Q Well, I'm referring to what you were talking

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about. What method were you referring to in terms of being able to judge the effective depth?

A I'm not sure that I-- If I was asked to estimate the effective depth of the cold working, those were the parameters that I would require. But I haven't calculated what the effective depth is because I don't know whether it's uniform in all places, and I haven't seen the final physical specimen.

Q Have you had access, Dr. Anderson, to the LILCO exhibits filed in this proceeding that relate to the shot-peening? Specifically, the various exhibits from Metal Improvements that relate to the quality assurance records.

A Yes, I believe I have.

Q Don't those records contain information as to the intensity at the time, the size of shot, the dimpling effect, and other things?

A Yes, and I believe they had some test strips in the area to insure coverage and the extent.

Q That would be an Almond strip?

A Yes, it would.

Q And can you take that data and then make a calculation or an estimate as to the effective depth of the shot-peening?

A Probably an estimate could be made.

Q Have you done such an estimate?

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A No, I haven't.

Q Why not?

A I'm not sure that it is necessary, since the problems that I'm addressing with shot-peening are not associated with the depth involved.

Q Do you agree with Metal Improvement's statement that the effective depth might be as much as 0.34 inches?

A I have not done the calculation; I can neither agree or disagree.

Q Did you have occasion, Dr. Anderson, to review any photographs of either the shot-peening by TDI or the shot-peening by Metal Improvement upon the replacement crankshafts?

A Yes, I did.

Q And when was that, sir?

A You mean the date that I examined them?

Q Yes, generally; not specifically.

A I believe it was Sunday, this last Sunday.

Q Had you not looked at those photographs prior to last Sunday?

A I don't recall, but I did have access to them on Sunday.

Q You sponsored, did you not, Dr. Anderson, the last answer on page 138 of the County's testimony?

JUDGE BRENNER: Why don't you read the first few

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words of the answer?

MR. STROUPE: "Note, however, LILCO made available to us some, but not all, the photographs taken of the original shot-peening."

WITNESS ANDERSON: No, I believe that Mr. Christensen -- I believe that Mr. Christensen had something to do with this, and that we may have had discussions on it.

BY MR. STROUPE:

Q .While you are, in fact, an indicated sponsor of that answer, are you not, sir?

A (Witness Anderson) No, other than discussions, I don't recall having access to the photographs before last weekend.

Q Dr. Anderson, isn't this answer necessarily based upon an examination of the photographs?

A Yes, it is. That's what I'm saying that I did not have access to them and, therefore, I did not write that paragraph.

Q Well, are you saying now that you did not sponsor this answer?

A Well, no, I'm not saying that, because I did have access to the photographs. I did look at them, did find the faults that were addressed there, and do conclude that the answer is correct.

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Q You did that after the testimony was written and filed?

A That's right. I did not write that testimony.

Q Let me see if I understand this, Dr. Anderson. You filed the testimony --

JUDGE BRENNER: Mr. Stroupe, can I make a suggestion? You're beating it to death. We've got the picture from your first two questions of this page 138. And I'm only making the suggestion because, as I told other Counsel, it is your time.

BY MR. STROUPE:

Q Dr. Anderson, let me address your attention, please, sir, to page 140 of the County's testimony. With respect to the first question and answer on that page, I will ask you again, with respect, if indeed you saw these photographs prior to the time this testimony was written and filed?

A (Witness Anderson) The first question and the answer?

Q Yes, I refer to the question that starts with: "Have you come to any conclusion based on your review of these photographs and the documents identifying deficiencies in the original shot-peening?"

And the answer and response thereto.

A The last sentence would be mine.

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Q Dr. Anderson, do you understand that the designation, which was served upon LILCO, indicated that you sponsored the entire answer to that question?

A No, I do not understand that.

Q That that is incorrect; you would only sponsor the last sentence of that answer?

A No, that's not correct. I think we are defining the word sponsored. I have examined the photographs and I do sponsor the testimony and the previous question that we had. However, on the writing, I did not do that writing.

MR. BRIGATI: Judge, may I clarify something for the record at this point?

JUDGE BRENNER: No, because I don't want to put words in the witness's mouth. We will let you do it at some point in some appropriate way.

MR. BRIGATI: Thank you.

BY MR. STROUPE:

Q Dr. Anderson, I would like, please, sir, an answer to my original question as to whether or not you had seen the photographs referred to in this question prior to the time that the answer was written and filed on your behalf?

MR. BRIGATI: Objection. Asked and answered.

JUDGE BRENNER: No, I'm going to let him ask it given Dr Anderson's previous answer.

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WITNESS ANDERSON: I have no recollection of having seen them prior to the time that I told you.

BY MR. STROUPE:

Q Were you given a copy of the testimony that was to be filed on your behalf prior to the time it indeed was filed?

A (Witness Anderson) I guess, yes.

Q Well, did you read it?

A Yes.

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Q Professor Christensen, have you seen copies of these photographs that Dr. Anderson and I have been talking about?

A (Witness Christensen) Yes, I have seen them at your office in the early part of September. It was either a Saturday, a Sunday or Labor Day. We came up there with Mr. Scheid and I can well remember we were busy in the other office and we spent quite a bit of time there while they were finding the photographs. And I think your representative of your office in Washington said that there were some more photographs to be produced.

MR. STROUPE: I am going to move to strike the last portion of that answer as to what some representative of my office said.

JUDGE BRENNER: It doesn't matter.

Professor Christensen, you could have provided a shorter answer to that question. I am not interested in the human interest side of your visit, I am interested in the substantive side when answering a question like that.

BY MR. STROUPE:

Q Professor Christensen, you sponsor both of these answers that I have been talking to Dr. Anderson about, don't you?

A (Witness Christensen) I do, yes.

JUDGE BRENNER: Mr. Stroupe, before I try to

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discourage you -- now you may think I am being inconsistent -- but the answer Professor Christensen gave you said he saw the photographs in early September and the testimony was filed at some other time. I assumed that your immediate next question would be along those lines but it wasn't.

MR. STROUPE: It was going to be.

JUDGE BRENNER: All right.

BY MR. STROUPE:

Q Did you in fact, Professor Christensen, have an opportunity to review these photographs prior to the time your testimony was written and filed with regard to shot-peening?

A (Witness Christensen) I may have the dates incorrect but I am sure that I have seen these photographs before this testimony was filed, but the exact time and date I maybe cannot recollect correctly.

Q So when you stated that you believed it was on Labor Day, you may have been incorrect?

A There is a possibility of that perhaps, yes.

Q You are aware, aren't you, Professor Christensen, that the County's testimony was filed on July 31, 1984?

A It may have been some other date than -- that I have seen these photographs then.

Q Have you seen these photographs recently, Professor Christensen?

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A Yes, I have seen them this weekend.

Could I make some other comment? I have also seen the final shot-peening on one of the crankshafts at Shoreham last year, so maybe I am getting my times and dates mixed up.

Q Professor Christensen, let me focus your attention to page 138 of the County's testimony, more particularly, to the last sentence in the first answer to the question that says:

"In the location of the inadequate shot-peening, in the lower third of the re-entrant crank pin fillet area, important...," do you have that in front of you?

A Yes, I am just finding it now.

Q Could you take a look at the last sentence in that paragraph, please, sir?

A I see the sentence there, yes.

Q Are you aware, Professor Christensen, that the October 31, 1983 FaAA report on the original crankshafts determine that what is referred to as "cracks" in this sentence was really just fold-overs or layers of metal in the material?

A I am aware of that.

Q So you are aware that the scanning electron microscope photographs in this area did not show, in effect,

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cracks?

A Could I have that question again, please?

Q Yes, sir.

I said so you are aware, are you not, that the scanning electron microscope photographs in this area did not show cracks?

MR. BRIGATI: Objection to the characterization of the FaAA report. That is a conclusion, that is not a fact.

JUDGE BRENNER: Overruled. It is fair cross-examination given Mr. Stroupe's previous foundation question.

WITNESS CHRISTENSEN: Could I ask if the scanning electron microscope pictures you are referring to are of the crankshaft that severed?

BY MR. STROUPE:

Q Well le. me ask you, Professor Christensen. This is your testimony, isn't it?

A (Witness Christensen) It is my testimony, yes.

Q Do you not know whether it referred to the severed crankshaft or not?

A Can I go through the question again so that I can get things clear in my mind, please?

Q Yes, indeed.

(Witness Christensen reviewing document.)

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JUDGE BRENNER: After he has done that, Mr. Stroupe, you should put the question to him again, I believe.

WITNESS CHRISTENSEN: Yes, I have been through the testimony now.

BY MR. STROUPE:

Q Okay, let me restate the question to you, Professor Christensen.

Isn't it true that the scanning electron microscope photographs in this area did not, in fact, show cracks in the initial stages of propagation?

A (Witness Christensen) In the report, the first FaAA report, it mentions that there -- in the severed crankshaft, it mentions that there was a nucleation site, if we like to use that word, which came from -- I think they suggested it was a tool mark and they also went on to say that the crankshaft severed through being overstressed. That is what I was referring to there, if my memory serves me correctly.

Q You were referring here to the score mark in the original 102 crankshaft from which the fatigue crack initiated?

A If I remember the tested -- if I remember the report, I think that was a report by Dr. Wells. He did say that although there was a point there, that it had nothing

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to do with the fact that the crankshaft failed because the crankshaft failed through overstressing. That I well remember.

Q Dr. Anderson, would you agree with me that shot-peening can indeed improve fatigue resistance of a particular component or part?

A (Witness Anderson) Generically?

Q Generally speaking.

A Generally speaking, I agree with you.

Q And will you agree with me, Dr. Anderson, that shot-peening can indeed increase the resistance of a surface of a particular component or a part to fatigue cracking from surface nicks, dings, score marks or scratches, things of that nature?

A Well it is not recommended for rehabilitating a bad surface. If there are cracks and dings and nicks, as you characterize, it would not be recommended. But if the surface was acceptable to begin with, then it certainly would be considered.

Q Would it be considered as having a good effect on the surface in that situation?

A On the surface?

Yes, it would, from the standpoint of putting compressive forces to work to help the physical properties.

Q Dr. Anderson, do you recall testifying in your

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deposition on May 10, 1984 that if the new crankshafts had been surface treated as FaAA recommended that that certainly should improve the fatigue resistance?

A No, I don't recall.

MR. STROUPE: May I have just a second, Judge Brenner?

(Pause.)

MR. STROUPE: At this time I would like to have marked as cross-examination exhibit for identification purposes an excerpt from the May 10 transcript of the deposition of Dr. Anderson.

JUDGE BRENNER: Well let's give it the next LILCO "C" number, whatever we are up to. I don't have a record of having marked any LILCO exhibits after the prefiled C-39.

MR. STROUPE: I believe that is correct.

JUDGE BRENNER: All right. So this will be LILCO Exhibit C-40 for identification. And I take it from the handwritten heading that as of now LILCO is representing that this exhibit for identification consists of excerpted pages 70 and 71 from a May 10, 1984 deposition of Dr. Anderson?

MR. STROUPE: Precisely.

(Whereupon, the excerpted pages 70 and 71 from the 5/10/84 Anderson deposition were marked as LILCO Exhibit C-40 for identification.)

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BY MR. STROUPE:

Q Dr. Anderson, could I ask you to take a moment to review that excerpt from your deposition transcript?

(Witness Anderson reviewing document.)

Have you had a chance to review that, Dr. Anderson?

A (Witness Anderson) Yes, I have.

Q Does that refresh your recollection at all about the question I asked you?

A Only in part. It tells me the question you are referring to but I have the statement "as we have talked about," so apparently there is some previous material.

Do you have the rest of my --

Q I don't have it available now but I can get it for you.

This does not refresh your recollection at all?

A No, I am not sure what was talked about.

Q Well are you aware of any other surface treatment process talked about in your deposition other than shot-peening?

A I don't recall.

JUDGE BRENNER: Mr. Stroupe, you know, to be substantive evidence you are going to have to put the question to him.

MR. STROUPE: Yes, I understand that.

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BY MR. STROUPE:

Q Dr. Anderson, on page 70 of this excerpt that I have given you, at line 26 appears the question:

"Do you know whether or not the fatigue life of the new crankshafts is better or worse than the old?"

Do you see that?

A (Witness Anderson) Yes, I do.

Q And on line 28 the answer appears:

"Indirectly, if it has been surface treated as we have talked about and was recommended by Failure Analysis, then that should certainly improve fatigue resistance."

Now do you recall making that response to that question?

A No, I don't.

Q Is this indeed your testimony to the best of your knowledge?

A I have no reason to doubt it. I would like to see the rest of it so that I could recall what we had previously been talking about.

JUDGE BRENNER: Yes, but that is not the question right now, Dr. Anderson, the question right now is do you remember giving this answer that Mr. Stroupe just read to you?

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WITNESS ANDERSON: No, I don't.

JUDGE BRENNER: I am going to need some testimony at some point if anybody is going to use this that this indeed is from Dr. Anderson's deposition, since you don't have the answer of Dr. Anderson one way or the other on the point and maybe we can get a stipulation of counsel. If not -- and if it is important, somebody could work something out.

MR. BRIGATI: We will stipulate it is an extract from Dr. Anderson's deposition, Judge.

JUDGE BRENNER: All right.

BY MR. STROUPE:

Q Professor Christensen, do you agree that shot-peening, if done properly, can indeed increase the resistance of the surface of a particular component or part to cracking from nicks, dings, scratches, things of that nature?

MR. BRIGATI: Objection, asked and answered.

JUDGE BRENNER: I thought it was, too, but have you switched witnesses?

MR. STROUPE: I meant to say Professor Christensen.

Did I say Dr. Anderson?

JUDGE BRENNER: Well in any event you are addressing it to Professor Christensen?

WRBagb

MR. STROUPE: Yes.

JUDGE BRENNER: Okay.

I take it that moots the objection, Mr. Brigati?

MR. BRIGATI: Yes, Judge.

BY MR. STROUPE:

Q Do you understand the question, Professor Christensen?

A (Witness Christensen) If you could just give it to me again, please?

Q Yes.

Do you agree that shot-peening, if done properly, can increase the resistance of the surface of a particular part or component to fatigue cracking from surface dings, nicks, scratches or abrasions?

A Yes, but. The "but" part is that we know statistically that shot-peening will improve the surface so that there is less chance of fatigue failure.

Possibly in diesel engine practice, as I know it, the best example of that is exhaust valve springs. But we always fit two springs because we are never sure of one breaking and allowing the valve to fall down into the head. So statistically we know it does good, yes.

Q Professor Christensen, may I please direct your attention to page 138 and 139 of the County's testimony, specifically to the answer that follows the question:

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"Have you inspected the original shot-peening on EDG's 102 and 103?"

Will you take a moment to look at that answer?

(Witness Christensen reviewing document.)

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A Yes, I think I have that in my mind now.

Q Could you tell me, Professor Christensen, what you mean by the statement that,

"It appeared that the depth of the undercut areas from machine tool runout was excessively deep in some areas, although it was difficult to tell how deep because of the effect of light and shadows from the photographs."?

A The reason I raised that point was because it appeared from the photographs that the runouts placed in the fillet area from the tool was deep, and it would appear that the compression had made it deeper. From the light and shadow effect, it did not look uniform around the boundary area of the machined part of the pin.

We know that any depths there of any form does act as a stress raiser, and this is why I mentioned it.

Q Did you intend, Professor Christensen, to refer to the area immediately adjacent to either side of the fillet radii?

A Could I have that again, that question please?

Q Yes.

Did you intend by this statement to refer to the area on either side of the fillet radii?

A No, I meant to refer to the area of the tool runouts, which is adjacent to the fine surface of the pin.

WRBpp

Q Would that be in the fillet area itself?

A Yes, it's the tool runouts where we cannot allow a lathe tool to come up to a hard shoulder, because you will break the tool. So in the machining process for a crankshaft, you take a little deeper area in your fillet radii so that the tool can come out to nothing and then the chip breaks away and you do not leave bad stress raises. The space is referred to as machine tool runout, and it is adjacent to the fine surface of the journal. And if you look in the FaAA reports, you will see sketches of it there. And I think it's given as a quarter inch radius on the new crankshafts.

Q Have you had occasion, since the filing of your testimony, Professor Christensen, to review the testimony filed on behalf of LILCO on crankshaft shot-peening?

A I think I've reviewed all the testimony; in fact, I'm sure I've reviewed all the testimony from all parties.

Q Do you recall testimony in LILCO's shot-peening testimony, indicating that the undercut areas for tool runout were not excessively deep, but blended smoothly into the edges of the pins, journals, and the webs?

A Have you finished?

Q Yes.

A What I see in the photographs --

Q That's not what I asked you, Professor

WRBpp

Christensen.

A Could you repeat the question then, please?

Q Yes.

Do you recall having read testimony filed on behalf of LILCO, with reference to crankshaft shot-peening, which indicated that the undercut areas for tool runout were not excessively deep and, to the contrary, blended smoothly into the edges of the pins, journals, and the webs? And, to be fair with you, let me refer you to page 17 of LILCO's crankshaft shot-peening testimony.

A I don't have that testimony here.

(Document handed to Witness Christensen.)

Yes, I can recall the testimony now.

Q As a result of that testimony, are any of your concerns with regard to these potential stress risers alleviated?

A Yes, we may say that it blends in smoothly, but even a large undercut area can blend in smoothly, but it is still a stress raiser there. And this is why I raised the question there, or raised that point.

Q Well, Professor Christensen, isn't it true that even if there were a stress riser or raiser there, the shot-peening would have placed it in compression?

A That is so, yes.

Q So is this really something that you were

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concerned about?

A I am concerned of anything that I see which can have an effect on the life of the crankshaft. And within the realms of my experience, and looking at many, many crankshafts, I deemed this area something of what I will consider unsafe. And that's why I raised the question.

And I have also seen one of the crankshafts at Shoreham, after it had been shot-peened, and I noticed the same effects there. Although you may blend in, if there's some considerable depth there then it becomes a stress raiser, even though it may be removed from some point, some distance from some point, of higher stress. It will create its own higher stress point from the fact that it is a stress raiser or a stress riser.

Q But if, indeed, it is shot-peened, Professor Christensen, would it not be eliminated as a stress riser?

A It would on the surface, but not below.

Q Have you done any calculations to support that answer, Professor Christensen?

A I have not done any calculations, but as I mentioned yesterday, after shot-peening became a question, I researched from the technical literature as much as I could on shot-peening. I can say this very, very definitely, that it is not a process which is normally used in large crankshafts. The reason being that the depth of the

WRBpp

shot-peening related to the diameter of the crankshaft as a ration is very, very small.

MR. STROUPE: I'm going to interrupt, Judge Brenner, and ask that he be instructed to answer my question instead of giving me a dissertation.

MR. BRIGATI: Judge Brenner, I don't think that was a dissertation. I think that Professor Christensen does have a tendency to answer questions a little bit in the long form.

JUDGE BRENNER: He certainly does.

MR. BRIGATI: Well, I have tried to explain to Professor Christensen that you like short answers and that I like short answers. But he comes from Britain and I don't think British people speak as tersely as Americans do, and I hope we can bear that in mind.

JUDGE BRENNER: I would have thought it was the other way around.

MR. BRIGATI: No, Judge.

JUDGE BRENNER: Let me stop you right there and let's deal with this particular example.

Professor Christensen, that was beyond what I would consider a normally acceptable explanation, given the question. We see the connection but it was -- just as I said -- beyond the normal realm of an answer, given the question, which was a specific question. You cannot inject

WRBpp

anything you want to say on a subject, regardless of the question. It's up to your Counsel to come back on redirect.

Most assuredly, by the time our cross-examiner is done your client, and perhaps you, yourself, may feel that some things have not been fully explained because of the way the cross-examiner posed the questions. But that is the cross-examiner's right. And it is up to your Counsel to come back for redirect for any clarification.

You are allowed an explanation but it is a matter of degree, and I think you do have a tendency to exceed the degree that we are used to. And I think we are pretty lenient, based on other Boards and Courts I have seen. And I have him under a time limit and that's another reason why I'm concerned.

You don't have to say anything in reply. I just want you to consider my comments. I don't mean to be critical of you, either. In fact, your answers are interesting. But that isn't the guiding light in deciding whether an answer is too long, given the question.

Mr. Stroupe?

MR. STROUPE: Judge Brenner, let me make sure that I got the answer.

BY MR. STROUPE:

Q Did you, indeed, state you had not done any

WRBpp

calculations to support that statement?

A (Witness Christensen) I did not do any calculations, no.

Q Dr. Anderson, you sponsored this answer too, did you not, sir?

A (Witness Anderson) Yes, I have seen the photographs and I do concur.

Q And do you concur in the answer that Professor Christensen gave and in the machine tool runout and the stress risers?

A No; in that area I don't feel competent to talk about machine tool runout. And what I was looking at was the surface texture which I do see is, by every means, defective. And I was also talking about the apparent appearance of cracks. But the machine tool runout, I just did not recognize it.

Q Well, just so we can get this straight in my mind, and for the purpose of the record, can you look at the answer to, indeed, the second question on page 138 that goes over to page 139 and, indeed over to 140, and tell me what portions of that answer you, indeed, sponsored as your testimony?

(Witness Anderson reading.)

A Starting with seven lines down with, "in addition it appears," and then going to the end of the

WRBpp

paragraph.

Q The first two sentences of that answer, then, you do not sponsor?

A No, I do not.

And that should go down to, "Other photographs showed what appear to be cracks in the shot-peened surface."

Q Could I get that again. It goes from, "In addition it appears, " to where?

