ORIGINAL

UNITED STATES
NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF:

LONG ISLAND LIGHTING COMPANY

(Shoreham Nuclear Power Station)

DOCKET NO: 50-322-OL

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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In the matter of:

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

(Shoreham Nuclear Power Station):

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

Friday, March 8, 1985.

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

BEFORE:

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

JUDGE PETER A. MORRIS, Member.

JUDGE GEORGE A. FERGUSON, Member.

APPEARANCES:

On behalf of Long Island Lighting Company:

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

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

On behalf of Suffolk County:

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

On behalf of the Commission Staff:

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

C O N T E N T S

E X H I B I T S

P R O C E E D I N G S

JUDGE BRENNER: Good morning. We are on the record now.

Mr. Stroupe, you said you had a preliminary matter. Is it something that we have to take up this week?

MR. STROUPE: Yes, your Honor, I believe so.

In response yesterday to your question as to whether or not I wish to make an offer of proof with regard to the motion I made or the proposal I made to present the testimony of Paul R. Johnston, I would now like to present to the Board proffered testimony which I have already furnished a copy of to the CAunty and to the Staff.

I would just like to state for the record several things:

One, that we believe indeed that this is in the nature of rebuttal testimony because it addresses two issues raised in the questioning of Dr. Bush where we believe he was incorrect in the statements that he made, specifically with regard to the crankshaft stresses, and specifically with regard to tensile stresses.

So at this time we would renew that motion. It turns out that the crankshaft stress in both those instances was contained in prior LILCO crankshaft exhibits, Exhibit C-16 and Exhibit C-17 from the hearing last fall, and it has the stresses, as can be seen from that proffered testimony,

from 1750 kw up to 3800 kw. And we would make that offer of proof this morning.

JUDGE BRENNER: Well, we'll consider it, not right now. You've made a motion for reconsideration and we will consider whether to reconsider it. We won't be able to do that today.

You had better give us the exhibits, just one copy for the Board to share on loan would be fine, if you could do that Monday.

MR. STROUPE: I will do that.

JUDGE BRENNER: We will look at it on Monday.

MR. STROUPE: Also in an effort to try to assist the Board, I believe one of the Board members, perhaps Judge Morris, asked for the ABS certificates, or grade of the ABS metal for the crankshafts. And that is contained also in LILCO Crankshaft Exhibit C-12, which is already in the record. And if the Board wishes, we will make copies of that available Monday, too.

JUDGE BRENNER: Why don't you do that also?

But we want to get from Dr. Bush what he thinks the composition is, and then we will have it in both places. I at least don't know what C-12 is off-hand.

MR. GODDARD: Judge Brenner, Dr. Bush informed me this morning that he misstated a matter in response to a question asked I believe by Judge Ferguson yesterday. He has

prepared something. We would like him to read it into the record this morning to correct his testimony of yesterday.

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

MR. GODDARD: I have discussed it with the other parties. They have not had a chance to read the information that's involved. It is a correction to one of Dr. Bush's answers yesterday.

JUDGE BRENNER: What is the subject?

MR. GODDARD: It was with regard to the stresses on the crankshaft, the tension on the crankshaft.

JUDGE BRENNER: Well, I don't know what he is going to say of course. It might be better to do it now, so we don't have to then go back in case it leads to questions of other witnesses also.

Does any party have a problem?

MR. STROUPE: Your Honor, we don't. We believe this relates to a portion of the rebuttal testimony that we have proffered.

MR. DYNNER: I would like to see what he is going to say because if it is going to reopen new issues, then I would object. If it is just a simple correction of a number or something like that, I would not object.

JUDGE BRENNER: All right. Well, of course we will allow the witness to make a correction, and if it is something

else we will deal with it.

All right, I guess you want Dr. Bush back on the stand.

MR. GODDARD: Yes, that's correct.

Dr. Bush, will you please take the stand at this time?

JUDGE BRENNER: And as long as you are going to be focusing or asking him questions, Mr.Goddard, ask him about the composition of the ABS metal in the crankshaft at Shoreham.

Whereupon,

SPENCER H. BUSH

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

MR. GODDARD: I will also state at this time for the information of all parties that testimony was served on all parties and the Board entitled "Testimony of Carl H. Berlinger on Load Contentions Concerning TDI Emergency Diesel Generators at the Shoreham Nuclear Power Station," dated February 5, 1985.