A To, "Other photographs showed what appear to be cracks in the shot-peened surface."

Q And it ends there?

A Yes, with that paragraph.

Q What about for the next paragraph?

A Yes, the next paragraph.

Q You sponsor the next paragraph?

A That's what I said; yes.

Q Have you read FRC report, Dr. Anderson?

A Yes, I have.

Q When did you read that, sir?

A I don't recall the date.

Q Professor Christensen, getting back to the answer you and I were talking about, isn't it true that machining a part would create residual compressive stresses on the surface?

WRBpp

A (Witness Christensen) Generally, with modern machine tools, yes.

Q Let me direct both Dr. Anderson and Professor Christensen's attention to the language that starts on page 129, seven lines down,

"In addition, it appears that damage to some of the journal fillets may have occurred," et cetera.

And I ask you to look at that testimony, please?

JUDGE BRENNER: Do you have a question on it?

MR. STROUPE: Yes, sir.

BY MR. STROUPE:

Q Have you both had occasion to look at that?

A (Witness Anderson) Yes.

Q Have you also had a chance to review the testimony filed by LILCO, which indicates that no deep single-shot impacts were found in the original TDI shot-peening?

MR. BRIGATI: Can we have a page reference?

JUDGE BRENNER: That will be helpful because the part I'm looking at doesn't have the characterization "deep."

MR. STROUPE: Page 17.

JUDGE BRENNER: The last answer?

MR. STROUPE: Yes.

JUDGE BRENNER: Where do you see "deep"?

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MR. STROUPE: It's in the question, apparently, if not in the answer.

JUDGE BRENNER: I see; thank you.

MR. STROUPE: Question 21.

JUDGE BRENNER: I see it, now; thank you.

WITNESS ANDERSON: Yes.

MR. BRIGATI: Judge, I object to the form of that question. It does not correctly characterize the testimony.

JUDGE BRENNER: All right. I have it reformed in my mind, and I will state it for the record so we can approach it this way.

All we have so far in the last four minutes is Mr. Stroupe has directed him to two portions of written testimony. That's where we are and now he has to ask a question about it.

BY MR. STROUPE:

Q After reviewing this testimony, would this alleviate any concern you have about deep single-shot impacts which may act as stress risers or raisers?

A (Witness Anderson) No, it would not. First of all, with respect to the answer, they "found no evidence of any isolated single-shot impacts," it is contrary to the photographs that were provided to me, and I would be happy to mark it to show where there is a single impact.

So it is contrary to evidence that I have seen .

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"The second part of reshot-peening by MIC has eliminated any stress risers which could have been produced." It's not clear that they would have eliminated. If they had done the best possible job they would have produced a compressive, a uniform compressive surface. But there still would be differences in that surface.

Q What differences would there be in that surface?

A Well, if you have an anomaly in the surface, and you are damaging the surface -- cold working the surface -- the anomaly will still be there.

Q Other than this photograph that you've referred to, are you aware of any other record, document, or testimony in this proceeding that would indicate such deep, single-shot impacts indeed occur?

A No.

Q Professor Christensen, do you agree with Dr. Anderson's answer?

A (Witness Christensen) Could I have Dr. Anderson's answer read back, please?

JUDGE BRENNER: No, I don't want to go through all that.

MR. STROUPE: Let me just ask the question.

BY MR. STROUPE:

Q Have you had occasion to look at the testimony filed on behalf of LILCO, with reference to the deep, single

WRBpp

shot impacts?

A (Witness Christensen) Yes, I have.

Q Does this testimony alleviate any concerns you have or had with regard to this particular problem?

A No.

Q Why not?

A Because in the photographs there are single-shot impacts which I have seen and I know every single-shot impact will be a stress riser.

Q Are those single-shot impacts that you are referring to all deep?

A It is difficult to see from photographs. But from the light and shadow effect, they appear deep, yes.

Q And you do not believe that reshot-peening would correct or would place in compression, a single-shot impact?

A I am still concerned as to damage occurring from the second shot-peening, whether it will mask previous damage.

Q Professor Christensen, isn't shot-peening a series of multiple single-shot impacts?

A It is that, yes.

Q And I believe you have indicated, have you not, sir, that, generally speaking, shot-peening can be beneficial?

A I have indeed stated that; yes.

WRBeb

Q Have you had occasion, Professor Christensen and Dr. Anderson, to review the records of Metal Improvement and LILCO relating to the second shot-peening of two of the replacement crankshafts attached as exhibits to LILCO's testimony?

A I have seen that exhibit, yes.

Q Are either of you aware of anything in these exhibits that would indicate there is any problem with the second shot-peening performed by Metal Improvement Company?

A Before I make any decision on that I would just like to have a look at any points that you are referring to in the testimony.

Q Well, let me see if I can speed it up by referring you to LILCO Exhibit C-29 and C-30.

A Yes, I have had a chance to look at the testimony here now.

Q Is there anything in that documentation that you are aware of that would indicate to you there is any problem with the re-peening by Metal Improvement Company?

A There is nothing there that would suggest that there is anything bad there, but you must remember that I have a lot of experience in other areas where I have seen shot-peening in effect do damage, and this is in the areas of ships' plates far removed from crankshafts.

Q Well, you are speculating now, aren't you,

WRBeb

Professor Christensen? I asked you if you're aware of anything in these documents or records that would indicate to you that there was any problem with the re-peening or the peening by Metal Improvement Company.

JUDGE BRENNER: Wait a minute. Isn't that the same question you just asked previously and got an answer to?

MR. STROUPE: I didn't think I got an answer.

JUDGE BRENNER: You got an answer in the first half. He was very good about giving you the answer first, and then the explanation. But it is your time.

BY MR. STROUPE:

Q Dr. Anderson, do you agree with that?

A (Witness Anderson) I'm sorry, I was reading a document. I did not hear that answer.

Q Have you had a chance to review those documents?

A The documents that were previously questioned on? No, I haven't. They are down at the other end of the table.

Q Have you had a chance prior to today to review those documents?

A Yes.

Q Do you recall seeing anything in those documents that would indicate to you that there was any problem with the second shot-peening on the 102 and the 103 crankshafts?

A No, I do not. I believe they had an advocacy or

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supportive position.

JUDGE BRENNER: I don't know what you mean by that in the context of the question and answer, Dr. Anderson. Could you explain it?

WITNESS ANDERSON: I find when it comes to shot-peening that people that are in the business tend to advocate shot-peening for just about everything. They believe it is always beneficial, and so that was the thrust of my answer.

JUDGE BRENNER: But where do you see anything in C-29 and C-30 that supports that?

WITNESS ANDERSON: This will take a minute to review.

JUDGE BRENNER: I'll come back later, or somebody else can come back.

But let me return to the general answer you gave me, and then we'll give you an opportunity to look through these exhibits.

How does that description by you of what might be in these exhibits differ from your position as an expert witness before us on behalf of the County?

WITNESS ANDERSON: Well, there were two things in here that support what I just said.

JUDGE BRENNER: I changed the question. Then I will go back to the other one.

WRBeb

WITNESS ANDERSON: May I have it again?

JUDGE BRENNER: How does the description by you of the fact that professionals in the field might have an advocacy or supportive position with respect to shot-peening differ from your position as an expert witness before us on behalf of Suffolk County?

WITNESS ANDERSON: Well, I am neither an advocate nor a detractor, and I will take it on face value and try and be as fair in its application as I can be.

Judge Brenner, there is no free lunch, and when you put the compressing forces on the surface you have to have a balance by tensile forces beneath the surface. And what the literature generally says is what happens is you move the nucleation site from the surface to below the surface.

JUDGE BRENNER: I understand that is your substantive testimony, but you are describing some motives, and I was trying to get a better feel for what you meant by asking you to compare it to your situation here, and I'm not sure you answered the question.

WITNESS ANDERSON: I'm not sure what you are looking for.

I see statements in this documentation saying the company is well-qualified, and I think they are self-serving. I see other statements that say that they

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take no responsibility for scratches or rub marks present. I could go over it and put those together if you wish.

JUDGE BRENNER: All right. Let's return to the specifics.

I took your answer to mean when you talked about their being in an advocacy position -- that is, the authors of C-29 and C-30 -- that there were some statements there that were not supported by the facts which an advocate, in trying to exaggerate the situation, might make. And that's the kind of thing I'm looking for.

WITNESS ANDERSON: May I have a minute?

JUDGE BRENNER: We'll come back to it. Since you apparently had no particular example in mind at the moment, I think it would be fairer to you to give you more time rather than just a minute.

Mr. Stroupe.

If your Counsel wants to come back with it I will allow him to do it. I am not going to pursue it on my own.

MR. STROUPE: I would like to go back and ask just a couple of questions about that. Maybe we can eliminate the problem to a certain extent.

BY MR. STROUPE:

Q Dr. Anderson, would you agree with me that the documents contained in Exhibits C-29 and C-30 are LILCO Quality Assurance documents and Metal Improvement Company

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Quality Assurance documents respectively?

A (Witness Anderson) Yes.

Q Do Quality Assurance documents normally contain an advocacy position?

A I can't comment on that.

Q Dr. Anderson, let me refer you back to page 134 for just a moment, please, sir, of the County's testimony.

Specifically with regard to the answer to the first question on that page that begins with:

"Would properly performed shot-peening of the crank pin fillets to the Shoreham replacement crankshafts significantly improve their fatigue resistance?"

I ask you to please look at that answer.

A Yes, I've read the answer.

Q Have you had a chance to review the letter that is cited as County Exhibit Number 48 in that answer?

A Yes, I have.

Q Do you have any independent knowledge as to whether the author of this letter is a metallurgist or a stress analyst?

A No.

Q And you have never spoken to this gentlemen, I take it.

A That's correct.

WRBeb

Q And you know, don't you, Dr. Anderson, that the R-5 type crankshaft is a V crankshaft?

A Pardon? I did not hear the question.

Q You know, don't you, Dr. Anderson, that the R-5 type crankshaft is indeed a V crankshaft?

A Yes.

Q And wouldn't it be true, sir, that a V crankshaft such as this would have different stresses and strains upon it than the replacement crankshafts in the Shoreham R-48s?

A I have not looked at that. I would defer to Mr. Christensen.

Q You haven't done any stress calculations on crankshafts?

A No.

Q You know, don't you, Dr. Anderson, that TDI regularly shot-peens its V configuration crankshafts?

MR. BRIGATI: Objection. There is no foundation for that testimony or that statement.

JUDGE BRENNER: He is asking him.

MR. BRIGATI: He is asserting it as a fact, sir.

JUDGE BRENNER: No, he is putting it to the witness. The objection is overruled.

WITNESS ANDERSON: No, I do not know that.

BY MR. STROUPE:

Q Have you had occasion to read the testimony of

WRBeb

LILCO with regard to shot-peening that indicates that?

A (Witness Anderson) Do you have a reference? I don't recall that.

Q Instead of taking up my time with that, let me ask you this, Dr. Anderson:

Do you know of any reason why TDI would shot-peen the fillet area of its V crankshafts, if indeed it does, other than to increase the fatigue endurance of those crankshafts?

A Is the question do I have direct knowledge, or am I using my background to try and imagine other reasons that it would be done?

Q Let me state the question to you again, sir.

Do you know of any reason why TDI would shot-peen their V configuration crankshafts in the fillet radii area, if indeed they do, other than to increase the fatigue endurance limits?

A I have no direct knowledge if they do or why they do. The only other reason I could think that it might be appropriate was as a surface finish, to provide a different surface finish.

Q Why would you be interested in a different surface finish, other than for endurance purposes?

A Well, since the photographs that I saw previously are so reminiscent of a shot-blasting, the difference

WRBeb

being you use angular impacting material, that that may be a reason for doing it. I cannot tell.

Q Well, what is the reason for that, though?

A Principally cosmetic.

Q Dr. Anderson, why would you want to affect the cosmetic appearance of a crankshaft?

A Well, you would be removing surface slags or any material that happened to be on the surface, and cleaning it.

Q Isn't that surface a machined surface?

A I cannot tell in these photographs.

Q Do you know whether the surface on the R-48 crankshaft is a machined surface?

A No, I don't.

Q Have you made any attempt to find out?

A No.

Q If indeed the surface was machined, would that make a difference in your analysis?

A There would be no reason for cosmetic, so therefore it would be to enhance the surface compression forces.

Q Thereby increasing the endurance limits of the crankshaft?

A Hopefully, yes.

JUDGE BRENNER: Mr. Stroupe, we can take a break

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at this time. You will have 35 more minutes from the time we return from the break. I hope you can finish up in less than that, but we'll give you that much time.

So we will come back at 10:50.

(Recess.)

AGBeb

JUDGE BRENNER: All right.

Mr. Stroupe, using that clock, keep an eye on things as it approaches 11:30, if it gets to that point while you are still inquiring.

MR. STROUPE: I believe I can finish by that time.

BY MR. STROUPE:

Q Dr. Anderson and Professor Christensen, let me direct your attention to page 134 of the County's testimony, specifically the first answer on that page in response to the question that begins with:

"Would properly performed, shot-peening of the crank pin fillets of the Shoreham replacement crankshafts significantly improve their fatigue resistance?"

I would like to direct your attention specifically to the last sentence of that answer.

A (Witness Christensen) Yes.

Q Have you both now had a chance to review that answer?

(Pause.)

Do you need to consult to answer that?

A I think I was the author of that answer.

Q Dr. Anderson, you do not sponsor that last sentence as your testimony?

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A (Witness Anderson) I agree with that answer, yes. I rely on discussions with Professor Christensen.

JUDGE BRENNER: Let's go off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

BY MR. STROUPE:

Q I will ask these questions of both of you to attempt to save some time.

A (Witness Christensen) I think I can answer this.

Q I haven't asked the question yet, Professor Christensen.

Is it true that the operating temperature for the crankshaft at Shoreham is in the range of 200 degrees to 240 degrees Fahrenheit?

A That is so, but.... The "but" is if you get some warm bearing, then you can come up to quite high temperatures.

Q That's in the event of a problem. Correct?

A Not necessarily in the event of a problem. Usually it occurs after you have taken bearings out of an engine and replaced them.

Q Dr. Anderson, do you agree with the two answers that Professor Christensen just gave?

A (Witness Anderson) I accept his characterization of the temperature, yes.

AGBeb

Q Can you tell me if either one of you has done any calculations that would indicate that at these temperatures, 200 degrees to 240 degrees Fahrenheit, which would support your statement that stress relief of the shot-peening has caused?

A (Witness Christensen) Normal operating temperatures--

Q Could you give me a Yes or No, and then you can explain, Professor Christensen? Have you done any calculations?

A No, but I don't need to do any calculations on the operating temperatures of bearings because I have witnessed so many times the splash-off temperature of the oil coming away from the bearing and I know that the bearing surface will be a few degrees higher.

But when we are speaking here of appreciable heat, I am speaking of a warm bearing and the heat -- the temperature rise can be very, very appreciable.

Q Well, have you done any calculations that would indicate what the degree of stress relief, if indeed there is any, that can be attributed to this rise in temperature?

A Again, I don't need to do observations because I have made observations on crankshafts that have failed, and I have seen a blue color in the area of the fillets where there is no rubbing between the bearings and where the area

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is left completely unrubbed.

JUDGE BRENNER: Professor Christensen, maybe for the record you should explain what a blue color on a ferrous metal surface means to you.

WITNESS CHRISTENSEN: Yes. That color indicates a temperature I think of somewhere around about 600 degrees Fahrenheit.

BY MR. STROUPE:

Q Professor Christensen, this answer indicates that it is intended to apply to the situation as the crankshafts are, does it not?

A (Witness Christensen) I don't quite understand your question. I'm sorry.

Q Well, doesn't the statement in this answer reflect that the material, that being the crankshaft, is subject to appreciable heat as the crankshafts are? Isn't that what it states?

A I don't really understand what you mean by "as the crankshafts are." I'm sorry.

Q Well, is it your testimony that the crankshafts are, in general, subject to appreciable heat?

(The panel conferring.)

I have asked this question of you, Professor Christensen.

A Normally, as I said, I have observed the

AGBeb

splash-off temperature of oil coming from bearings many times, so I don't need to have calculations as to what the temperature of the bearing is.

Q That is not my question, Professor Christensen.

A I thought I had answered it. I'm sorry.

Q Let me repeat my question.

Is it your testimony that the crankshafts, replacement crankshafts in the Shoreham EDGs are subject to appreciable heat?

A Not in normal operation.

Q So this testimony does not refer to the normal operation of the crankshafts in the EDGs?

A It refers to a condition which can easily arise after people have been taking out bearings, for example due to examinations on the crankshaft.

Q Isn't it true, Professor Christensen, that you have had occasion to inspect the bearings in the Shoreham EDGs?

A Yes, I have inspected bearings of the Shoreham EDGs. Yes.

Q Have you ever observed any melted bearings when you were inspecting bearings of the EDGs at Shoreham?

A No, I have not.

Q Do you know, Professor Christensen, what the melting temperature of the babbit on the surface of the

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bearing would be on the Shoreham replacement crankshafts of the Shoreham EDGs?

A I cannot recall without looking at tables the temperature points of babbits because so much depends on the nature of the alloy, whether it is a tin-base alloy, a lead-base alloy, or other factors coming into the piece.

Q Professor Christensen, and Dr. Anderson for that matter, have you had a chance to review that portion of LILCO's crankshaft shot-peening testimony on page 21 thereof, relating to calculations as to thermal relief of shot-peening residual stresses at certain temperatures?

A (Witness Anderson) I have read that. It is true it's a time-temperature response phenomenon and it is linear with respect to the activation energy in the one over T, the log of the effect.

JUDGE BRENNER: Dr. Anderson, I'm sorry. I just didn't hear the end of your statement.

WITNESS ANDERSON: There is a linear arrhenius relationship that exists and therefore, if you go down in temperature, the times for recrystalization take much longer.

I'm not familiar with the low temperature activation energy that was used. However, it does change at low temperatures, and there has been some recent work on that. It would be difficult to predict or extrapolate the

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results at higher temperatures down to lower temperatures because there is a change in the slope, and I don't think you can predict it but it will occur at some time.

BY MR. STROUPE:

Q Do you have any evidence, Dr. Anderson, that at 260 degrees -- pardon me -- that at 392 degrees Fahrenheit approximately 18 percent of the residual stress is not relieved in one hour at that temperature, or more than 18 percent is relieved in one hour?

A (Witness Anderson) That troubles me a bit because normally one talks about 50 percent or half relief, and that's the normal way that it's presented. So the 18 percent, I'm not sure exactly how that was calculated.

I have not tried to reproduce the calculations because I know you can't extrapolate to the lower temperatures.

Q Have you made any calculations on your own which would indicate a percentage or amount of shot-peening residual stress relief caused by thermal effects on the crankshaft?

A No.

Q Professor Christensen, have you?

A (Witness Christensen) No, I have not.

Q So would it be fair to say, gentlemen, that you had no specific figure in mind when you made the statement

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that you made in your testimony on page 134?

A The statement there that is made is based on a statement from one of the largest manufacturers of crankshafts in the world.

Q I am referring to the last sentence that we've been talking about for the last five minutes, Professor Christensen, not to the first sentence.

A I beg your pardon.

No, with my knowledge of what the temperatures can go up to I am not worried about the shot-peening effect of temperature at normal operating temperatures of the engine, but I will know what can go up and what can go on if a bearing is misplaced or a small amount of dirt is left there. And this is the reason why this has been mentioned. It is a very pertinent part of the piece.

Q Do you know what LILCO's bearing inspection procedures and/or intervals are?

A I have seen them recorded, and this is what worries me, because I think they are pulling out bearings far too often, not from the point of view that they are just pulling them out to look at but because there is some doubt there. That's why they are pulling them out for inspections of the crankshaft.

And I know from very hard experience in the repair world of diesel engines that every time you open a

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crankcase door you put the engine at risk.

Q Are these bearings that are being pulled out far too often being pulled out as a result of heat problems?

A No, they are being pulled out by virtue of other problems.

MR. STROUPE: I would move to strike that entire response to my question preceding it then.

JUDGE BRENNER: I thought it was very responsive. Motion denied. If you want to follow up on his answer you can.

MR. STROUPE: I'm saying that answer was responsive. It is the prior answer that I move to strike.

JUDGE BRENNER: I'm sorry, I misunderstood you. Which prior answer?

MR. STROUPE: The immediately preceding answer that dealt with pulling out bearings far too often, because it did not relate to the question that I asked.

JUDGE BRENNER: No, your motion is denied.

Why do you think they are pulling the bearings out, Professor Christensen?

WITNESS CHRISTENSEN: For inspection of the crankshaft and for inspection of the shot-peened areas, and various other inspections because it would appear that there have been doubts in somebody's mind.

JUDGE BRENNER: What is your basis for the last

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part of your answer?

WITNESS CHRISTENSEN: From the various documents that I have seen where LILCO has said they would do something to account for something else, and that they will carry out inspections.

BY MR. STROUPE:

Q I will direct this question to both Dr. Anderson and Professor Christensen.

Have either of you done any calculations as to the size of a subsurface void or inclusion that would be necessary for a fatigue crack to initiate in the subsurface of the replacement crankshafts?

A (Witness Anderson) No, I haven't.

A (Witness Christensen) May I give an answer here also?

Q You certainly may.

A I don't think calculations are needed because experience shows the-- I don't know the exact word in English. A "deficiency" might be the best word. But the smallest possible size, coming down to microns, can act as a stress raiser, even below the surface.

Q But don't you have to know, Professor Christensen, the state of stress acting on that stress raiser or riser to know whether a fatigue crack could initiate?

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A We know that the higher the stress, the greater the chance of it, yes.

Q And you haven't done any calculations that would show you what those stresses are, I take it.

A I have not done any calculations, no, but I think I have sufficient experience to come to some valid idea on the thing without making calculations.

Q Can you then tell me what size inclusion or void in the subsurface area in your opinion, based on your experience, would be necessary to initiate a subsurface fatigue crack in the replacement crankshafts?

A Something microns in size.

Q And is there any method you are aware of for detecting something that is a micron in size in the subsurface of metal?

That is to Professor Christensen.

A Yes, there are various non-destructive examination devices that can be used, but whether they will find particles of the smallest size I don't know. I am not sufficiently well-versed into the smallest size of particles that they can find, but I believe I've seen figures that say certain testing methods will not detect particles under a thirty-second of an inch in size.

Q Is that surface or subsurface?

A I cannot recall now.

AGBeb

Q Professor Christensen, if indeed this is true, how can any manufacturer of any crankshaft be certain that they don't have an inclusion or a void in the subsurface material of the crankshaft which would act as an initiation point for a fatigue crack?

A That is easily covered-- When we take-- This I'm afraid is a -- might be a little lengthy answer, but it is covered by the reduction in the area of the ingot and related to the amount of forging work which is done at the time the crankshaft is made.

Q How does that create an assurance that there is not a void or inclusion of sufficient size to cause a fatigue crack?

A That is accounted for by the fact that the forging is done when the material is hot, and you go through a process of welding much the same as the old blacksmith welded the rim of a cart wheel.

Q Professor Christensen, do you mean to say that thus any crankshaft manufacturer would never have the problem of an inclusion or a void of such a size that would cause a fatigue crack?

A The history of failure of crankshafts is so well written that you will find in most cases that some nucleation site has started very often a very, very minute fault.

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Q What is your definition, Professor Christensen, of a nucleation site?

A The point where a stress raiser is and where a crack may propagate from.

Q Do you have a reason, Professor Christensen, to believe that there is any more risk that there are subsurface nucleation sites or voids or inclusions in the Shoreham replacement crankshafts than there would be in any other crankshafts?

A No. I know that the forging method that these crankshafts were forged on was different and was not the best forging method, and that will give rise to the problem of anisotropy.

Q Do you know, Professor Christensen, who forged the Shoreham replacement crankshafts?

A Yes, Krupp, in Germany.

Q Do you have any knowledge as to whetner they are a reputable forger or manufacturer of crankshafts?

A Yes, I know that they are a reputable company, but it is not the reputation of the company that is in question here; it is the method of forging.

Q I direct this question to both Dr. Anderson and Professor Christensen: If, indeed, there were surface indications or cracks in the fillet radii at the Shoreham replacement crankshafts after peening by TDI, prior to the

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peening by Metal Improvement -- subsequent to Metal Improvement's peening, if that crack or indication was no deeper than .027 inches to .034 inches, would you agree with me that it would be placed in compression or eliminated by the plastic deformation of the surface material?

A (Witness Anderson) It is possible that you can close it, but the literature recommends that you never try to shot-peen to close a crack, independent of its depth or dimensions.

Q Professor Christensen, do you agree with that answer?

A (Witness Christensen) I generally do; yes.

Q And isn't it true, Professor Christensen and Dr. Anderson, that the high resolution eddy current test that LILCO performed on the replacement crankshafts, after 300 hours of operation, would have detected a crack-like indication as small as 1/32 of an inch by 1/64 of an inch?

JUDGE BRENNFR: On the surface, do you want to --

MR. STROUPE: On the surface, yes, thank you, Judge Brenner.

WITNESS CHRISTENSEN: I didn't think we were -- on the surface there are some figures given, in the testimony I believe, on the pistons.

BY MR. STROUPE:

Q Forget about the pistons, let's concentrate on

AGBpp

the crankshafts and the shot-peening and the eddy current testing of the replacement crankshaft.

MR. BRIGATI. Excuse me, do we have a reference in FaAA's testimony to this?

MR. STPOUPE: I can certainly give you one.

JUDGE BRENNER: All right. Maybe that would be helpful.

MR. STROUPE: I believe the reference in testimony is on page 19 of the testimony of LILCO in response -- it is contained in the answer to question 25 and I believe the exhibit is Exhibit C-8.

JUDGE BRENNER: And your question to these witnesses is: Do they have a basis for disagreeing with that, is that the essence of it?

MR. STROUPE: I think I asked these witnesses if they agree with that statement, if they knew that was the case.

JUDGE BRENNER: All right.

WITNESS CHRISTENSEN: I got diverted from the question a little bit. Could I have the question read back to me, please?

MR. STROUPE: Let me restate the question to try to move on.

BY MR. STROUPE:

Q You know, don't you, that according to LILCO's

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testimony the high resolution eddy current testing performed after 300 hours of operation of the replacement crankshafts of the Shoreham EDT's after they had been re-peened by TDI, had the capability of detecting crack-like indications on the surface that would be as small as 1/32 inch long by 1/64 inches deep?

A (Witness Christensen) That is stated there, yes, I would agree with that, that that is capable of that.

Q Dr. Anderson, would you agree with that?

A (Witness Anderson) Yes, I see the statement, yes.

JUDGE BRENNER: That's not the question, Dr. Anderson.

The question is: Do you agree with it?

WITNESS ANDERSON: Yes.

BY MR. STROUPE:

Q I'll direct this question to both of you. Then isn't it true that any crack smaller than .027 inches in depth would have been arrested by the re-peening, whereas a crack larger than .027 inches in depth would have been detected by the high resolution eddy current examination? This, again, is surface cracks I'm talking about.

A (Witness Christensen) Yes, the equipment that you have will find these cracks. But then we go on to other statements that are relevant to this and we see in another

AGBpp

LILCO document that it says, "non-relevant indications found." I don't know what the term "non-relevant" means there. If there is some way of -- whether that is gobbledy-gook for something.

And then we have another document --

Q Let me interrupt you, Professor Christensen, to speed things up.

Would you not agree with me that it is logical to assume that a "non-relevant indication" would be an indication that is smaller than 1/32 inch long by 1/64 inch deep?

MR. BRIGATI: Objection. Mr. Stroup is asking Professor Christensen to interpret the meaning of language used apparently by FaAA.

JUDGE BRENNER: No, I will allow the question. It is a follow-up to the line we have been following -- that Mr. Stroupe has been following.

WITNESS CHRISTENSEN: I don't know for sure.

JUDGE BRENNER: Mr. Stroupe, I don't want to take any time from you, but can you tell me where you got .027 using 1/64 of an inch; or what were you using?

MR. STROUPE: The .027 to .034 is the effective depth of the shot-peening.

BY MR. STROUPE:

Q Dr. Anderson, let me direct your attention

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please, sir, to page 141 of your testimony, specifically the answer in response to the only question on that page.

A (Witness Anderson) Yes.

Q Have you had a chance to look at that?

A Yes, I have.

Q You indicate, do you not, sir, that the masking off and shot-peening of one area and masking off the adjacent area results in stressed areas located directly next to unstressed areas, is that correct?

A That's correct.

Q And you indicate that that difference in surface energy is the driving force for corrosion and environmental attack of the fillet in stress cracking, correct?

A Correct.

Q Isn't it true that the area immediately adjacent to the shot-peened area, in other words, the journals, pins, and webs -- that the webs are machined and the journals are ground?

A The journals are ground. I'm not sure what the webs are.

Q You don't know whether they're machined or ground?

A No.

Q Would you agree with me that machining places a surface in residual compressive stress?

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A Always -- every single time any machining operation? --

Q Generally, sir --

Let's make it more specific.

If, indeed, the webs were machined on the crankshaft in the Shoreham EDG's, would it be your opinion that those surfaces would be placed in compression by the machining?

A You're saying they're not ground, they're machined?

Q Yes.

A Okay.

I'm not sure. I can't really say.

Q Would you agree with me that if the journals and pins are indeed ground or polished, that those surfaces would be placed in compressive residual stress?

A Well then we have a real problem, if they're ground and polished; we have exacerbated the problem that I refer to here. Because one of the driving forces for a homogeneous block of metal is if I rough-in one surface by whatever mechanism and polish the rest of it then the potential -- statically, I will measure a very sufficient voltage and I will have an exacerbated corrosion problem.

Q Have you calculated, or can you determine, sir, the difference in the surface energy between the journals

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and pins and the fillet radii of the replacement crankshafts?

A In this case, no, I haven't seen the crankshaft. But it is an easy measurement. I have all the instruments to do that, and you can measure it quite precisely.

Q Did you request anyone's permission to make such a measurement, sir?

A No, I did not.

Q Can you tell me the difference in surface energy you would have to have between the peened surface of the fillet radii and the polished or ground surface of the journal or pins to act as a driving force?

A That really isn't a very good question from the standpoint it can't be answered. A driving force is any difference in energy. So what you probably should ask is what difference --

Q I'm not really interested in what you think about my qyestion, Dr. Anderson.

A I can't answer it, then.

Q You can't give me a yes or no answer to that?

A No.

Q And you can't give me a figure?

A Pardon?

Q You cannot give me a difference in the figure of surface energy required?

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A Required for what?

Q For the driving force for corrosion?

A Any difference -- any difference in the surface texture will be a driving force.

Q No matter how slight?

A No matter how slight.

Q Well, don't you necessarily have a difference, some slight difference in surface energy whenever you have two different pieces of a part beside each ther?

A Well, more than that, we are talking about a homogeneous piece of metal and the driving force being the difference in surface finishing. And you always have a corrosion condition existing then.

Q And, thus, every piece of that particular component should corrode?

A No, only the anodic areas. The anodic areas are actually protecting the more finished surfaces. So the rougher areas are anodic, they will have a tremendous corrosion tendency, and the polished areas are cathodic and protected by the anodic areas.

Q Isn't it necessary for this difference in surface energy to result in corrosion for there to be an electrolyte present?

A I will get a more rapid rate. There are three components --

AGBpp

Q Could you give me a yes or no before you give me your explanation?

A No.

Q That question is not capable of being answered by a yes or no?

A I answered it no.

Q No, you do not need an electrolyte present?

A That's correct.

Q Why not?

A There are three components necessary for corrosion: driving force, an ionic pathway and an electronic pathway. Now the driving force we have already talked about in great detail. The ionic pathway is electrolytic or any other type of contact that's possible on the surface. It can be a thin film of absorbed moisture. It can be the natural out in the environment or it can be dust. The electron pathway is due to the flow of electrons through the metal itself.

Q Well, isn't moisture an electrolyte?

A Moisture is an electrolyte.

Q Didn't you refer to moisture in your answer?

A Yes, that's one of them. Moisture, film, or dust.

Q So would it be correct you have to have some electrolyte such as dust or moisture present?

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MR. BRIGATI: Objection. Asked and answered.

JUDGE BRENNER: Sounds like it to me, Mr. Stroupe. Do you disagree?

MR. STROUPE: Well I think he gave me a "no" to my original question, you didn't need an electrolyte present and proceeded to give me an answer that included electrolytes.

JUDGE BRENNER: All right. This is about your last question.

MR. STROUPE: I understand that.

JUDGE BRENNER: All right. I will allow you to put it, and then one more after this and that's it.

Do you recall the question?

WITNESS ANDERSON: Yes.

No, I can use non-electrolytes and still have an ionic pathway.

BY MR. STROUPE:

Q Is this possible -- or probable, let me say that -- is it probable, Dr. Anderson, that this would occur in the presence of the grade of lubricating oil that is used in the Shoreham EDG's?

A (Witness Anderson) I don't have the composition of the oil so I cannot answer a yes or no or a probability. But oils do not prevent corrosion. You have to add corrosion inhibitors, and I don't know to what extent those

AGBpp

have been added.

JUDGE BRENNER: I am going to stop you here, Mr. Stroupe, unless you want to make some strongly supported motion, if I am cutting you of in the middle of some golden information here.

MR. STROUPE: I don't think it is golden information, I wouldd have to be quite frank about that.

JUDGE BRENNER: Okay, let's go to the Staff.

MR. GODDARD: Staff has no cross for this panel.

EXAMINATION BY THE BOARD

BY JUDGE BRENNER:

Q Dr. Anderson, in several answers to some questions from Mr. Stroupe you gave your view that the re-peening by Metal Improvements Company would not remove anomalies which may be present or might not; do you recall that?

A (Witness Anderson) Yes, I do.

Q My recollection is you gave that answer in the context of discussing your view that from the photographs there were some single-shot impacts from the original TDI shot-peening that appeared to you, is that correct?

A That is correct.

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Q Are those single-shot impacts the types of anomalies you had in mind that would not be removed by the re-peening?

A In part. The anomaly I was talking about was a crater and the crater is just going to receive the impacts, the second -- the re-impacts differently. They are not going to receive them as a flat surface would, and you can't use it for rough surfaces.

The second would be any impurities or oxides or slags that happen to be on the surface in the area of holidays that could be essentially driven down. So those were the two things that I was referring to at that time.

Q All right. I don't understand as a non-technical person why single-shot impacts that might appear from the initial shot-peening would not be removed by a re-peening that would be of the appropriate level and strength and coverage -- we have to make those assumptions, I'm not saying we will find that but for the purposes of my question I am making this assumption as to the second re-peening -- as to the re-peening --

A Could I try to answer?

Q Yes.

A If you have a flat surface and you are impacting it with the steel balls that are all perfectly spherical, you would expect that you would have approximately equal

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contact on the flat surface. If there was a pit or something like that, you do not get -- there is a shape effect. You do not get a complete impact because you may be at the angle of this pit, you may be at the peak of the rim of it and so that you get some off-center strikes just due to the roughness. You can't use a really rough surface because you get such uneven strikes of the surface. So normally you want to smooth the surface before you shot-peen it.

And in the case where it had been done the first time, it was kind of roughened up. There were some statements about it looked like it had been grit blasted. It had been roughened up and so they should have really smoothed it down before they went and did it again.

Q Well as part of your answer you talked about the problems with a "really rough surface," those were your words.

Is the degree of the isolated single-shot impacts that you believe existed from your review of the photographs in that category -- that is, a surface sufficiently rough -- such that we should worry about existing stress raisers continuing to exist after the re-peening due to the single shot impacts?

A Yes, sir, or I wouldn't have brought it up.

Q Was the depth of these single-shot impacts

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greater than the effective depth of the re-peening?

A I can't tell that. The photograph, because of side light, gives me a feeling for the topography and the roughness but really it sort of flattens out the depth, so I can't really comment on that.

Q Would it affect your conclusion in any way to know the relative depths of the original isolated shots, if any existed, as you believe they did, and the effective depth of the re-peening?

A I think I would want to take depth into consideration. If it was extremely shallow, then I would have a better chance of re-shotpeening.

It didn't appear shallow by the shadows, but that is all I have to rely on.

Q Thank you.

Professor Christensen, I don't have any separate questions for you, but you were involved in some of the testimony on the subject that I just asked Dr. Anderson about and if you wanted to add anything to Dr. Anderson's answer, I didn't mean to preclude you and I want you to know that now.

A (Witness Christensen) I would agree with Dr. Anderson's answers completely.

BY JUDGE FERGUSON:

Q Just a point of curiosity, either Dr. Anderson or

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Professor Christensen, on page 138:

There are two questions asked and I would like for you to look at the second question. The question reads, and I quote:

"Have you inspected the original shot-peening on EDG's 102 and 103?"

And your answer, and I quote is:

"No, however LILCO made available to us some, but not all, of the photographs taken of the original shot-peening."

My curiosity is why did you include the little phrase "but not all?"

A (Witness Christensen) That statement came from me and was in respect to our visit to the office of LILCO's lawyers in Washington and I think the representative there told us that there were more photographs. I think my memory serves me correct on that point.

Q It's just the fact that they did not show you the whole file, nothing was held back, is that correct?

A I believe the photographs were sent from the Richmond office to the Washington office and I think there was possibly some glitch. I don't recall exactly what happened but I am fairly certain in my mind now as my memory serves me that we were told that there were other photographs but they were not available at that point in

AGBagb

time.

Q And you had no interest in inquiring further, is that correct, at that time?

A At that particular time naturally I was interested but so many other events came along and I don't know whether I have seen the rest of the photographs or not.

Q All right. Thank you very much.

BY JUDGE MORRIS:

Q Professor Christensen, do you know whether these photographs were originals or copies or black and whites or color or....

A (Witness Christensen) I don't know, sir, no. The photographs we have here are in color.

Q Are they the same ones?

A I couldn't say, I have no way of knowing.

Q Do they appear to be the same? Do they disclose the same things you observed originally?

A I cannot recall whether some of the photographs that I looked at in the office of Hunton and Williams in Washington -- I have a feeling that I had looked at some black and white photos there as well as color photos.

Q My question was in your opinion do they exhibit the same features that you observed in the original photographs?

A They do. yes.

AGBagb

Q Thank you.

JUDGE BRENNER: Redirect?

MR. BRIGATI: Yes, Judge. Could I have about two minutes to organize my thoughts?

(Pause.)

JUDGE BRENNER: While you are organizing yourself, consider how much time it will take because I will ask you that.

MR. BRIGATI: I think it will take me less than three minutes, Judge.

JUDGE BRENNER: Okay.

REDIRECT EXAMINATION

BY MR. BRIGATI:

Q Professor Christensen, the County's testimony is dated July 31, 1984.

Did you have an opportunity to review that testimony before it was filed with the Board on that date?

A (Witness Christensen) I did, yes.

Q Did you see photographs or the photographs referred to in the answer on page 138 and page 139 prior to the filing of that testimony?

A I must have done, yes.

Q Was that testimony prepared on the basis of your review of those photographs?

A I am sure it was, yes.

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Q Do you recall precisely when you saw those photographs in relation to the time the testimony was filed?

A Could I just have that again, please? I'm sorry.

Q Do you recall precisely when you saw those photographs in relation to the time the testimony was filed?

A Not precisely when, no.

Q Do you recall whether it was more than two weeks before filing of the testimony?

A I cannot recall. The thing that I can recall, it was over a weekend and it may have been on a public holiday.

Q Dr. Anderson, did you see the photographs that are referred to in the testimony on pages 138 and 139 --

MR. STROUPE: Objection, asked and answered.

JUDGE BRENNER: He didn't finish, so I don't know yet, Mr. Stroupe. The other questions were largely asked and answered but since he said he only had three minutes, I didn't want to get too abusive of his time.

Go ahead.

MR. STROUPE: I withdraw the objection to the questions asked.

BY MR. BRIGATI:

Q -- prior to the time that you gave your sworn testimony in adopting the answer on those two pages?

MR. STROUPE: Objection, asked and answered specifically.

AGBagb

JUDGE BRENNER: That is sustained.

MR. BRIGATI: No further questions, your Honor.

JUDGE BRENNER: I told you you would have an opportunity to straighten out the photo problem and you wanted to straighten it out anyway but Dr. Christensen, after you had raised your initial point, answered some questions that I think supplied essentially the same information you just got. But in any event --

MR. BRIGATI: Judge, there is an additional fact that I think should be reflected on the record concerning those photographs.

JUDGE BRENNER: Let me say one thing and see if that helps you or not and, if not, I will let you make your statement. Let me make sure we are finished with the witnesses first and then we will come back to it, if that is acceptable to you.

MR. BRIGATI: Certainly.

JUDGE BRENNER: Am I correct that you had finished your redirect?

MR. BRIGATI: Yes, Judge.

JUDGE BRENNER: All right.

I can't imagine any follow-up based on the questions asked since you asked Mr. Stroupe.

MR. STROUPE: I have just a couple of them based on the questions that you asked of Dr. Anderson.

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I think if you would give me the benefit of asking a couple of questions I can show the relevance.

JUDGE BRENNER: You are entitled to that. Go ahead.

MR. STROUPE: Thank you. You are very charitable.

RECROSS-EXAMINATION

BY MR. STROUPE:

Q Dr. Anderson, you indicated in response to Judge Brenner's questioning that the single-shot impacts still cause you concern in spite of the repeening, correct?

A (Witness Anderson) Correct.

Q Isn't it true, sir, that any time shot-peening is performed and a process such as the peen scan process utilized by Metal Improvement is used, there is a stoppage period of time during which there is stoppage of shot-peening to see if indeed there is full coverage and if there is not then more shot-peening is done for a particular area?

A Yes, peen scan is used for that purpose.

Q Why don't you have the same problem or effect with that situation as you would with a single-shot impact?

A Do you mean the stopping and starting?

Q Precisely.

A Different mechanisms, different mechanisms. If

AGBagb

you have a surface that is perfectly prepared and you can make your contacts on it continuous and not have them spin off into different directions because of the roughness, then that is entirely different than having the process interrupted. I see no relationship to that.

Q But sir, you do not indeed have full coverage in shot-peening, doesn't that mean that there are areas where there may not be a dimple or a crater which then is shot-peened?

A I assume that there is a marginality between that full coverage and where it is coverage, that it tails off or that it's missing areas, holidays. And so I'm not talking about a large condition as I saw in these photographs.

Q Would it be fair to say that any time that shot-peening that you have a single-shot impact or a stray shot, that that destroys the whole shot-peening process?

A No.

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MR. STROUPE: No further questions.

JUDGE BRENNER: Anything based on those questions?

MR. BRIGATI: Yes, Judge, I do.

JUDGE BRENNER: Okay.

MR. BRIGATI: The last question triggered my curiosity.

JUDGE BRENNER: Go ahead.

FURTHER REDIRECT EXAMINATION

BY MR. BRIGATI:

Q Either Professor Christensen or Dr. Anderson, were you referring to a single stray shot when you were discussing stray shot-peening in the photographs, or were there instances of more than one stray shot? Do either of you know?

A (Witness Christensen) There were instances of more than one stray shot, yes.

A (Witness Anderson) Concur.

MR. BRIGATI: No further questions, Judge.

JUDGE BRENNER: All right.

I think we are finished with the questions of the parties of these witnesses. Let them stay there in case our dialogue that we're going to have right now regarding the photos requires any further testimony by the witnesses. I don't think it does, but just in case.

AGBeb

Well, it does. Let me ask Professor Christensen.

FURTHER EXAMINATION BY THE BOARD

BY JUDGE BRENNER:

Q Professor Christensen, do I understand correctly that the time you viewed the photographs of the original shot-peening prior to the time the testimony was filed, you did so at the offices of Hunton and Williams in Washington?

A (Witness Christensen) I know that I looked at some photographs of the shot-peening in the offices of Hunton and Williams, yes..

Q Are those the photographs that you based your written testimony on?

A I cannot really recall. I'm sorry.

Q Were there other times when you viewed photographs of shot-peening prior to the time the testimony was filed?

A I think there are some pictures that I have of finish shot-peening that were taken by my son when we were out to Shoreham on one occasion, and I believe some shot-peening effect is shown in those photographs.

Q I am probably not being very clear. I am talking about the pictures that form -- the photographs that form the basis -- which you said for the basis for your testimony, the answer starting at the bottom of page 138, which is:

AGBeb

"No. However, LILCO made available to us some, but not all, of the photographs...." and continuing on.

And I believe you had one other answer based on photographs, too.

(Pause.)

Maybe I heard you wrong. When you answered questions from your Counsel and also Mr. Stroupe, after which you stated you were certain you had viewed such photographs prior to the time the testimony was filed, you said you recalled doing that at the offices of Hunton and Williams in Washington over a weekend.

A I'm pretty sure that I have seen photographs at Hunton and Williams, but I am not sure whether I have seen other photographs. I have looked at so many photographs, photographs that I have taken myself and photographs that have been taken by other people.

Q Wait a minute. Calm down.

We are talking about photographs of the crankshafts after they were shot-peened by TDI but before they were re-peened. Correct?

A [illegible]s.

Q [illegible] such photographs you [illegible] some

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photographs I have.

Q Stay with the subject of the photographs that you have seen before filing the testimony, according to you, which you believe, among other things, showed some single-shot impacts that might act as stress raisers.

A I'm sure I have seen that before testimony was filed, yes.

Q All right.

Now where would you have seen such photographs?

A I cannot really recall now, Judge. I'm sorry.

Q So that is different than your previous testimony where I thought you said you were sure you had seen such photographs over a weekend, perhaps a holiday weekend, in the Washington offices of Hunton and Williams.

A I did see some photographs in the offices of Hunton and Williams but whether that was the first or the second photographs I am afraid I cannot remember now. I'm sorry.

Q Well, would those photographs-- Whether or not they were the first or second photographs you saw, do you know whether that occasion was prior to the time the testimony was filed?

A I am sure that I have seen photographs that relate to the testimony before it was filed. Yes, I am sure of it.

AGBeb

Q That was not my question. My question was whether the time you say you saw photographs at the Washington offices of Hunton and Williams was a time before the testimony was filed, or could that have been after the testimony was filed?

A I cannot recall now, sir.

Q Okay.

JUDGE BRENNER: So much for my solution that I will now not suggest.

MR. BRIGATI: Thank you for your effort, Judge. It made sense.

JUDGE BRENNER: Not in the end.

MR. BRIGATI: Let me see if I can try to clarify this.

JUDGE BRENNER: You had finished questions of the witness. I will certainly give you the opportunity to follow up on my questions if you want to, but you were also going to make a statement I believe.

MR. BRIGATI: Yes, Judge. We can do this out of the hearing of the witnesses if you prefer this.

JUDGE BRENNER: Maybe we should, because I don't know what you are going to say.

Let's dismiss the witnesses and ask them to leave the room in fact.

(Witnesses temporarily excused.)

AGBeb

JUDGE BRENNER: Perhaps we should do it as a bench conference off the record first, and then, depending on what develops, very quickly after put it on the record.

MR. BRIGATI: That is fine with me, Judge.

JUDGE BRENNER: Let's go off the record, but not yet recess for lunch. Maybe we can clear it up before the lunch break.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

We will adjourn and come back at 1:45.

(Whereupon, at 12:10 p.m., the hearing in the above-entitled matter was recessed to reconvene at 1:45 p.m. the same day.)

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AFTERNOON SESSION

(1:45 p.m.)

JUDGE BRENNER: Good afternoon. We are back on the record.

Whereupon,

ROBERT N. ANDERSON,
STANLEY G. CHRISTENSEN,
G. DENNIS ELEY,
DALE G. BRIDENBAUGH,
and
RICHARD B. HUBBARD

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

JUDGE BRENNER: We had an off-the-record discussion with Counsel for all parties prior to the lunch break involving the testimony by the County's witnesses on shot-peening regarding the photographs they viewed. And Counsel might want to make some statements for the record regarding that, and any further discussions that may have taken place among the parties during the lunch break.

MR. STROUPE: Your Honor, we indeed have talked about it. After conferring with my people, I am willing to stipulate that indeed Professor Christensen and I believe Mr. Bakshi examined photographs -- as indicated in their testimony -- the Saturday prior to the filing of their

WRBpp

testimony, I believe, in the offices of Hunton and Williams in Washington, DC.

JUDGE BRENNER: All right; fine. That would be the Saturday prior to July 31?

MR. STROUPE: Yes.

JUDGE BRENNER: That takes care of that.

Anything else that the parties want to raise regarding the photographs?

MR. BRIGATI: I would like the record to reflect, Judge, that because of the lateness of the opportunity to review those photographs, we were unable to get them out to Dr. Anderson in California in time to review them prior to filing of the testimony itself. But the observations of Professor Christensen were communicated to Dr. Anderson and he tentatively agreed to them, subject to being able to review the photographs in person which he, of course, subsequently did as reflected by his testimony.

JUDGE BRENNER: And, of course, had Dr. Anderson decided otherwise prior to the time the testimony was moved in, Counsel for the County would have been able to use that opportunity to sustain?

MR. BRIGATI: Yes. If Dr. Anderson had disagreed with the testimony, based upon his review of the photographs, we would have moved to correct the attribution of testimony as we did in respect to other testimony that

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has been ascribed to Dr. Anderson.

JUDGE BRENNER: Okay, fine.

Well, as part of the off-the-record discussion we offered the parties the opportunity to consider whether any party wished to move the appropriate examples, limited numbers, of the photographs into evidence. Do the parties have anything on that?

MR. BRIGATI: Judge, the photographs are here and the County would be perfectly happy to move the introduction of one or two examples, if the Board has a desire to see the photographs or make them part of the record. Otherwise, we are prepared to rely upon the testimony as it now stands to describe the County's position concerning the first shot-peening.

JUDGE BRENNER: Let me get the views of the other parties on that.

LILCO?

MR. STROUPE: Your Honor, we would object to the introduction of those photographs. That would necessitate our making a determination, if the photographs that we believe are shot-peening were indeed being presented, and I think we'd have to then make a determination whether we want to present further photographs at that time. And I would prefer, quite frankly, that they not be introduced at this point.

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MR. BRIGATI: In weighing this matter, Judge, you might note that these are photographs produced by LILCO to the County.

JUDGE BRENNER: I understood that.

MR. STROUPE: I don't dispute that.

JUDGE BRENNER: I understand your position.

MR. STROUPE: I'm just saying, basically, that we would have liked to have had these presented as exhibits some time ago.

JUDGE BRENNER: The Staff?

MR. GODDARD: The Staff would not oppose the admission of the photographs, but questions the value they would have to the record in view of the fact that they are not identified one at a time and testified to by particular witnesses. I think putting them in at this point might be somewhat meaningless, but we would not oppose them.

JUDGE BRENNER: Well, if we did them when we've got the witness to say, yes, this is a representative example or examples of photographs we were relying on for that point.

MR. GODDARD: Which the Staff feels would be of limited value, but we would not opposed it, as we stated.

JUDGE BRENNER: All right. We will leave the record where it stands now, given the parties views. And if we have a change of mind we will let you know on a timely

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basis.

MR. BRIGATI: Thank you, Judge Brenner.

JUDGE BRENNER: Given that, the next order of our business would be to proceed with the LILCO cross examination of the County's panel on the subject of crankshafts other than the sub-issue of shot-peening, correct?

MR. ELLIS: We have some preliminary matters, if we may, Judge?j

JUDGE BRENNER: All right.

MR. ELLIS: Which we hope will be brief.

JUDGE BRENNER: Okay.

MR. ELLIS: Judge Brenner, the matter I have is simply to report to the Board in the interest of keeping the Board advised. As the Board knows, and the SER, the Staff has recommended certain confirmatory testing. LILCO and the Staff have been discussing that, and LILCO has agreed to perform some additional testings along lines that are satisfactory to the Staff. I'm prepared to go into some of the details of that now, if the Board wishes. Not all of the details are yet agreed to. When they are, of course, we will give that information to the County and, indeed, hope that we can entice the County to agree to resolve the matter on that basis as well.

But, in any event, there will be some

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confirmatory testing of the 740 or 750 hours, I believe, with credit being given for existing hours since the replacement of the crankshaft. And I'm prepared to go into more detail if the Board wishes.

JUDGE BRENNER: I don't know enough to know if we need more detail.

Do the other parties know what you are about to tell us?

MR. ELLIS: The other parties know what I have just told you, but other than that -- I'm sure the Staff knows what -- or elements of the Staff may know.

I might say this. It's confirmatory testing. I don't think it has anything to do with the scheduling of this hearing. It's going to take a matter of weeks, I think -- 10 to 12 weeks is what I've heard -- if it is done as now contemplated.

JUDGE BRENNER: All right.

But just as a matter of orderly procedure, I think we have made very clear from time to time, that absent exigent circumstances, we want announcements of any nature to be discussed first among all the parties. At a minimum, it avoids the need for another party feeling compelled to react on the record, in part, with the statement that, "This is the first time I've heard it." and then, "but these are my first thoughts on it," and on and on. And it

WRBpp

unnecessarily takes up record time because, very often, we have to revisit the subject anyway after the parties have had an opportunity to think about it.

Given that preference, unless there is a reason why we need to hear more now, prior to the cross-examination of the County's witnesses on the subject of crankshafts, I would like to thank you for the announcement you have made, but stop it at that point, and direct you to discuss it with the other parties, and then inform the Board of what it was you were going to tell us after the parties know and inform us in some efficient manner, whether that involves a writing or an oral report; I will leave it up to you.

MR. ELLIS: Yes, sir. I think that's more appropriate. I had not intended to go into detail today. All the details are not yet resolved. And I told Mr. Dynner today, when I told him about this, that in two days I'd be able to give him additional details about this. I just wanted to take this earliest opportunity, in view of the Board's desire to be kept informed, to tell you, at least, the overall conclusion that there will be some additional confirmatory testing..

JUDGE BRENNER: All right. While you've informed us of that, it's not enough for us to really be informed. But let's leave it at that and discuss it with the other parties. Whether or not what you tell us is timely, given

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what has occurred in the proceeding, we'll decide when you do tell us.

MR. FARLEY: Judge Brenner, may I add one thing?

JUDGE BRENNER: Yes.

MR. FARLEY: It is appropriate background, I think, for you to know this information. In connection with the Board's admonition on the 24th of September, we -- the parties have, as you urged, zealously endeavored to produce a number of volume of documents, beginning with the 24th, the 26th, and even this past Saturday. We represented Mr. Dynner at the time we did that, that there were only two categories of documents -- and to Mr. Goddard, too -- there were only two categories of things or documents that he didn't have that we would make available to him in New York this week.

JUDGE BRENNER: You're talking about documents relating to the blocks?

MR. FARLEY: Yes, sir. And these were the original photographs and pieces of the old 103 block that were cut off -- cut up by FaAA for their examinations.

Unbeknownst to any of us, in connection with this confirmatory testing that Mr. Ellis had related to you, LILCO started to prepare the new 103 machine this weekend for this testing, and in the course of that -- which was confirmed yesterday, and I first learned about it this

WRBpp

morning -- there were surface indications noted in the cam saddle areas numbers 2 and 8 on the new 103 block. And I'm bringing that to your attention at the first opportunity. I have told Mr. Dynner about it and Mr. Goddard. And I have promised Mr. Dynner to produce for him tomorrow, the LILCO reports on that inspection.

JUDGE BRENNER: Okay. That is a different subject than when Mr. Ellis just addressed about further testing and inspections; correct?

MR. FARLEY: It was just background that prompted this continuing preparation of the machine. Otherwise, it would have never have come up.

JUDGE BRENNER: All right.

Anything else?

MR. DYNNER: In view of your comments before, Judge Brenner, I have nothing whatsoever to say at this time, with respect to Mr. Ellis' announcement. I have only one question, which I will address to the Board, but it is really for LILCO, and that is: Do we anticipate supplementary testimony on the indications now found in the new 103 block?

JUDGE BRENNER: Let me stop you there. Talk about it among yourselves. You can more efficiently address it directly to them outside the hearing, in the first instance. And anything we need to be apprised of on a

WRBpp timely basis, I assume we will be.

MR. FARLEY: Thank you, Judge.

JUDGE BRENNER: Off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

WRBeb

You may begin whenever you're ready, Mr. Stroupe.

MR. STROUPE: I think I can just state for the record, too, Judge Brenner, that with regard to Dr. Anderson and Mr. Bridenbaugh and Mr. Hubbard, I do not believe I will have any questions since their testimony related to shot-peening.

JUDGE BRENNER: Yes, I understand.

DIRECT EXAMINATION

BY MR. STROUPE:

Q Mr. Eley and Professor Christensen, let me direct this series of questions to you.

Would you tell me what experience you have had in the design of crankshafts for diesel engines?

A (Witness Christensen) I have had considerable experience in the design of crankshafts.

Q And just briefly, sir, what did that experience consist of?

A That has covered all areas of design for new buildings and for repair work as well.

Q What make engines have you designed crankshafts for, Professor Christensen?

A I have not designed crankshafts for any make of engine, but I was engaged in this area of work whilst as a surveyor of Lloyd's Register of Shipping.

WRBeb

The work that I was involved in was when Lloyd's was called upon to act as consultants in these areas.

Q Would that work-- Strike that.

Isn't it true, Professor Christensen, that that involved determining, under Lloyd's rules, whether the crankshafts met the allowable horsepower limits rather than any design matters?

A That is the way all crankshafts were designed, originally in the marine field and for much of the work in the stationary field.

Q Well, did you use your independent engineering judgment, or did you indeed rely upon the various provisions and codes of Lloyd's rules?

A We relied on codes and on engineering judgment as well.

Q Would this have been a situation where you were making the determinations as to the allowable limits of the crankshaft by yourself, or with other people?

A In most cases by myself; in extreme cases at Lloyd's my work would have been supervised by the senior of the department.

In the area of repair work I stood alone and made my own decisions and fell or stood by them.

Q What sorts of design work was necessary in the area of repair work, sir?

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A There I converted a series of solid forge crankshafts which had failed in a certain area; that is at the after-web area we went from a solid-forge crankshaft to a shrunk-fit repair.

Q So that didn't really involve design of the crankshaft, I take it?

A It involved stress analysis because of the room available to carry out the repair.

Q You said it involved stress analysis?

A Correct.

Q Did it involve torsional stress analysis?

A That came later. The first part was that I got involved with the amount of area that we could leave around the eye that formed the shrink-fit in the web.

Q Mr. Eley, what has your experience been in the design of crankshafts for diesel engines?

A (Witness Eley) Once with a ship-building company called Austin and Piersgills, which is part of the British ship-builders group, it was my responsibility to determine the adequacy of all of the equipment that went onboard those vessels, and that included the adequacy of the design of the main engines, the generating engines, the pumps, compressors, all of the equipment onboard the vessels.

I have also done, in my courses in UK, torsional analysis and vibration analysis on shafts, but they were not

WRBeb

crankshafts, they were shafts.

Q And when did you do that torsional vibratory analysis, sir?

A I didn't say that it was a torsional vibratory analysis. Well, it is in a way. Okay.

I did shaft torsion, which was one separate section, and whirling of shafts, which was another separate section, which was a torsional vibration analysis.

Q When was that, sir?

A In the second from last year of my Higher National Certificate so it would have been about 21 years ago.

Q When you were determining the adequacy of the design of those engines you referred to, both the main engines and the auxiliary engines, did you have occasion to attempt to make a determination as to the adequacy of the crankshafts?

A All I did for the engine that we were considering used to be supplied to me. I would then look at all of the data and determine its adequacy under Lloyd's rules.

I do believe we had one vessel that was to the American Bureau of Shipping requirements also. That was Ship Number 854, if my memory serves me correctly.

Q Were you determining the adequacy of those crankshafts under Lloyd's empirical formula for allowable

WRBeb

allowable horsepower?

A Yes, I was.

Not just the crankshafts, I might add, the whole engines also.

Q Other than that experience, have you had any occasion, Mr. Eley, to be involved in the design of a crankshaft from the ground up, so to speak, from the beginning of that shaft?

A I served an apprenticeship with George Clarke in Northeastern Raine, the engine builder for the Salzer group, and I was responsible for fitting those engines right from the bedplate upwards, which included putting the crankshafts in there.

And once we had completed the engine build, I did assist with the setting up of the torsiograph as such, but I was not involved with the torsional section at that time. I did assist but I did not actually do the stress analysis.

Q So it is true, isn't it, that you haven't in fact been involved with the design of a crankshaft from the outset?

MR. BRIGATI: Objection, asked and answered.

MR. STROUPE: I don't believe I got a Yes or No answer to my question. He gave an explanation without giving an answer.

JUDGE BRENNER: All right. Let's get a precise

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answer rather than trying to infer it from the explanation.

Do you recall the question?

WITNESS ELEY: Would you repeat it, please?

MR. STROUPE: Yes, Mr. Eley.

BY MR. STROUPE:

Q It is true, isn't it, sir, that you have not been involved with the design of a crankshaft from the ground up, so to speak, from the beginning?

A (Witness Eley) That is true.

A (Witness Christensen) Could I comment here, please?

Q I haven't asked you a question, Professor Christensen. If you can add to something Mr. Eley hasn't told me about his experience, fine.

A I'll come in later then. Thank you.

JUDGE BRENNER: Go ahead. Do it now.

WITNESS CHRISTENSEN: What I wanted to say was that nobody today in any of the engine builders that I am aware of -- and I am very close to many engine builders -- designs a crankshaft from first principles, that is, involving the torsional stresses coming on. And here I am not talking about torsional vibration; I'm talking about pure torsional stresses.

I am also talking about bending stresses. Nobody designs crankshafts from the bare principles. There must be

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a lot of empirical experience going into it. And to design it from first principles would be too costly.

But I can tell you today if you want to design a crankshaft from first principles, you can go to Lloyd's Registry of Shipping in London and they will do a design for you, based on input into a computer program which covers many, many areas. But nobody designs a crankshaft from first principles. It would be too costly for a commercial operation to start thinking about even.

Thank you.

BY MR. STROUPE:

Q Professor Christensen, are you capable of calculating or performing force torsional vibration calculations?

A (Witness Christensen) I have worked in that area some years ago, yes.

Q What methodology would you utilize to do that?

A I would come right back to the first of all the natural frequencies. Then I would go for stresses in the areas of the natural frequencies. Then I would go for the stresses in the resting conditions, and follow on from there.

Q And what mathematical method would you utilize to give you the natural frequencies?

A I would do a Holzer tabulation.

WRBeb

Q After you had obtained the Holzer tabulation of the natural frequencies, what mathematical method would you utilize to give you the torsional stresses operating upon a particular crankshaft?

A From my first Holzer tabulation I would have the relevant -- I'm sorry -- the relative angles of deflection for the various sections of the crankshaft. From that I would do another calculation to get the actual angles. And then, from there on, I would go into the resonant conditions between the critical speed and the engine operation speed and build up from that.

Q Have you in fact done any forced torsional vibratory calculations for purposes of this litigation?

A No. The only thing I checked out was the natural frequencies with the Holzer tabulation.

Mr. Eley has just reminded me that we did some calculations-- Well, we didn't do the calculations. We carefully checked a set of calculations the other day.

Q What set of calculations was that, Professor Christensen?

A A set of calculations under the IACS rules or proposed rules, I should perhaps be more correct in saying.

Q Whose calculations were those?

A They were the calculations, if I remember correctly, which had been made by Mr. Yang of TDI.

WRBeb

A (Witness Eley) May I just add there that it was either Mr. Yang or Mr. Beshouri. I'm not sure which one.

Q Professor Christensen, how would you calculate the phase relationship between two orders --

A How would I--

Q -- in arriving at force torsional vibratory stresses?

A (Witness Christensen) Could you give me that question again, please?

Q .Yes, sir.

How would you calculate the phase relationship between two orders?

A I wouldn't calculate it. I would look at the numbers of cylinders, the firing orders, and I would pull it out of a table.

Q Professor Christensen, so in summing the orders for purposes of making this calculation you would find the relationship of of a table. Is that correct? The phase relationship, I mean.

A In doing the phase relationship I would have to know the crank angles and the firing orders, and then I would bring in the phase relationship from tabular notations which are in any book on torsional vibrations.

Q Mr. Christensen, have you ever in fact performed forced torsional vibration calculations for crankshafts?

WRBeb

A Some years ago when I was in Lloyd's, yes.

Q And did you do that without using any of the empirical rules of Lloyd's?

A When you say "empirical rules," I feel I might be stepping into an area where I don't know. Could you define for me in this instance what you mean by "empirical," please?

A Yes. I'm defining that as the rules or calculations provided by Lloyd's rules.

Q Lloyd's did not make the rules for the calculations. They are based on mathematical science. What-- The rules that Lloyd's proposed was to put some value on the allowable stresses.

Q Mr. Eley, are you capable of performing forced vibrational -- torsional vibrational calculations?

A (Witness Eley) No, I don't profess to be a torsional vibrational expert at all, but I have performed those torsionals that I told you about on shafting, not on crankshafts, and I have performed the whirling of shaft torsionals; that's a vibrational form which gives you various nodes.

So I have advised you of that.

We haven't done a set of torsionals in here at all, but we have the background to know whether the torsional vibrations as such have been exceeded in the

WEBeb

shaft.

Q And that's by using the various rules of classification societies, I take it.

A That's right.

Q Professor Christensen, have you ever utilized the sum of the square roots method for determining the phase relationship between orders?

A (Witness Christensen) No.

Q Have you ever used TORVAP C or TORVAP R for summing orders?

A No.

Q Have you ever used any computer program for summing orders?

A No.

Q When you summed orders as you indicated to me a moment ago, do you recall how many orders you summed?

A No. I don't know that you asked me -- did you? -- if I had summed any orders. Could I have your question again, and the previous question so I can get the thing in context?

Q Didn't I ask you if you had had occasion to do forced torsional vibratory calculations?

A You did, yes.

Q And didn't I ask you if you had occasion to arrive at the relationship between the phases?

WRBeb

A You did, yes.

Q Don't you have to sum orders to be able to do that?

A I would have to think that one out for a bit. I would have to think that one out for a bit.

Q Do you want to think about that, and I will ask Mr. Fley some questions?

A I'll think about it, yes.

WRBagb

Q Mr. Eley, would it be fair to say that you did not make any independent calculations with regard to DEMA for purposes of the Shoreham replacement crankshafts?

A (Witness Christensen) No --

Q This is for Mr. Eley, Professor Christensen.

A I beg your pardon.

A (Witness Eley) I did do some investigating with regard to DEMA, yes.

Q Well did your investigation include making any independent calculations?

A When I looked through the DEMA regulations -- albeit these are the marine book that I have here, I could not get hold of the stationary book at all -- so I contacted Mr. Beaubaker to try and confirm this information, to get the actual stationary book and he advised me that --

MR. STROUPE: I am going to object to this answer and move to strike. I don't want to hear what he advised you, I am asking you what your knowledge is.

JUDGE BRENNER: I am not going to strike it. Just follow up with your next question.

Mr. Eley, you may proceed.

WITNESS ELEY: Can I continue?

JUDGE BRENNER: Go ahead.

WITNESS ELEY: Based on the information that was given, he advised me that the standards were outdated and

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that DEMA was going to release a new set of standards, so I felt the relevance of looking at it with regard to these crankshafts was not there.

BY MR. STROUPE:

Q Well does DEMA tell you, Mr. Eley, how to calculate torsional stresses?

A (Witness Eley) DEMA advises me that it does not attempt to set forth basic design criteria.

Q Well doesn't it in fact set forth allowable limits of psi levels without any reference to how torsional stresses are calculated -- Let me rephrase that question.

Can you look at DEMA, sir, and calculate the stresses in a particular crankshaft, the torsional stresses?

A It is extremely difficult to do so. In fact, I have gone to try and establish some clarification of the method of -- that is employed in the rule that is given on page 108 of DEMA which says that the superimposed -- Might I just read it to you:

"For crankshafts, line shafts, tail shafts, flange or coupling components, et cetera, made of conventional materials, torsional vibratic conditions shall generally be considered safe when they induce superimposed stress" -- then in brackets or parentheses -- "superimposed upon the main transmission stress" --

WRBagb

close parentheses -- "at less than 5000 psi created by a single order of vibration, or for superimposed stress at less than 7000 psi created by the summation of the major orders of vibration which might come into phase periodically."

Q Mr. Eley, am I correct that that does not in itself --

MR. BRIGATI: Judge, I don't believe Mr. Eley has finished his answer. He was conferring with Mr. Christensen and he was interrupted by Mr. Stroupe.

WITNESS ELEY: I have not finished my answer, Judge.

JUDGE BRENNER: All right. Go ahead.

It appeared as if he had finished it, but now we have it straight.

WITNESS ELEY: DEMA does not give an explanation of how to sum those major orders, so I established that with the engine builders that are in DEMA that they comply with the DEMA rules insofar as they don't allow their stresses to go beyond 2000 psi.

MR. STROUPE: I am going to object and move to strike again. He is giving me information I had not asked for. It is hearsay.

JUDGE BRENNER: Hearsay, per se, is not

WRBagb

objectionable, as we have discussed many times.

MR. STROUPE: I understand that but this might necessitate in my getting involved in who he talked to and those people are obviously not here for purposes of cross-examination.

JUDGE BRENNER: Why don't you remind me of what your question was, if you can.

MR. STROUPE: I believe my question was....

JUDGE BRENNER: Bill, I guess you had better read back the question.

MR. STROUPE: Maybe we had better read it back.

MR. BRIGATI: Judge --

JUDGE BRENNER: Wait.

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

(The Board conferring.)

JUDGE BRENNER: Mr. Brigati, you wanted to say something in response?

MR. BRIGATI: I believe that he was in the course of explaining why he did not -- and why he could not get anything from DEMA, Judge. I know it is a rather long explanation but it is also a rather long story.

JUDGE BRENNER: Well it was a rather short question to which a short answer would have been appropriate. And we are going to grant the motion.

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Now the effect of the motion, of course, is the material still stays in the transcript, it is just a statement by us that we are going to disregard it. Now you can put it in quotes and tomorrow when we have the transcript you remind me, Mr. Stroupe, and give me the reference and we will explicitly state what portion we will disregard. It may be the entire portion and it may not be, I don't want to have it reread now, we can pick it up tomorrow.

BY MR. STROUPE:

Q Mr. Eley, it is true, isn't it, that by looking strictly at the DEMA code or the DEMA rules one cannot calculate the torsional vibratory stresses?

(Pause.)

Do you need to confer for that answer, Mr. Eley?

A (Witness Eley) The methodology for so doing is not specified in the rule.

Q So the answer to my question would be "no," is that correct?

A That's correct.

Q Mr. Eley, had you had any experience with interpretation of DEMA or the application of DEMA prior to your involvement in this proceeding?

A The reasons why -- I tried to explain those earlier to you, Mr. Stroupe, because it was that I had not.

WRBagb

Q So you had not had any prior experience with DEMA?

MR. BRIGATI: Objection, asked and answered. His answer was clear there, Judge.

MR. STROUPE: Well it may have been clear to you but not to me.

JUDGE BRENNER: Wait a minute.

The objection is sustained. It was asked and answered.

BY MR. STROUPE:

Q Professor Christensen, have you had any prior experience with DEMA's interpretation or application prior to this proceeding?

A (Witness Christensen) No.

Q Professor Christensen, I would like to direct your attention please, sir, to page 114 of your testimony with reference to the answer to the first question on that page.

A All right.

Q Have you had an opportunity to look at that testimony?

A I have, yes.

Q And I believe this is testimony where the figure of 1750 psi has been changed to 1720 psi, is that correct?

A That's correct, yes.

WRBagb

Q And where the 4422 horsepower has been changed to 4496 horsepower?

A That is correct, yes.

Q Isn't it true, Professor Christensen, that at the full load calculation you did using the Lloyd's empirical formula for allowable horsepower you came up with a horsepower rating of approximately 5 percent or less than the actual horsepower of the Shoreham EDG's?

A I would have to work that out to get a percentage.

MR. BRIGATI: At what horsepower are we addressing that question, Mr. Stroupe?

JUDGE BRENNER: I think the witness knows but why don't you state for clarity?

MR. STROUPE: I believe we are talking about 4890, the rated horsepower of the Shoreham EDG's.

WITNESS CHRISTENSEN: Yes, I was just working out the percentage. You mentioned the figure 5 percent, I said I would have to work it out and I am in the process. That is what I am in the process of doing now.

JUDGE BRENNER: Do any of the witnesses have a calculator up there?

WITNESS CHRISTENSEN: I am just putting the figures down, Judge, so I can get them into the calculator.

JUDGE BRENNER: We can calculate it later,

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Mr. Stroupe. I have the numbers in the record and so do you.

WITNESS CHRISTENSEN: I make that figure approximately 8 percent, I think it is.

BY MR. STROUPE:

Q And that's based on what allowable horsepower und Lloyd's?

A (Witness Christensen) That is based on the horsepower that I calculated from Lloyd's vis-a-vis the required horsepower at 100 percent load.

Q At 1680 peak firing pressure?

A No, at 1720 peak firing pressure.

Q Could you tell me what it is at 1680 peak firing pressure, isn't that less than 5 percent, sir?

A I would have to do a whole calculation on that and that will take some time, because I did this on a computer run.

Q You cannot just divide those two numbers and tell me?

A Can I have your question again?

Q Yes.

A -- so I can get the gist of it, please?

Q Can you just divide 4621 by 4890 or vice-versa?

A I can, yes, but I have used the calculator so much -- my calculator is in the other room -- that I have

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forgotten how to do hand calculations.

(Laughter.)

Q Okay; let's move on to something else.

A My colleague here tells me that it's 94.4.

MR. BRIGATI: Judge, we will stipulate it's about 5 percent.

JUDGE BRENNER: Fine. Thank you, Mr. Brigati.

The last time I had a mathematical stipulation from a counsel, I believe in this case, it turned out to be off by a large amount because it was the reciprocal. But we'll put that aside.

Go ahead.

BY MR. STROUPE:

Q Professor Christensen and Mr. Eley, it's true, isn't it, that these marine -- these classification societies that you refer to at numerous points in your testimony generally relate to marine operation of diesel engines?

A (Witness Christensen) No; not wholly. Lloyd's rules I know are used by many people buying engines for stationary installation.

Q I asked you "generally," Professor Christensen, not wholly.

MR. BRIGATI: Objection. He answered the question on that basis.

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JUDGE BRENNER: No, we'll allow Mr. Stroupe to ask his followup question, and we'll see what the answer would be to that.

WITNESS CHRISTENSEN: If I didn't answer the first question correctly, could I have the first question again?

JUDGE BRENNER: No. Answer the second question. Ask it again, Mr. Stroupe.

BY MR. STROUPE:

Q Professor Christensen, isn't it true that generally these classification societies that you and Mr. Eley refer to in your testimony relate to marine operation generally?

A (Witness Christensen) Generally, yes.

Q And you would agree, would you not-- Strike that. Let me ask you, Mr. Eley, do you agree with that?

A (Witness Eley) I know of engine builders who comply with these rules that build engines for shore-side facilities.

Q I understand that, sir. What I asked you is: Generally speaking would you agree with me that these classification societes referred to in your testimony relate to marine operation of diesel engines?

A The rules themselves are primarily laid out for that purpose, yes.

Q Do you both of you agree with me that whether

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we're talking about main propulsion engines or units or auxiliary engines on board ship, that these engines are subjected to much more severe operating conditions than land-based stand-by generators?

A (Witness Christensen) I would not agree with that, no.

A (Witness Eley) Neither would I.

Q And would bothe of you, one at a time, give me reasons for not agreeing with that?

A (Witness Christensen) Yes. First, we are talking of generators. They are not connected to the ship's propellor.

The next case is, diesel generators on board ship do not normally use the same low-quality fuel that the main engine uses.

The next variant between that and the main engine is that the generators are on a much stiffer foundation, their crankshaft length is shorter, and in no circumstances should we consider the generator in a similar manner to a main engine, because the conditions under which the generator acts are different.

The only variant in there would be the holding-down bolts holding the generator to its foundation. They will sustain more load than the holding-down bolts would in a shore installation. But in a shore installation

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would in a shore installation.

But in a shore installation one of the things we have to watch also is subsidence of the ground on which the generator stands.

A (Witness Eley) I concur with Mr. Christensen in that remark.

Q Would you agree with me that the baseplate or foundation of an on-board ship engine, whether it be a main propulsion unit or an auxiliary unit, is subjected to thermal distortion as a result of the water temperature affecting the baseplate temperature through the hull?

A (Witness Christensen) I think I would have to say that that is a hypothetical question. I don't know whether I'm allowed to say it, but I have said it. And the reason is that we have to look at the temperature of the hull, the temperature of the engines, and so many things there. And people who have been in the business know that these things cancel out, and that there is really no variation with a shore-based installation or a ship-based installaton.

The whole problem here is crankshaft length.

Q Do you agree, Mr. Eley?

A (Witness Eley) I wonder if you might repeat the question for me, Mr. Stroupe?

Q Certainly.

Is it true that the baseplate or foundation of an

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on-board ship engine, whether it be a main propulsion unit or an auxiliary generator, is subjected to thermal distortion as a result of the water temperature affecting the baseplate temperature through the hull?

A The diesel generators, in my experience on ships, are on the middle flat, and they are right in the center of the engine room at mid-deck level. The situation with regard to their seating in these conditions is nowhere near the hull, they are mounted on a steel plate which comes off the boat head in the middle of the ship.

Q What about main propulsion units? They're mounted in the--

A The main propulsion unit is based on the bottom flat, of course, which is directly connected to the propellor, which is outside the vessel, yes. But there is a double bottom; in other words, there is a tank underneath the engine which supports the whole engine frame. So there may be three or four feet between it and the water.

Q Is that true of every ship, sir?

A I can't think of one that I ever sailed on that didn't have that.

Q Then, is it your testimony that the water temperature does not in fact affect the temperature of the baseplate or foundation of the engine on board ship?

A That is not my testimony, no. I suppose it would

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have a very, very small effect, but marginal, in my point of view.

A (Witness Christensen) I would like to add some further comment on this.

As I mentioned earlier, the question is hypothetical, and we would have to look at this in so many angles. Is the ship in operation? If the ship is in operation, the lowest temperatures to which the ship is normally subject to is somewhere of the order of about 26 degrees Fahrenheit: that's the temperature which water can go down to below the level of the sea at the bottom part of the ship.

Normally when the ship is in operation we have heat on the fuel tanks, we have warm lubricating oil going into the double-bottomed drain tank, and the situation on board the ship is that the temperature of the steel, whilst it would vary with seawater temperature, the variation is slow, and the bedplate of the main engine -- of a very long main engine -- will give with it.

If we shut the ship down and the plant is shut down, then things will change. But we're getting into a whole area, and I'm trying to give short questions, so I have to leave it there.

Q Professor Christensen and Mr. Eley, it's true, isn't it, that the stresses and strains that on-board ship

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engines are subjected to, whether they be main propulsion units or auxiliary units, by virtue of seas affect crankshaft misalignment?

A (Witness Eley) I would say on the main engine it has a significant effect, yes, because of, again, what Professor Christensen says, the size of the crankshaft. These could be anything up to twenty feet along. They are really huge crankshafts. Consequently it's a huge bedplate. But if you're talking about diesel generators, they are much stiffer, much shorter crankshaft which is mounted on the middle flat on a very stiff and rigid base.

JUDGE BRENNER: I wonder if I might jump in? I got confused a few answers ago, and this answer just now, Mr. Eley, continues to confuse me.

We are interested in the crankshafts in the diesel engines are Shoreham, and that's what the testimony presented by, Mr. Eley and Dr. Christensen, is about; correct?

WITNESS ELEY: That's right. I would say that to make a good comparison between a ship's crankshaft and those at Shoreham you would have to consider the generators are not the main propulsion plant.

JUDGE BRENNER: That confuses me, because in terms of -- and I'm asking you so you can help me out. In terms of Shoreham I thought I was interested in the engines and

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not the generators.

WITNESS ELEY: I understand now, Judge Brenner.

JUDGE BRENNER: All right. And you're drawing a distinction between main propulsion engines and auxiliary engines on a ship which have a purpose of generation, I believe.

WITNESS ELEY: That's correct.

JUDGE BRENNER: I wonder if you can straighten me out on all this so I make sure what comparison you think we should be drawing.

WITNESS ELEY: Yes. The main propulsion shaft engine is the main engine of the vessel which drives the vessel via the crankshaft and the propellor on the outside of it.

The generators I am referring to are the engines which provide the electrical power to supply electrical power to the ship, exactly the same as it does in a power plant ashore.

When I refer to the generator I mean the engine with the alternator mounted on its end exactly the same as the engines at Shoreham.

JUDGE BRENNER: Alll right. Thank you.

It may be we should watch some of the language in referring to generators when, in reality, which is being meant is, in fact, the diesel engine driving the generator.

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By you have explained what you meant, Mr. Eley, and I thank you.

JUDGE MORRIS: While we are interrupted, Mr. Stroupe, can I ask a question also?

MR. STROUPE: Certainly.

JUDGE MORRIS: Gentlemen, for example, the Lloyd's rules-- Do the Lloyd's rules distinguish between the propulsion engines and the engines used for electrical power?

WITNESS ELEY: Yes, they do.

JUDGE MORRIS: That is explicit in the rules?

WITNESS ELEY: It is.

JUDGE MORRIS: The criteria are different, for example?

WITNESS ELEY: In some regards they are, yes.

JUDGE MORRIS: Do you concur?

WITNESS CHRISTENSEN: In the crankshaft area they are virtually the same. I think Mr. Eley is into other areas. But for the crankshaft, which is what we're speaking about now, they are virtually the same; yes.

WITNESS ELEY: There are distinctions in various areas, yes, but not necessarily related to the crankshaft as such.

JUDGE MORRIS: Do you agree that they are virtually the same? --the crankshaft?

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MR. ELEY: One is a constant speed engine and one is a variable speed engine. So I think there are some differences in that regard. I would have to look at that again, but they're basically the same.

JUDGE MORRIS: Thank you, Mr. Stroupe, for the interruption.

BY MR. STROUPE:

Q Mr. Eley and Professor Christensen, isn't it true that even with regard to the auxiliary diesels on board ship, that different loading patterns in the cargo spaces of the ship can cause changes in the hull deflection which can affect crankshaft alignment?

A (Witness Christensen) Yes, that is true. And if we get an awkward loading pattern, then the Chief Engineer will check out the alignment of the crankshaft before proceeding onto the next port, to see if he has to straighten out the hull by the addition of ballast so that his crankshaft alignment becomes the same again. We never have ever to exercise that in relation to a generator, as I said much earlier.

The whole thing is related to the length of the crankshaft. When I say I'm relating it to the length of crankshaft, we've got to distinguish between a crankshaft that weighs 5 or 10 tons up to a crankshaft which is weighing 300 tons. And that is what we have to deal with in

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areas of main propulsion.

Q I referred specifically to -- not to main propulsion -- but the diesel generator sets.

A I did mention that we never have to take deflection readings to check out the alignment of generator sets, no matter how bad the loading of the hull will be. And then I tried to illustrate that with an example that we have to do that in the case of the main engines. And I was trying to answer your question completely.

A (Witness Eley) I personally have installed generating sets myself and aligned bed plates. This is 20 years ago. The limits were then about a quarter of a thou. We used to rotate the crankshaft, align it, and chuck it underneath, to align it in that condition. And it has been my experience that on checking this alignment under various loading conditions, there is very little fluctuation.

With regard to the main engine, it's a different kettle of fish; that does fluctuate to a higher degree.

Q Would you gentlemen agree with me that in heavy weather at sea, as waves pass along a ship, the increased buoyancy from the wave crest causes hull movement which, again, can affect the alignment of the crankshaft in both the main propulsion unit and in the standby diesel generators?

A (Witness Christensen) I can answer that. As a

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hypothetical question, the answer is yes. But there is a bit "but" with it. As I keep reiterating, the thing is related to the length of the crankshaft. The diesel generator -- the diesel set driving the electrical generator is such a small crankshaft by comparison with the other one, that the effect on it is virtually nil.

Q Is the crankshaft that is in the Shoreham generators small in comparison to what is generally found in the auxiliary diesel generators on board a particular ship?

A Again, that question needs some clarification. If you are speaking about a large container ship the answer is they are about the same size. If you are speaking of a small break bulk ship, that is a ship with normal cargo hatch -- not a container ship -- a dry cargo ship, then the generators will be much smaller. If you get into a refrigerated cargo ship where you have an enormous refrigerated load, then your generators will be much bigger again. We have to qualify these things.

Generally speaking, the -- I can give you an example of generators of approximately the same size as the Shoreham generators, that is the generators on the American President Line ships. I think they're the same bore and stroke. I'm not sure whether they're eights or sixes. But when you come up to ships of that size, then you have enormous generator capacity. If you come to a passenger

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ship, you have enormous generator capacity. If you come to a tanker, with steam driven cargo pumps, you have relatively small electrical generating capacity.

A (Witness Eley) You will find with most engine builders, as well, that the engine that they supply to the vessel will be the same as that supplied to a shoreside plant.

Q Well, let us confine this question and answering to diesel sets on board ship that are comparable to the Shoreham EDG's.

With that in mind, Professor Christensen and Mr. Eley, isn't it true that in heavy weather as waves pass along a ship, the increased buoyancy from the wave as the wave crests, causes hull movement which can affect crankshaft misalignment?

A (Witness Christensen) As I mentioned a little bit ago --

Q Can you give me a yes, sir, and then explain, or a no?

A I will give you a yes, but. The but is this: the wave crest that you are speaking of can be picked up with scientific instruments in a supertanker a thousand feet long. The engines which you have a Shoreham might be fitted in a tugboat which will be much, much shorter. It will be much, much stiffer a hull. In consequence, a wave passing

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under that ship will have virtually no measurable deflection on it. And therefore, there will be no measurable deflection coming back onto the crankshaft. It's wholly a question of size and you're making me come back to the area again of crankshaft length. It is wholly a question of crankshaft length.

Q Well, Professor Christensen, can you keep in mind the fact that I asked you to consider that we're talking about crankshaft length comparable to the Shoreham EDG crankshafts?

A I just said that that crankshaft of that length you might find in a tugboat or in a small coaster. But what we have to look at is the way the structure underneath the engines is built. The question is hypothetical because we make allowances for waves passing under the ship in the design of the hull. And if you look at the substructure of the hull underneath the set of main engines, you will find that that is very, very well catered for. The other thing that must come out in this piece is that it's true that there is a deflection of the hull, that it is not of an amount which will considerably affect the operation of the main engine as such, and much, much less effect on a generator of the size of the engines at Shoreham.

Q Professor Christensen, are you aware that these questions I have been asking you came as a result of some

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statements you made in your book "Lands Questions and Answers on the Marine Diesel Engine"?

A Could well be; yes.

Q And don't you state, sir, in that book that as a wave passes along the hull of the ship, and as it crests, the increased buoyancy can lead to crankshaft misalignment on either main or auxiliary engines?

A I do state that, yes, but I think you're possibly taking it out of its context because here we've got to lookat a time factor as well. And we're getting into an area of complication where I want to give short answers but I'm precluded from doing to because we're moving into very, very complicated areas. But, believe me, I can well handle them.

Q Mr. Eley, do you have anything to add to that?

A (Witness Eley) No.

Q I'll ask this question of both you gentlemen.

Isn't it true that crankshaft alignment on board ship, whether it be in the main propulsion unit or in the auxiliary diesel generators, is a much more severe problem than that encountered in an enclosed nuclear standby generator room, where the ambient air temperature is controlled and the base plate is anchored into reinforced concrete, and there are no waves subjecting the area to any sort of distortion?

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MR. BRIGATI: Objection. I think that this question has been asked and answered in different forms for the last 15 minutes.

JUDGE BRENNER: Mr. Stroupe?

MR. STROUPE: I don't believe that question has been asked or answered, Judge Brenner. I think I'm putting in context the whole --

JUDGE BRENNER: The objection was a little more sophisticated than that, it was in different forms, so I want you to address that part.

MR. STROUPE: I'm trying to put in context the whole series to get an answer that, hopefully, will allow me to leave this subject. I'm trying to save some time.

JUDGE BRENNER: Yes, but just because you don't like the answers you're getting, doesn't mean you should keep asking the question.

MR. STROUPE: Well, I didn't say I didn't like the answers. I think this is a legitimate question, but I haven't gotten answer to.

JUDGE BRENNER: You don't believe you've got an answer to that question?

MR. STROUPE: I do not.

JUDGE BRENNER: We'll give you the benefit of the doubt, to try to pull it all together. And we'll allow the question; although I harbor some doubt.

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MR. STROUPE: Thank you, Judge Brenner.

WITNESS CHRISTENSEN: Can I have the question again so that I can answer it shortly, please?

MR. STROUPE: I'll try.

BY MR. STROUPE:

Q Isn't it true, Professor Christensen and Mr. Eley, that crankshaft alignment on board a ship, whether it be in the main propulsion unit or in the standby auxiliary diesel generators, is a much more severe problem than that encountered in an enclosed nuclear standby generator -- and I'm referring to the diesel engine -- where the ambient air temperature is controlled and the base plate is anchored into reinforced concrete and there is no seismic or wave action involved?

A (Witness Christensen) On those grounds, yes, the crankshaft alignment problem might be less. If you've got subsidence there, then you may have a whole worse problem than you have on board a ship.

Q What do you mean by subsidence?

A If the ground subsides.

Q You mean if the ground caves in?

A No. I'm just talking about normal settling. If you put a heavy structure on soil, you may get some settling. But this is an area that I'm not normally working in. I'm normally working in the hull of a steel ship. But

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I know from looking at cases of crankshaft failure -- because I read everything that I can about crankshaft failure, it's such an important area -- I know that crankshafts have failed in shore installations because there has been subsidence of the foundation on which the engine stands. And it has not been recognized by the people onsite.

Q Do you have any knowledge as to how thick the reinforced concrete that the Shoreham EDG's are anchored into is?

A I have no idea; no.

Q Mr. Eley, could we get back to you?

A (Witness Eley) Excuse me, Mr. Stroupe. The question -- the one earlier --

Q That's what I'm talking about.

A I wonder if I might ask you to repeat it, please?

Q I will try.

Mr. Eley, isn't it true that crankshaft alignment is a much more severe problem on board ship, with regard to a main propulsion unit or a standby diesel generator, than any crankshaft misalignment problem encountered in a nuclear standby generator room where the ambient air temperature is controlled and where the base plate for foundation of the engine is anchored into reinforced concrete and there is no seismic or wave action operating?

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A I would say, yes, it is true for the main engine, and there are marginal differences with the generating sets.

And I would like to add that I have personally aligned both of the main engine and the generator sets myself. I didn't have any problem with those generator sets alignments at all.

A (Witness Christensen) Could I come back here? Were you specifically speaking of misalignment problems through ambient temperatures, or were there other factors in the piece, Mr. Stroupe, please?

Q I'm not going to answer that question. I think the question I asked was pretty clear, Professor Christensen. I've stated it three times and if you want to change your answer, you're perfectly free to do so.

A No, I don't want to change my answer but I want to say that ambient temperatures, whether they be within the normal range of Arctic cold or tropical heat, do not have a great bearing on crankshaft alignment if the foundation has been designed correctly, whether it be ashore or whether it be at sea.

A (Witness Eley) The generator bed plates are very stiff.

JUDGE BRENNER: I wonder if I can ask a question? I don't know if it's important or not, but I'm a

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little confused.

Gentlemen, isn't it correct that engines very similar to the TDI diesel engines used at Shoreham, are used as main propulsion engines in some ships?

WITNESS ELEY: Yes, they are. But that situation will be very difficult. What we're talking about here is the stiffness of the generator shafts and the alignment of the generator shafts. When you're talking about the engines that drive the generators, that's the shafts to which we refer and which are very stiff bed plates.

WITNESS CHRISTENSEN: Could I clarify a point here, please? That is, if you use the Shoreham-type engines for ship propulsion, they are mostly coming in as a geared drive set. The bed plate underneath that engine -- you will have the normal substructure of the ship, then you will have another tressle-type bed plate fitted on that, which is all adding to the stiffness of that part of the hull under the engine. Because it's a fact that we don't want effects to come on there. It is, perhaps, a little more onerous than a shore-based engine but, again, it comes right back to the length of the engine and the design of the substructure underneath that. And I, myself, don't think that there is a lot of difference between the two.

JUDGE BRENNER: Between the engine in service at Shoreham and between a similar engine being used as a main

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propulsion on a ship?

WITNESS CHRISTENSEN: Correct, yes.

JUDGE BRENNER: Okay. Thank you.

Mr. Stroupe?

BY MR. STROUPE:

Q Professor Christensen and Mr. Eley, isn't it true that one of the major reasons that these marine classification societies rules on crankshaft are conservative is because of crankshaft alignment problems and the conditions that engines are subjected to at sea?

MR. BRIGATI: Objection to the form of the question. He has characterized the rules of the classification societies as conservative. I'm not sure exactly what that means in the context of this proceeding. And there is no foundation for it, in any event.

JUDGE BRENNER: Well, I'm going to overrule the objection because, once again, it's my view that he's putting the question to expert witnesses who can answer it. Maybe a little initial explanation will help you, Mr. Brigati.

Feel free to object when you get a compound question where there are premises stated in the question that are not put to the witness, and the questioner attempts only to put the last part of the question to the witness. That's a different problem and may be closer to the concern

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you're expressing the objection here. But your particular objection here is overruled.

WITNESS CHRISTENSEN: Could I have the question again, please?

BY MR. STROUPE:

Q Isn't it true, Professor Christensen and Mr. Eley, that one of the major reasons marine classification societies rules, with regard to crankshafts, are conservative is because of the concerns with regard to crankshaft alignment and the operating conditions encountered at sea?

A (Witness Christensen) No, I think the whole thing there of what some people regard as the conservatism of the rules is associated with safety, wholly with safety.

A (Witness Eley) I agree.

WRBeb

Q Professor Christensen, could I please get you to focus your attention on pages 113 through 114 of your testimony, specifically the answer to the last question on page 113 that goes over onto page 114?

A (Witness Christensen) Yes, I have the picture in my mind of the question and the answer, yes.

Q You have indicated, haven't you, that in your view Lloyd's rules is the most conservative of the major classification societies?

A (Witness Eley) In some regards, yes, not all.

Q I didn't ask you the question yet, Mr. Eley.

JUDGE BRENNER: It sounded like a question to me, in fairness to the witnesses.

MR. STROUPE: Well, I started off with the phrase, "Professor Christensen." I'll be happy to get Mr. Eley's answers, too.

JUDGE BRENNER: Why don't you ask them both because we are going to be here a long time, in fact, double-time, unless you have a particular reason on a particular question.

That's number one. In terms of the confusion as to whom you were directing it to, did you nevertheless finish the question?

MR. STROUPE: I did.

JUDGE BRENNER: All right. You've got Mr. Eley's

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answer.

Did you finish the answer, Mr. Eley?

MR. STROUPE: I'm not sure I got his answer.

WITNESS ELEY: I will repeat it, Judge Brenner.

WITNESS CHRISTENSEN: The fact that Lloyd's-- You state here that I state that Lloyd's is the most conservative. I think that is generally based on my experience, and where I have been working with different classification societies' rule. I don't think there is a lot of difference between some of the other major societies' rules and Lloyd's Register of Shipping. You will get variations on them.

I think in the main, within the realms of my own experience in looking at particular crankshafts, that Lloyd's has come up with the heaviest scantlings for a crankshaft, but there is another major classification society in the northern part of Europe known as Scandanavia where they have a set of rules and they are very, very similar, the figures that come out from them.

JUDGE BRENNER: All right.

Now since Mr. Eley is also a sponsor of that answer, let's see if he has anything to add.

WITNESS ELEY: I would just like to say that we said LLoyd's generally is considered to be the most conservative. There may be some other more conservative

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that we don't know, but in general, we feel that way.

There are-- Each classification society has its individual method of determining the adequacy of the crankshafts and consequently, they cannot be exactly equated to one another, so there are slightly different ways of viewing things. Consequently we have to say Lloyd's generally was considered to be, not in all respects.

JUDGE BRENNER: All right.

Now let me interject something, aside from any particular question and answer.

The pace since the lunch break in which we are adducing substantive information versus wasting time is deplorable and I am going to put a stop to it a lot more harshly than I have so far. But to avoid the need for me to do that, I want parties to think carefully before they make an objection. And I also want questioners to think carefully as to how they can most efficiently obtain the information they want, and to whom the question should be directed in order to achieve that efficiency.

MR. STROUPE: Well, let me just state--

JUDGE BRENNER: No response is necessary.

If I wanted to go further I could ask Mr. Brigati if he wanted me to back up and grant his objection that I overruled now that we've got the answer of his witnesses after I overruled it, but I think he probably would not want

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to do that. And it is an example of where I think expert witnesses are more capable than just a factual witness off the street in a tort case, for example, and it is why I don't grant too many objections of the nature that the question may be confusing or may misstate something, unless it really does so badly.

All right. Let's proceed with substantive questions and adducing factual information here.

BY MR. STROUPE:

Q Gentlemen, is it also your view that, as stated here, Lloyd's generally provides the greatest margin of safety?

A (Witness Christensen) It is hard to be definite about that, but I think that is generally so, yes.

A (Witness Eley) Generally, yes.

Q Professor Christensen, it is true, isn't it, that on page 114 of your testimony you have calculated an allowable horsepower for an overload condition for Lloyd's?

A (Witness Christensen) I calculated horsepower I think for one condition and then I calculated an allowable horsepower for another condition.

Q And those conditions were in fact, were they not, a calculation at 3500 Kw and a calculation at 3900 Kw?

A I just have to look at the exhibit here, if you will bear with me for a moment, please.

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(Pause.)

Yes, I can recall what I did now.

Q Mr. Eley, you did also, did you not, on page 115 of your testimony?

A (Witness Eley) 1680 psi on page 115.

Q Was that just at the continuous rating of the Shoreham EDGs, or was it also--

A Yes, at 1800 psi.

Q So it was not at the overload condition?

A The 1800 psi is the overload condition.

Q Can either or both of you gentlemen tell me where in Lloyd's it is indicated that an overload calculation for allowable horsepower should be made?

A (Witness Christensen) The calculations I did here was to find various things, and to get some picture of the crankshaft, and you can see the calculations that I have performed there.

If you turn to page 2 of those calculations you will see that I have put various figures in for various things so that you can get some picture of what is happening there.

Q Are you referring to the exhibit?

A I'm referring to the exhibit, yes.

Q Well, does that exhibit explain or detail, Professor Christensen, where in Lloyd's there is required

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an allowable horsepower calculation at overload?

A No. The Lloyd's formula, if you would like to call it that, for the scantlings of the crankshaft cover many, many inputs. I took the inputs from the crankshaft drawing and put them into the Lloyd's formulas. Then I transposed the formula and put a horsepower figure in there, and then came up with what the maximum pressures would be for those various horsepowers.

I also did the calculations which are shown in the testimony.

Q Well, isn't it true, gentlemen, that Lloyd's rules does not require a calculation at overload for allowable horsepower?

A There is nothing in Lloyd's rules, as you say, about that, but I looked to the thing in its entirety here.

Q Mr. Eley, do you want to respond to that?

A (Witness Eley) Lloyd's rules specifically specify that at 100 percent load, an overload period of 15 minutes would be permissible. Because of the fact that in this condition you have a two-hour in any 24-hour overload condition, this will be construed as in excess of that and consequently, one would need to use the 110 percent overload condition as the MCR.

I checked with another engine builder to establish that fact also.

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Q Isn't it true, Professor Christensen and Mr. Eley, that Section 3 of Lloyd's on crankshaft, specifically the empirical formula designed to obtain a figure on the maximum allowable horsepower at continuous rating, has no provision for a calculation for 10 percent overload for 15 minutes, or any other period?

A (Witness Christensen) Could I have a look at that rule? I don't have a copy of Lloyd's rules with me here now, so that I could comment on it effectively?

MR. STROUPE: Judge Brenner, I am going to pass out two exhibits that I ask to be marked for identification.

JUDGE BRENNER: Before you do it, are you sure we are going to need them as exhibits?

MR. STROUPE: Yes.

JUDGE BRENNER: All right.

Hand them out, and then you identify them and number them.

MR. BRIGATI: Judge, I prefer that the witnesses be given one exhibit at a time in order to avoid unnecessary confusion.

JUDGE BRENNER: Let him give them both. I don't want him to have to get up twice. I'm going to make him identify them individually, and they will follow it.

(Documents distributed.)

JUDGE BRENNER: While he is doing that, let me

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inform the County that page 2 of its Exhibit 36 is not fully legible. Page 1 can be made out by careful reading, but page 2 has some numbers that I cannot read. I can make some guesses as to what they are but I cannot read them.

Are you going to give us copies, Mr. Stroupe?

MR. STROUPE: I'm sorry, your Honor.

(Documents distributed to the Bench.)

JUDGE BRENNER: So perhaps before it is all over, through the witnesses we can get them to state what the numbers are, particularly in the left-hand column of page 2 of County's Exhibit 36.

MR. BRIGATI: Judge, I thought it might be simpler to get you a better copy of it, but if you want it read into the transcript, we will.

JUDGE BRENNER: Off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

MR. STROUPE: I would like to have marked for identification now -- actually they can be two separate exhibits or one together; I have no real preference.

The first is Rules and Regulations -- an excerpt from the Rules and Regulations for the Classification of Ships from Lloyd's Register of Shipping, dated July 1982, entitled Part 5, Main and Auxiliary Machinery, Chapter 2, Oil Engines. And it consists of the cover page and one

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additional page, that additional page being entitled "Rules and Regulations for the Classification of Ships' Main and Auxiliary Machinery - Oil Engines."

JUDGE BRENNER: We can make it one exhibit.

MR. STROUPE: That's fine.

The next portion of that exhibit is again -- has a cover page entitled Rules and Regulations for the Classification of Ships - Part 5 - Main and Auxiliary Machinery, Chapter 1, General Requirements for the Design and Construction of Machinery.

And again attached to it is one page entitled "Rules and Regulations for the Classification of Ships' Main and Auxiliary Machinery, General Requirements for the Design and Construction of Machinery." And this is dated I believe January 1983.

And I would represent to the parties and to the Board that these are both excerpts from Lloyd's rules, and would ask that that be marked as Cross-Examination Exhibit 41.

JUDGE BRENNER: We don't need the Cross-Exam designation.

MR. STROUPE: Just Ehxibit 41.

JUDGE BRENNER: This will be LILCO Diesel Exhibit C-41 for identification.

MR. STROUPE: Thank you, Judge.

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(Whereupon, excerpts from Lloyd's Rules re: Ship Classification was marked as LILCO Diesel Exhibit 41 for identification.)

BY MR. STROUPE:

Q Professor Christensen and Mr. Eley, are you familiar with the first part of this exhibit, the second page attached to the Part 5, Chapter 2?

A (Witness Eley) Yes.

A (Witness Christensen) Yes.

Q Is that in fact the empirical formula of Lloyd's for computing allowable horsepower of diesel engines crankshafts?

A First I would like to comment on your term "empirical formula."

It is not an empirical formula. It is based on the basics of crankshaft design with a large input from studying many, many crankshafts that have operated successfully, and a few crankshafts that have filed, and this is what that formula is based on. It is not wholly empirical.

Q Well, Professor Christensen, does it require anything other than making certain inputs as defined by these various numerical and letter indications under this

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formula?

A No. It is what is, in common parlance, called a chug-and-plug formula. You plug in your numbers and you chug along and you get an answer out. It is very, very simple.

(Laughter.)

Q And is this in fact the chug-and-plug formula that you utilized to make your calculations?

A It is. And it is the most commonly used design formula for finding the initial scantlings of crankshafts.

Q Mr. Eley, do you agree with that?

A (Witness Eley) Yes, I do.

Q And can both of you or either one of you tell me how this formula defines the power rating?

A (Witness Christensen) Yes. If you transpose the revolutions figure over to the right-hand side of the equation, you are left with a value for horsepower.

Q Well, Professor Christensen, doesn't this formula state that the power rating is defined in Chapter 1, Section 3.3?

A You would have to look at that, yes.

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Q Well, I would ask you to turn over to the fourth page of this exhibit, which is the last page, and ask you to look specifically, both of you, at section 3.3.1, entitled, "Power Ratings."

A Yes.

Q Have you both had a chance to look at that?

A Yes.

Q And doesn't that, indeed, for auxiliary machinery such as the Shoreham EDG's, define the power rating as the maximum and continuous shaft power in corresponding revolutions per minute which will be used in service?

A It does that; yes.

A (Witness Eley) Yes, it does.

Q Well, isn't that the continuous rating in the case of Shoreham at 3500 kw?

A (Witness Christensen) No. In the case of Shoreham, what you call the two-hour overload period would be classified as the normal load on the engine in this context here.

Q Do you agree, Mr. Eley?

A (Witness Eley) Would you repeat the question to me, please? I'm sorry.

Q Yes, sir.

Doesn't this section define the power rating used

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for purpose of the empirical formula or the chart and plug formula, as the maximum continuous shaft power in corresponding revolutions per minute, which will be used in service?

A That's correct. Under section 361, it also specifies our conditions for generator sets.

Q Well, let me go back to section 3.3 and then we're going to get to --

MR. BRIGATI: Objection. He was answering the question and he was explaining the answer. I think he should be entitled to finish his answer.

MR. STROUPE: I thought he was finished.

MR. BRIGATI: We were --

JUDGE BRENNER: All right; I hear you.

I was not watching the witness at the moment and I could not tell that he had not finished his answer.

Mr. Eley, would you --

WITNESS ELEY: I might explain that this is at page 112 of our testimony. It says, under 3.6.1, that

"The auxiliary engines come out to electrical generators are to be capable under service conditions of developing continuously the power to drive the generators at full rated output killowatts. And in the case of oil engines and gas turbines, of developing for a short period

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(15 minutes) an overload power of not less than 10 percent."

BY MR. STROUPE:

Q Have you continued your answer?

A (Witness Eley) Yes.

Q Where does that 3.6.1 tell you to go back to section 3 entitled "Crankshafts" to make a calculation at overload?

A There is no reference back.

Q Well, do you know that the maximum continuous rating of the Shoreham EDG's is, Mr. Eley?

A Yes.

Q What is that?

A 3,500 kilowatts for one year with a two-hour in any 24-hour overload period of 10 percent overload.

Q Well, the overload is --

A I'm sorry -- 3,000 -- sorry. 3,900 kilowatts for two hours in any 24-hours.

Q You know, don't you, Mr. Eley, that the 3900 kw overload rating is not a continuous rating?

A No; I just specified it's two hours in any 24-hours.

A (Witness Christensen) Could I come in here with some interpretation to these rules. I am a former light surveyor. I've also been engaged in the areas of design.

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And if I was called upon to produce an engine that has a specification of 3,500 kw output on the generator end continuous rating, and 3,900 kw output for two hours rating, I am sure that most engine designers would produce a crankshaft that was capable of producing 3,900 kilowatts output of the generator end continously. They wouldn't play around with the interpretation of these words here.

The words here, continuous, mean continuous rating in the context that that will be the maximum rating put on them. But every ship owner, and most people who own stationary plants ashore, down-rate their engines from the designed rating. But here at Shoreham, we've up-rated it.

A (Witness Eley) Might I just add to that?

Q Certainly.

A Cooper-Bessemer, who provide diesel engines to the nuclear industry, do design their crankshafts to the 110 percent overload condition.

They are a member of DEMA.

JUDGE BRENNER: Mr. Stroupe, is this a good time to take a break? We've been plugging along for quite a while, although, not chugging very well.

MR. STROUPE: I'm plugging as hard as I can, your Honor.

JUDGE BRENNER: I didn't think I was going to hear about chugging anymore in this proceeding, but this is

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a different context.

We'll take a break until 3:50.

(Recess.)

JUDGE BRENNER: Back on the record.

We are ready now.

Mr. Stroupe?

MR. STROUPE: Thank you, Judge Brenner.

BY MR. STROUPE:

Q Professor Christensen and Mr. Eley, if indeed section 3.6.1 that we have been talking about this afternoon in Lloyd's Rules, defines the maximum continuous shaft power as used in section 3 under "Chrankshafts", would it be your opinion that section 3.6.1 would also require that the Shoreham EDG's be capable of operating at at least 10 percent over 3,900 for short periods of time?

A (Witness Eley) I believe the FSAR specifies that the engine should be capable of doing two hours in any 24-hours at 3,900 kilowatts.

Q What was not my question, Mr. Eley.

A I wonder if you would repeat the question, please?

Q Could we get it read back?

(The reporter read the record as requested.)

JUDGE MORRIS: Mr. Stroupe, by short periods of time, do you mean 15 minutes or so?

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MR. STROUPE: Judge Morris, I believe Lloyd's defines it as "for a short period (15 minutes)." That's what I intended.

WITNESS CHRISTENSEN: If you wanted to build the engines to Lloyd's class, that is what they would have to be capable of doing.

A (Witness Eley) Yes, that is what I -- yes, I would say so.

BY MR. STROUPE:

Q So it would be your testimony they would have to be capable of operating at approximately 4,290 kw for a period of 15 minutes?

MR. BRIGATI: Objection. This cross-examination is beyond the scope of the contention. The County isn't contending that the Shoreham diesels have to be capable of operating at those power levels and I, frankly, don't understand what this examination is accomplishing.

JUDGE BRENNER: I'm going to overrule the objection because it is material for LILCO to explore the bases of the interpretation by the County's witnesses of Lloyd's Rules and then their application of them, given those bases.

A (Witness Christensen) As I mentioned just now, if you wanted to build the engine to comply with Lloyd's Rules, you would have to cover this. But as I mentioned

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earlier Lloyd's Rules are wholly associated with safety, as they're associated with safety, then any designer would see that that capacity is in the engine.

I don't want to digress, but I have been responsible for the overall design of many ships --

MR. STROUPE: I want to interrupt here, Judge Brenner. I asked the question. I believe he's capable of a yes or no answer about the 4,290 kw.

JUDGE BRENNER: Yes; I agree with you. Can we get an answer?

WITNESS CHRISTENSEN: I thought I gave the answer, but there is a "but" to it and I was trying to explain the "but" part of it.

JUDGE BRENNER: I didn't hear the answer, if you gave it, Professor Christensen. I wonder if you could do that and I will allow you to explain the answer.

WITNESS CHRISTENSEN: I said if any builder of a diesel generates a set, wanted his engine to comply with Lloyd's Rules, the engine would have to be capable of meeting this requirement. And if it was the Shoreham engine, and the figures that Mr. Stroupe gave me are the correct ones, then it would have to be capable of meeting that. The bad part of the thing is this: that Lloyd's Rules are wholly associated with safety. And as such, prudent designers -- and I'm citing my own experience here,

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and work as a designer in the marine field -- if -- I use these figures as an example.

If I had a generator that had to put out 100 kw, I would put an engine on that that was capable of making, at any time, 120 kw. And this is what is usually done. And, therefore, engines have no problem in meeting this rule. But, as I said earlier, we normally down-rate engines but at Shoreham they have up-rated them from the continuous rating -- as they call it -- to a 3,900 horsepower rating. And the only thing that I can think of is that the rules that allow you to put that engine in at Shoreham are not as strict as Lloyd's Rules, which we have here. And these are only for ships which are going around the ocean.

But, as I said earlier, it is wholly associated with safety.

BY MR. STROUPE:

Q Mr. Eley, would it be correct that under this interpretation of Lloyd's Rules, the Shoreham EDG's would be required to operate for a short period, 15 minutes, at a kw level of approximately 4,290?

MR. BRIGATI: Asked and answered.

JUDGE BRENNER: Sustained.

MR. STROUPE: I believe I asked that question of Mr. Eley. I don't believe I have ever gotten an answer from him on that, Judge.

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JUDGE BRENNER: All right. You didn't make it clear to me you were now addressing it to Mr. Eley.

MR. STROUPE: I think I prefaced by question by saying Mr. Eley.

JUDGE BRENNER: I'm sorry, Mr. Stroupe, I apologize. I missed that.

MR. BRIGATI: I apologize to Mr. Stroupe, too. I misunderstood.

JUDGE BRENNER: All right.

MR. STROUPE: Accepted Mr. Brigati.

JUDGE BRENNER: Mr. Eley?

WITNESS ELEY: I believe I did answer it, Judge Brenner.

JUDGE BRENNER: All right. Why don't you answer it again and do me a favor?

WITNESS ELEY: Yes.

JUDGE BRENNER: Thank you.

Go ahead, Mr. Stroupe.

BY MR. STROUPE:

Q Professor Christensen and Mr. Eley, you are aware, are you not, as a result of previous testimony in this proceeding, that actual measured firing pressures in the cylinders of the Shoreham EDG's, are less than 1680 psi?

A (Witness Christensen) I have seen figures which state that, yes.

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Q Mr. Eley?

A (Witness Eley) That's true. And some are bigger.

Q And are you aware of any larger figures that have been measured with a Piezo electric transducer larger than 1680 psi?

A We don't have all the measurements for Piezo, I don't think.

Q I didn't ask you that. Are you aware of any measurements with a Piezo quartz transducer that exceeded 1680 psi, with regard to the Shoreham EDG's?

A I don't recollect any, offhand, but I do believe it was the Piezo electrical one that gave the mechanical efficiency of one percent somewhere in an FaAA report, which gives me some cause for concern as to the actual amounts of pressure.

JUDGE BRENNER: Off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

BY MR. STROUPE:

Q Professor Christensen?

A (Witness Christensen) Yes. With regard to the Piezo quartz transducers, this is an area in which I've done quite a bit of work --

Q Let me stop you, Professor Christensen. Are you

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going to give me a yes or no answer first before you explain?

A The answer that I'm giving is that I've had figures presented to me but I find them very, very difficult to reconcile with my own experience.

Q I understand that. But are you aware, sir, of any figure in this proceeding that was arrived at by the use of a Piezo electric quartz transducer that exceeded 1680 psi for the Shoreham EDG's?

A No, I am not aware of any figure but I have some extreme doubts about the authenticity of the figures presented, based on the test with the Piezo quartz transducer. And I have many reasons why I doubt their authenticity.

Q Did you have occasion to hear or read Dr. Pischinger's testimony with regard to the T-sub-n values?

A I am not talking about T-sub-n values, I'm talking about authenticity of the values presented.

Q Did you have occasion to hear his testimony with regard to the measured cylinder pressures?

A I did hear his testimony, yes.

Q And are you aware that he agreed with the accuracy of those measurements, based on his experience?

A My experience, I'm afraid to say, and I've done

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quite a lot of work in this area, is completely different than his.

Q That's not the question I asked you, Professor Christensen. Are you aware that, based on his experience, he testified that he concurred in those measurements?

A I did hear that, yes. But his experiences are different than mine.

Q And isn't it true, gentlemen, that to the extent the actual average firing pressures in the Shoreham EDG's are less than 1680 psi, the allowable horsepower rating under Lloyd's Rules increases?

A As you reduce the maximum pressure, so the allowable horsepower may go up. But only if that maximum pressure is fairly even through the engine. If you get one cylinder going higher, then you can get a much worse state of stress than if the pressures are evenly balanced, though, or near humanly possible evenly balanced through the engine.

Q Mr. Eley?

Let me restate the question for you.

A (Witness Eley) If you would, please?

Q Yes.

Isn't it true that under Lloyd's Rules for calculating allowable horsepower of diesel engines, as cylinder pressure go down allowable horsepower goes up?

A Yes, it does. But I would state the same points

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that Mr. Christensen did after he made his statement.

JUDGE BRENNER: Something is beginning to disturb me just as a procedural matter. I don't know how I allowed things to drift into the mold where it becomes necessary to restate the question to a second witness just to get on the record whether that witness agrees. The panel rules that we have been operating under are that, unless there's a disagreement among all witnesses participating on the panel, that's going to be the answer on behalf of all the witnesses involved. On this subject the only witnesses involved, as I understand it, are Professor Christensen and Mr. Eley.

MR. STROUPE: I restated the question because upon looking at Mr. Eley, he appeared not to have the question in mind, Judge Brenner.

JUDGE BRENNER: Yes, but my point is you didn't have to ask him at all. In other words, if he had a disagreement, he was under an obligation to add a comment.

WITNESS ELEY: Judge Brenner, I would do that if I didn't agree with what Mr. Christensen was saying.

JUDGE BRENNER: Okay. You anticipated him as going to ask each of you if you knew that, and at least you know it now. And it will be more efficient, but you're going to have to listen to the question and try to retain it.

WITNESS ELEY: I have listened to the questions,

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Judge Brenner.

JUDGE BRENNER: I'm not addressing a particular point, I'm just addressing the future. That's number one.

Number two is, although as an accomodation, we've got the entire County witness panel up there. A, I'm not sure why and now that I've got a better appreciation of what witnesses are contributing to what on this subject and, B, I don't know why there has been conferring among witnesses other than the two involved on this subject. Can the County Counsel explain that to me?

MR. BRIGATI: Well, I'm not aware there's been all that much conferring. I observed a heck of a lot more conferring when LILCO witnesses were involved and many of them were not being asked questions or dealing with questions tnat fell remotely within their expertise.

JUDGE BRENNER: Let's stay with my observation here. My observation does not agree with yours, Mr. Brigati. The conferring there, I thought, were on witnesses who were co-sponsoring testimony on the subject. But I don't want to go back over my recollection of the past three weeks.

What's the situation now on the County's witnesses?

MR. BRIGATI: Obviously, Mr. Eley and Professor Christensen are the primary witnesses up there. We had

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hoped that Mr. Hubbard and Mr. Bridenbaugh would be able to sit up there to help those witnesses with the papers, since there is an awful lot of paper floating around.

Dr. Anderson, obviously, isn't necessary up there right now. And if you --

JUDGE BRENNER: Obviously is not?

MR. BRIGATI: Obviously is not necessary up there right now, in view of the questions that are being asked, and if there are no questions that are going to be asked that fall within his expertise, I suppose he should be excused.

JUDGE BRENNER: What about whether Dr. Anderson need be up there for any testimony in the written testimony dealing with crankshafts other than shot-peening?

MR. BRIGATI: He is the sponsor of certain questions and answers in the County's written testimony, Judge. And if Mr. Stroupe doesn't care to ask Dr. Anderson questions about that written testimony, as I say, we are quite content to see him leave the panel for the time being.

Likewise, as I said, we believe Mr. Bridenbaugh and Mr. Hubbard can serve a useful purpose sitting up there to assist Mr. Eley and Professor Christensen. They are not up there giving them technical information because, obviously, neither one of them are marine engineers, and the questions that are being asked of Mr. Eley and Professor

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Christensen deal with that particular field of expertise at the moment. They sponsored other areas of the testimony. I don't know whether Mr. Stroupe plans to ask them any questions.

I do think it would expedite the proceedings here if they were permitted to sit there, whether Mr. Stroupe cares to ask them questions or not, in order to help the two witnesses fumble with all of the paper that's up there. But I'll leave it to you.

MR. STROUPE: Judge, if I might --

JUDGE BRENNER: Give me one moment, and then I will allow you to have the next word. I just want a minute

(Pause.)

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JUDGE BRENNER: All right, Mr. Stroupe, go ahead.

MR. STROUPE: I was just going to say, Judge Brenner, at the outset I believe I indicated -- and Mr. Brigati may recall this -- that I had no questions of Mr. Hubbard and Mr. Bridenbaugh and really Dr. Anderson because as I have read through the testimony relating to crankshafts and shot-peening -- and this is based on the documentation given to us indicating who was testifying as to what -- that indeed those three persons sponsored no testimony that didn't either relate to an admitted fact and/or shot-peening.

JUDGE BRENNER: All right. Well Mr. Brigati recalled that because he made express reference to it in his statement.

I have just turned the pages of the County's testimony dealing with crankshafts other than shot-peening, particularly pages 106 through 132 -- that is my old copy, I hope it matches roughly -- and there is no testimony other than the first answer which merely states that the contention sponsored by any witnesses other than Mr. Eley and Professor Christensen except for some passing mention by Dr. Anderson on shot-peening.

Am I correct, Mr. Brigati?

MR. BRIGATI: I believe so, Judge.

JUDGE BRENNER: Why don't we make it simple and

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just keep those two witnesses up there.

I disagree that it would assist efficiency to leave extraneous witnesses up there because by that argument we would have witnesses with assistants up there helping them and the purpose is to get the testimony of the witnesses.

So lets -- and smaller panels are easier to handle when it will not affect the substance. When it will affect the substance we allow larger panels.

This isn't an ironclad rule for the rest of the County's testimony, I am not thinking of that and the parties can consider that on their own and we will also.

But for now in the absence of any substantive objection, and I have heard none, let's restrict it to Mr. Eley and Professor Christensen and ask the other witnesses to take a break.

MR. BRIGATI: Judge, before you dismiss the witnesses, I would like to point out that pages 12 through 25 do bear on the rating standards and related information concerning the crankshafts and the diesel engines and assuming no questions are going to be asked in that area then I feel that the witnesses can be excused on the basis outlined by you.

JUDGE BRENNER: Mr. Stroupe, do you have a comment on that?

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MR. STROUPE: Could I have just one second to look at that section?

(Pause.)

JUDGE BRENNER: That is a good point, Mr. Brigati, which I had overlooked. I have a compromise proposal.

This is getting a little digressive from the main reason I interjected which was to stop the same question being asked twice unnecessarily but I also observed what I thought was unnecessary conferring and I raised it in the context of efficiency, not any alleged untoward purpose or anything of that nature.

Why don't we do this? I sense that you would prefer to have all your witnesses up there, Mr. Brigati, correct?

MR. BRIGATI: Judge, I do think it would expedite things in terms of the paperwork handling and I will be happy to instruct them not to be consulting while questions are being asked or whatever you have observed in this area. I didn't think anything excessive was going on.

JUDGE BRENNER: I didn't label it excessive.

MR. BRIGATI: Well I didn't think any worthy of comment was going on then.

JUDGE BRENNER: Well I guess I disagreed with you there since I made the comment.

MR. BRIGATI: I see that.

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I think it would expedite things, Judge, but if you disagree I am perfectly willing to go along with your ruling on the subject.

JUDGE BRENNER: All right. I don't agree they need to be up there to assist with paperwork. However, I am more sensitive to your last point dealing with substance, that is, some testimony involving the rating of the engines could become pertinent.

All right. Let's leave them up there and change the sequence of the panel. Move Mr. Eley and Professor Christensen to the end, move Mr. Hubbard over and let's have no conversation other than where questions might overlap into another area, namely the area pointed out in the beginning of the County's testimony.

MR. BRIGATI: Fine and if we might --

JUDGE BRENNER: And that way if there is conferring we will recognize it and understand that that is the situation.

I realize and will state for the record that maybe I am becoming more picky than I did earlier in the proceeding and it is not that I am asserting any distinction necessarily, it is just that I am becoming more sensitive that as the hearing is going on more time is being spent conferring than answering questions -- that's an exaggeration -- more time is spent conferring than perhaps

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need be spent conferring.

MR. BRIGATI: Fine.

JUDGE BRENNER: This is the left-end-of-the-line shift and it is no reflection on the witnesses, as I attempted to make clear.

MR. BRIGATI: And maybe we could bump Dr. Anderson, as long as we are going through this moving around, because my partner tells me that he would like to have a moment with him to....

JUDGE BRENNER: That is up to you. If I were to pick any third witness who might have some connection it would have been him, but that is up to you.

MR. BRIGATI: That is the way I would prefer it.

JUDGE BRENNER: Okay. Mr. Bridenbaugh, Mr. Hubbard, Mr. Brigati is not going to let you go, we have it on the record whose fault it is, and Dr. Anderson can go.

(Witness Anderson temporarily excused.)

MR. STROUPE: Judge Brenner, I wonder if it might be possible to have everybody slide down one so I can see Mr. Eley to ask questions.

JUDGE BRENNER: Sure.

MR. BRIGATI: Can we go off the record for a moment?

JUDGE BRENNER: Yes.

(Discussion off the record.)

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JUDGE BRENNER: Back on the record.

I want the length of this digression -- for which I take the blame -- to have some good in that the message is transmitted to all future panels through counsel. I recognize there are no ironclad rules but so that there can be an accomodation appropriate to the needs of the future testimony -- I didn't mean to get into the next point this early -- but when we get to blocks there is an extremely large number of witnesses slated for LILCO. That panel is too big in my opinion to be able to be handleable and I expect LILCO to come up with some solution given the fact that testimony may be severable and whatever LILCO wants to consider along those lines should be discussed with the other parties before we hear about it. But I don't think 12 witnesses at a table is going to work out.

MR. STROUPE: Judge, we will try to do something about that. I must state, however, that the way it looks right now is it may not be severable.

JUDGE BRENNER: All right. I didn't ask for a response now. Pass the message on and work it out.

MR. STROUPE: I will certainly do that.

JUDGE BRENNER: All right.

I didn't mean the interruption to be that long, Mr. Stroupe, but you may proceed now.

MR. STROUPE: Thank you.

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BY MR. STROUPE:

Q Professor Christensen, do you recall some time ago confirming to me that the difference between the rated horsepower of the Shoreham EDG's and the allowable horsepower under Lloyd's at 1680 psi was somewhere between 5 and 6 percent?

A (Witness Christensen) I do recall that, yes.

Q Well isn't it true that based on your education and your testimony that Lloyd's generally is the most conservative of the major classification societies and hence has the greater margin of safety that the 5 percent to 6 percent differential between the allowable horsepower under Lloyd's and the rated horsepower of the Shoreham EDG's at 3500 Kw would not be significant?

A I cannot say that it would not be significant, no, I cannot say that.

Q Is that to say that in your opinion it would be significant? Or you just can't say either way?

A I am getting a little bit mixed up now. I always have problems dealing with negative questions.

If I could get that question again then I think I can answer it correctly but at the moment I am a little bit befuddled with a negative question.

Q Again let me try to restate it:

Based on your previous testimony about the

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general conservative nature of Lloyd's being generally the most conservative of the major classification societies, hence with the greatest margin of safety, isn't it true that the difference between the rated horsepower of the Shoreham EDG's at 3500 Kw and the allowable horsepower calculated under Lloyd's at 3500 Kw, 1680 psi, which is between 5 and 6 percent, would be insignificant or not significant?

A Where safety is concerned I don't think it is significant, no.

What I am going to say is this, that is a "no" answer with a "but." What we have to look at here is the ultimate safety and I cannot believe that the requirements for steamships generator sets are required to be more onerous or more conservative than the diesel generator which is going into a nuclear plant. I thought that the safety requirement for a nuclear generator in -- I'm sorry, I'm getting my words mixed up.

I would have thought that the requirement for a diesel generator in a nuclear plant should be equal to or even more than the requirements for a generator in a ship. That is my feeling as an engineer.

Q Mr. Eley, do you have anything to add to that?

I take it you don't.

A (Witness Eley) I would confirm his answer.

Q Professor Christensen, do you have any opinion as

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to whether the margin of safety inherent in Lloyd's rules is more than 5 percent?

A (Witness Christensen) When you are saying 5 percent I have got to ask 5 percent based on what?

Q Well Professor Christensen, haven't you indicated in your testimony that Lloyd's has the greatest margin of safety of all of the major classification societies?

(Pause.)

A There was a 5 percent figure mentioned but what we have got to look at here is that this margin that you speak about is based on the input from many, many areas and over many, many years and being continually upgraded as material change, as the computer came into being and I don't think that Lloyd's rules are that much more conservative than the other major classification societies of Europe.

Q But you believe that they are generally considered to be the most conservative of the major classification societies, as you have stated?

MR. BRIGATI: Objection, asked and answered.

JUDGE BRENNER: I am going to sustain it unless you dissuade me in a hurry, Mr. Stroupe.

MR. STROUPE: I believe he just contradicted himself in the answer to my last question by saying that he doesn't believe there is any difference between the conservatism of Lloyd's and other major classification

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societies.

MR. BRIGATI: Objection to that characterization of his testimony.

JUDGE BRENNER: All right.

I am going to sustain the first objection which moots the need to even deal with the second objection. We have got the transcript.

BY MR. STROUPE:

Q Professor Christensen, do you believe that the Lloyd's formula for calculating allowable horsepower for diesel engines contains a margin of safety greater than 5 percent?

A (Witness Christensen) I couldn't give you that figure there. It would take a lot of working out and comparing with other rules. We would have to get into the areas of fillets and factors of safety to come up with an answer that would answer you fully.

I just can't say. It is too involved to make any real effort to answer that out of my head. I would have to sit down and look at figures to come up with an answer that would be reasonable and fair to you and fair to me.

A (Witness Eley) I would agree.

Q Isn't it true, gentlemen, that Lloyd's rules allow special consideration to be given to surface hardening with regard to crankshafts?

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A (Witness Christensen) That is true.

A (Witness Eley) Yes.

Q Did you give any consideration to surface hardening in making your calculations under Lloyd's rules for purposes of your testimony?

A (Witness Christensen) Yes. The first thing that we have to answer on that is that Lloyd's would have to know a lot about the surface hardening techniques in the first place. That would be looked at by Lloyd's metallurgists, it would be discussed with the engineering people who are dealing in these specialist areas so they would come up with an answer; they would possibly put shafts through tests in their own testing establishment, the Crawley, and they would not give an easy answer to that. They would want to be fair, they don't want to hold back advancement in engineering and you can see that they do allow a figure there which is shown in the rules for hardening to approved systems of hardening.

A (Witness Eley) Agreed.

Q And you didn't compute or input any benefit to the formula that you utilized to determine the allowable horsepower rating for shot-peening, did you?

A (Witness Christensen) I did not, because I spoke to people in Lloyd's --

MR. STROUPE: Well I am going to object to that

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portion of the answer. I am not interested, Judge Brenner, in what he learned from somebody at Lloyd's, I asked him what he did.

JUDGE BRENNER: I am going to allow him to finish the answer and then we will deal with it given the question you asked him. He answered your question no, he did not and now he is about to give the explanation as to why he did not.

Go ahead, Professor Christensen.

WITNESS CHRISTENSEN: I spoke to people in Lloyd's to see if they could give me any input because I want to be fair in this case and get to the real facts.

When it comes to shot-peening, I told you earlier that I had to do a lot of research to find out what I did find out eventually about shot-peening. And therefore I would go to people who know more about these things than I do, and I think that is the proper route to go in my own opinion. And they came up with similar answers to what is being given in the exhibits that we have put forward.

BY MR. STROUPE:

Q Is that similar answers in terms of allowable horsepower?

A (Witness Christensen) The figure is put into the formula.

The normal construction of crankshafts -- if I

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may just look at the rule here, just to clear my mind because we are again in a complicated area.

(Pause.)

Yes, that rule is covered by the figure which they refer to as the Zed factor. You have a normal factor of 1. If you have a diforged or a grain flow forging crankshaft, you are allowed a 15 percent increase in the Zed factor and if you have approved hardening systems -- and here the operative word is "approved" -- then you will be allowed a 25 percent increase on the Zed factor.

Q Can you tell me, Professor Christensen, what effect a 25 percent increase in the Z factor would have in terms of the allowable horsepower of the Shoreham EDG's at 3400 Kw?

A I couldn't tell you because I didn't work it out.

Q Is it linear?

A I would have to look at the formula to come up with an explanation there.

No, it is not wholly linear, it is somewhere possibly in between, I haven't worked the figure out to see if there is a curvature there.

For hardening obviously there is a 25 percent increase but that is multiplied by a DQ. I wouldn't like to say whether it is linear unless I sat down and put figures

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on paper.

JUDGE BRENNER: Professor Christensen, you said that is multiplied by something and I didn't hear you.

DQ did you say?

WITNESS CHRISTENSEN: I said the Z factor is multiplied by the stress figure and by the DQ, which is the diameter of the shaft.

BY MR. STROUPE:

Q If the Z factor or value is increased by 25 percent, isn't the resulting figure increased by even more as a result of what is done to the Z value?

A (Witness Christensen) It would be in those circumstances, yes.

Q And wouldn't it be true, Professor Christensen, that the ultimate change in allowable horsepower rating would be more than 5 percent?

A As I said earlier, I couldn't sit down -- I couldn't give you an answer off the top of my head, I would have to sit down and calculate the numbers out. I just can't tell you out of my head.

I'm not trying to be awkward but there we have quite a complicated figure and I've got to plug the numbers in.

Q Well based on all the experience that you have had calculating matters under Lloyd's, can you not look at

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that formula and tell me that generally speaking an increase of 25 percent to the Z value would result in an increase to allowable horsepower of more than 25 percent?

MR. BRIGATI: Objection, he has been asked and answered that question.

JUDGE BRENNER: No, the objection is overruled. The cross-examinater is allowed to probe some more.

WITNESS CHRISTENSEN: Yes, but you have got to remember that where that Z factor is applied it is multiplied by other things, it is divided by 7000 which somewhat lessens it again, there is a negative value to be applied to it before you apply the section which is outside the parentheses.

And it is on these grounds that I said I would not be ready to come to a rapid conclusion in that area, there are too many inputs to come up with an answer out of my head.

BY MR. STROUPE:

Q Professor Christensen, based on your years of experience with Lloyd's -- assuming for the moment that all other factors in the formula stayed the same -- don't you know that an increase of 25 percent of the Z value necessarily results in an increase in allowable horsepower of more than 25 percent?

MR. BRIGATI: That question has been asked and

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answered.

JUDGE BRENNER: I am going to overrule it. I don't have the formula in front of me but I believe he changed the question by saying assuming the other factors stayed the same. I will admit I am not sure, but we will see what the witness' answer is.

WITNESS CHRISTENSEN: My experience over the years dictates to me not to come up with a quick answer without due thought.

BY MR. STROUPE:

Q So you can't give me a yes or no answer to that question?

A (Witness Christensen) I gave you a "yes" answer earlier by stating that it would increase the allowable horsepower.

Q Would it be possible for you to consider this overnight, Professor Christensen, so I can ask you about it in the morning?

A Yes, it would be.

Q Mr. Eley, do you know the answer to that question?

A (Witness Eley) No, I don't. But if I might be excused for a couple of minutes, I can put that plan into progress now.

Q Why don't we let you do that tonight?

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A I have to do that before 5:00 this evening.

Q I'm sorry, I didn't understand that.

A Okay. I have this program on a computer. If I can get to a telephone before 5:00 I can get the answer straight away.

Q The only way you can do that is through a computer program?

A No.

Q You can do it by hand calculations --

A Yes, I can.

Q I don't think it is necessary to do it by computer.

JUDGE BRENNER: How long would it take you to do by hand calculations, Mr. Eley, about five minutes or so -- that is, hand calculations using a calculator?

(Pause.)

Can I get an answer to my question? Are we talking about minutes of calculations here or hours?

WITNESS CHRISTENSEN: I don't know whether I have a program in my calculator where I can plug the numbers in and come up with the answers --

JUDGE BRENNER: That wasn't my question.

WITNESS CHRISTENSEN: Oh, I'm sorry.

JUDGE BRENNER: How long will it take to do it regardless of how you do it?

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WITNESS ELEY: We'll do it this evening.

JUDGE BRENNER: Well tell me what is involved.

WITNESS ELEY: I don't recollect offhand now.

MR. STROUPE: Judge Brenner, if I can ask one question I might be able to straighten the whole thing out.

JUDGE BRENNER: I don't want them to have to spend hours. As I look at the formula --

MR. STROUPE: I don't think they will.

JUDGE BRENNER: Well let me finish.

As I look at the formula it should take minutes rather than hours, but I may be missing something.

Mr. Eley, can you help me?

WITNESS ELEY: I don't think it is going to take us that long.

JUDGE BRENNER: All right.

Now Mr. Stroupe, you can do whatever you want to do.

BY MR. STROUPE:

Q Professor Christensen and Mr. Eley, on page two of your calculations, which I believe is Suffolk County Exhibit 36, at the top of page two where it says "allowable horsepower," isn't all you have to do to determine this increase or the effect of the adding of the 25 percent to the Z value the multiplication of the figure 351412 by 1.25?

A (Witness Christensen) That would be virtually it,

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yes.

Q That's not very complicated, is it?

A (Witness Eley) No.

Q Could you do that for me now?

A (Witness Christensen) I don't have my calculator here now.

Q You can't do it without a calculator, sir?

A No, I cannot do figures -- I cannot do simple multiplication and division without a calculator.

JUDGE BRENNER: I thought I saw somebody up there had a calculator, am I wrong?

WITNESS CHRISTENSEN: I am afraid -- please, I am not trying to be awkward but I am used to working a calculator with reversed Polish notations. These calculators here have algebraic entry and I get lost on them --

MR. STROUPE: May I approach the witness? I can provide some assistance.

JUDGE BRENNER: Well I don't know if that is too much use, his calculator....

You've got one?

All right. Give him the calculator and see if he can do it.

We can do it ourselves at this point, frankly.

(Calculator handed to the witness.)

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Tomorrow he is going to have his very own calculator with him, right?

MR. BRIGATI: If he has it in this area, yes, Judge.

Do you have the calculator --

WITNESS CHRISTENSEN: I have it in the other room.

MR. BRIGATI: Do you want us to go get it? I mean, is it that important?

JUDGE BRENNER: What are you going to do after you get the answer from the witness, are you going to ask follow-up questions?

MR. STROUPE: No, all I want is the answer.

JUDGE BRENNER: Put the answer in your findings, and if overnight you don't think that will work out I will let you ask him tomorrow morning.

MR. STROUPE: I would like to demonstrate for the record what the answer is by multiplying the 1.25.

JUDGE BRENNER: We can do that.

MR. STROUPE: -- by use of the County's witness.

MR. BRIGATI: Judge, we are going to undertake to do it overnight.

JUDGE BRENNER: All right. See if you can handle that.

MR. BRIGATI: I can't but I'm sure they can.

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JUDGE BRENNER: You can do it, too. That's my point, any of us can do it at this point. I don't need a witness to do that for me.

But if you want to ask him -- that's why I asked if you had any follow up questions based on it.

MR. STROUPE: I just have some questions based on allowable horsepower and I want to know what the figure is. Hopefully we will establish --

JUDGE BRENNER: Do you know what the figure is?

MR. STROUPE: No, but I can tell you in about 30 seconds if you will give me a chance.

JUDGE BRENNER: Go ahead. Get your calculator back....

(Pause.)

MR. STROUPE: We come up with 6789.5.

JUDGE MOORE: .6.

JUDGE BRENNER: All right. Use that figure for whatever you want to use it for.

If the County disagrees with it after they work it out overnight, first th' tomorrow morning the County can inform us that they disagree and the first answer we will get from the witness is what the witness thinks the answer is. If we hear nothing, that is the answer.

Go ahead.

MR. STROUPE: Thank you, Judge Brenner.

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WITNESS CHRISTENSEN: Could I make some comment here which I think is pertinent?

And that is this: that when I discussed with the Lloyd people the wherewithal of whether they would approve a shot-peening technique --

JUDGE BRENNER: Professor Christensen, I am going to exercise my discretion and stop you. I don't think there is a pending answer -- a pending question. I don't think what you are giving now is explanation to the particular questions asked.

As I tried to explain to you before -- and let me recall it to you -- my ruling now does not mean that you will not be able to ever give us the information. I know it may be a little more difficult for you, but try to retain the point and then discuss it with your counsel and your counsel can come back on the record through your answers on redirect in appropriate sequence if you and your counsel agree and that way we will get the information that you want to give us and we will deal with it that way.

WITNESS CHRISTENSEN: I understand that. Thank you.

JUDGE BRENNER: Thank you.

Mr. Stroupe.

BY MR. STROUPE:

Q Gentlemen, have either one of you made any

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calculations with regard to Lloyd's rules since the time of the filing of your testimony?

A (Witness Eley) No.

A (Witness Christensen) I can't recall having made any, no.

Q You haven't made any calculations under Lloyd's rules as to 3300 Kw, I take it?

MR. BRIGATI: Objection. What is the relevance of 3300 Kw to these proceedings?

JUDGE BRENNER: I will ask Mr. Stroupe in a moment.

But first, Mr. Brigati, didn't the County ask questions as to what calculations LILCO's witnesses may have made at different load levels including 3300 and didn't Dr. Pischinger go back and check his numbers -- or attempt to check his numbers, but in any event come back and give us details at those different load levels?

MR. BRIGATI: I'm not sure, Judge. Did we open that area up or is that one that had been opened up on other examination? I just don't recall.

JUDGE BRENNER: I believe the County certainly asked questions about it. I don't recall who opened up the area, as you put it. But at the time I was wondering to myself why the County thought it was in its interest to pursue it; but the parties are wiser than me at the time

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they are adducing information.

Mr. Stroupe, why do you think it is material?

MR. STROUPE: For two reasons, I believe, Judge Brenner: one, the reason that you stated, that being that there was extensive questioning by the County, I believe, with reference to any calculations that had been made specifically at 3300 Kw and 3200 Kw of Dr. Pischinger and other members on the crankshaft panel.

And secondly, as is well before this Board and as we have intimated in our testimony, the loads that the Shoreham EDG's are subjected to is a matter of question at this point in the proceeding and we feel we are entitled to at least inquire and get an answer as to whether or not any calculations have been made at this load.

JUDGE BRENNER: On your last point I guess you weren't here when I had some dialogue with LILCO counsel on that subject. But the Board's views on that are inconsistent with what you just stated. I can see why you would want to do that but I told LILCO that there were certain notice and due process aspects that have not to date been squarely addressed by LILCO. And while you may get some facts in the record here that you may be able to use for other purposes, I am not going to engage in adducing those facts solely for that purpose.

I don't mean to arbitrarily limit it if it was

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easy to get such facts, but you are going to need a whole lot more than just pointing back to this record for this if LILCO ever wants to make a change and I think from our statement on the record it is there in that regard.

Give me a moment.

(The Board conferring.)

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JUDGE BRENNER: We are going to allow the question, and the reason is a practical one.

We are already down the road through testimony of LILCO's witnesses adduced in part by County cross-examination, and in fact I think quite extensively by County examination, but in any event at least in part by such examination.

It may turn out later that none of the information at those different load levels will be material to the contentions before us, but it also may turn out that it will be at least a useful check at what the different witnesses testifying for the different parties have done in terms of conclusions and calculations under different classification societies or other rules within the scope of the contention, and we can compare results and methodologies, since we already have quite a record by other witnesses at those different load levels.

And I should also mention that I believe we have testimony by the Staff witnesses at those different load levels also.

So primarily it is a pragmatic reason. Since we are that far down the road already, and this is the last party testifying on this subject, we can fill out the picture. It may turn out to be immaterial, and I may be sorry that we spent the time on it, but it may be material

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for the comparative purposes I just indicated.

And I do not have the sense now that it is going to take a lot more time. So we will allow the question.

BY MR. STROUPE:

Q Can you answer the question, gentlemen?

A (Witness Christensen) Could you just give me the question again?

Q Have you made any calculations under Lloyd's rules as to allowable horsepower at 3300 Kw?

A No.

A (Witness Eley) No, I have not.

Q Can that be done fairly simply by ratioing what you have come up with?

A (Witness Christensen) One of the things I must says here--

Q Professor Christensen, could you give me a Yes or No, and then you can explain.

A Could I just have the question again? I'm sorry, I've been knocked off track.

Q Yes.

Can the calculation under Lloyd's rules at 3300 Kw be made very easily by ratioing what you have arrived at at 3500, 4621 allowable horsepower, to the rating of 4890 for the Shoreham EDGs, and converting it and thereby coming up with a ratio to arrive at the allowable horsepower at

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3300 Kw?

A I wouldn't like to try it myself. For me the answer is No. And what I am going to say is this:

As soon as I tried to make quick calculations, then I find I am pressing the wrong inputs and then coming up with stupid answers. I know the answers are stupid and that makes me worse. So I don't like to make answers quickly on this. I prefer to sit down, put my inputs down, and see what I'm doing so that I can come up with correct answers.

A (Witness Eley) You are probably right, but I would have the same reservations as Mr. Christensen.

Q But you think it could be done that way?

A Yes.

A (Witness Christensen) Yes. If you want me to do it tonight I am going to volunteer to do it tonight, if you give me the way you want me to work it out.

JUDGE BRENNER: Professor Christensen, I think you may have gotten ahead of the questioner. It is late in the day for all of us.

Mr. Stroupe can correct me if I'm wrong. I don't believe he was asking you actually to do it, I think he was asking you if that would be the way that it would be done.

MR. STROUPE: Precisely, Judge.

MR. BRIGATI: And Judge, I might add I do not

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believe--

JUDGE BRENNER: Let me make sure we have got Professor Christensen's answer to that question. I think we do, but I am not sure now.

WITNESS CHRISTENSEN: When we talk of things, doing these things by ratio and proportion, I like to look at the thing before I give my answer so that I'm giving an answer which is valid.

When we are playing around with numbers in complicated formulas, if one can call them complicated, then I don't like to answer straight off the shoulder. I like to look at the thing and come to what I will call something valid when I give an answer. I really can't say whether it could be done by ratio and proportion by just looking at it now, without thinking -- spending a lot of time thinking about it.

JUDGE BRENNER: All right.

Mr. Brigati, do you need to say something? There is no pending question right now.

MR. BRIGATI: The only thing I need to say is that I believe Professor Christensen volunteered to do something and I don't think he is required to do it, and I am going to withdraw his volunteering of it.

JUDGE BRENNER: Okay.

BY MR. STROUPE:

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Q Professor Christensen and Mr. Eley, isn't it true that the CIMAK rules relating to crankshafts are proposed or draft rules?

A (Witness Eley) Yes, they are.

A (Witness Christensen) Yes.

Q And indeed, haven't they been proposed or draft rules since approximately 1978?

A I could not say the exact date when they came to be.

A (Witness Eley) I don't recollect either.

Q Did either of you hear Professor Sarsten's testimony with regard to how long the CIMAK rules have been in draft form?

A I didn't, no.

A (Witness Christensen) I cannot recall the actual testimony given by Professor Sarsten on that point, no.

Q You know, don't you, that they have been in draft or proposed form for some fairly long period of time?

MR. BRIGATI: Objection to the form of the question. Let's have a definition of "fairly long."

MR. STROUPE: More than five years.

WITNESS CHRISTENSEN: I couldn't say how long they have been in form, but if you ask me why they have taken a long time, that I can possibly--

BY MR. STROUPE:

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Q That is not what I asked you, Professor Christensen.

A (Witness Eley) I don't know how long they have been in draft form.

Q Do you know, either of you, when the CIMAK rules first came out in any form?

A No.

A (Witness Christensen) I have been aware of them for some considerable time, but the exact date or the exact year I cannot remember now.

Q Are either of you aware of adoptation of the CIMAK rules by either Lloyd's, ABS or DEMA?

A I can give some comment on that in respect of the fact that in July of this year, Lloyd's and Bureau Veritas out of Paris were trying--

Q Professor Christensen, I didn't ask you about anything but ABS, Lloyd's and DEMA.

A Now I am trying to explain something.

Could I have the question again, and I will try to answer it with a Yes or a No?

MR. STROUPE: I will withdraw that question, and move on.

JUDGE BRENNER: You can come to a convenient stopping point for the overnight recess whenever you want to, Mr. Stroupe.

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MR. STROUPE: I think I could ask maybe a couple more questions and be at a good point, Judge Brenner.

BY MR. STROUPE:

Q Gentlemen, isn't it true that neither one of you did any independent calculations with regard to CIMAK on the Shoreham replacement crankshafts?

A (Witness Eley) That is correct. Both Professor Christensen and myself did the checks on the CIMAK correlations using either the Beshouri or Yang correlation as we mentioned before. It is one of the included documents.

Q That is to say you did check calculations of TDI's CIMAK calculations?

A Yes.

A (Witness Christensen) We did, yes.

Q Did you utilize any other CIMAK calculations in reaching your opinions?

A I just used the calculations which I think have been offered as an exhibit here.

MR. STROUPE: Judge Brenner, I think we are at a good point to recess until the morning.

JUDGE BRENNER: All right.

We alluded to this off the record and also last week. I think some time before the end of the day tomorrow would be a good time to discuss the schedule over the next

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few weeks of the proceeding, rather than leaving it to Thursday, if the County could be in a position to do that tomorrow, and the other parties.

Mr. Stroupe, I will offer you the opportunity to answer now, but you can wait until tomorrow morning if you want. Do you know how much more time you will have with these witnesses?

MR. STROUPE: Judge Brenner, I apologize. I really don't. It has gone much longer today than I had anticipated, quite frankly.

JUDGE BRENNER: All right.

MR. STROUPE: I will try to pare myself down tonight and be in a position to tell you in the morning.

JUDGE BRENNER: All right. Thank you. That will be fine.

If there is nothing further, we can adjourn for the day and resume at nine o'clock tomorrow morning.

(Whereupon, at 4:55 p.m., the hearing in the above-entitled matter was recessed to reconvene at 9:00 a.m. the following day.)

CERTIFICATE OF OFFICIAL REPORTER

This is to certify that the attached proceedings before the UNITED STATES NUCLEAR REGULATORY COMMISSION in the matter of:

NAME OF PROCEEDING: LONG ISLAND LIGHTING COMPANY
SHOREHAM NUCLEAR POWER STATION

DOCKET NO.: 50-322-OL

PLACE: HAUPPAUGE, NEW YORK

DATE: TUESDAY, OCTOBER 2, 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) William R. Bloom/BSM
(TYPED)
William R. Bloom

Official Reporter

Ace Federal Reporters, Inc.

Reporter's Affiliation