Neither Dr. Berlinger nor any other Staff witness will sponsor that testimony, and it will not be introduced into evidence in this proceeding. I don't want anybody to be confused by the fact that we served it and--

JUDGE BRENNER: Moreover, you emphasized that and drew our attention to it just recently, so it is good you made

the statement.

I will state for the record that in fact it is not testimony. There is no substantive testimony in it whatsoever. It is one page which states his name and occupation, his qualifications. He references the fact that a copy of his qualifications is in the record. And beyond that, the testimony, so-called, states in its entirety that:

"This testimony is for purposes of stating that the joint testimony filed by our consultant contractor, Battelle Pacific Northwest Laboratory, has been reviewed by the NRC Staff and that their testimony has been accepted for filing on behalf of the NRC Staff."

Since it is not going to be in the record, I want to say that I disagree with your characterization of it as testimony. And now we know what it said in case anybody wants to disagree with my characterization.

Go ahead.

MR. GODDARD: Thank you, Judge Brenner.

FURTHER DIRECT EXAMINATION

BY MR. GODDARD:

Q Dr. Bush, yesterday you indicated you would provide the composition of the ABS steel for the Board upon request. Are you prepared to do so at this time?

A Yes, I am.

Q Please proceed.

A The shafts, as either certified by ABS or going directly to the Krupp records have carbon contents ranging from .46 to .50 percent, silicon contents ranging from .05 to.12 percent, manganese contents ranging from .65 to .70 percent, phosphores contents ranging from .006 to .010 percent, sulphur contents ranging from .008 to .010 percent, chromium contents --

JUDGE BRENNER: Let me stop you for a minute, Dr. Bush. I want to check something.

(Pause.)

JUDGE BRENNER: Go ahead, Dr. Bush. I'm sorry.

THE WITNESS: Chromium contents from .63 to .69 percent, and in one instance, aluminium content of .003 percent which would be used as a grain refiner.

In essence, these are what one calls a 50 carbon steel with the exception of the chromium, and at that level of chromium it would fall in the range that ASTM would designate roughly as a 50 50 steel.

The attachments consist of the American Bureau of Shipping Reports, as I cited and, in addition, the reports from Krupp.

MR. GODDARD: Thank you, Dr. Bush.

BY MR. GODDARD:

Q Dr. Bush, you indicated to me this morning that you

wished to correct a misstatement which you made on the record yesterday in response to a question asked by Judge Ferguson. Are you prepared to do so at this time?

A Yes.

Q Will you please state the subject matter of the question to which you initially responded?

A The specific item as to which I was incorrect in my statement had to do with a misrepresentation of the tensile load, and I would like to clarify the record by indicating why it would not be important in the first place and, secondly, in that fact that it is taken care of automatically in effect, if I may do so.

Q Dr. Bush, before you proceed, I notice you are apparently reading from a few pages which you have in front of you. Were those prepared by you?

A Yes.

Q When did you prepare those notes?

A About five o'clock this morning.

Q Did you prepare those by yourself and without discussion of the content thereof with any other person?

A That's correct.

Q And your purpose in doing so was to correct what you perceived as a misstatement made on the record yesterday?

A That's correct.

Q Thank you.

Will you proceed, please?

A My statements to questions by Judge Ferguson were incorrect in one specific respect. I misrepresented the tensile load on the shaft by equating it to the value of the tension strain gauge values. I certainly knew better and can only attribute it to battle fatigue, plus a massive injection of undigested data which I received the previous day.

In fact our method of analysis which was a vector summation of bending and torsional stresses will yield a maximum equivalent alternating stress comparable to that cited in the Failure Analysis document which I cited on March 7th.

Tensile stresses should play little or not role if one examined the rotating shaft for the following reasons:

The shaft rests on a bearing surface so in essence it floats. This means one would not expect major end thrust leading to axial tension or compression. A rotating shaft, particularly one transmitting loads through a gear train, will be subjected to twisting generating torsional stresses along the shaft.

The rapid rotation of the shaft, particularly with a shaft such as a crankshaft where the local centers of gravity are offset from the centerline of the shaft, will cause portions of that shaft to essentially lift off its

seat, generating highly localized bending stresses. These will concentrate at the discontinuity regions where crank joins shaft, and these discontinuity regions, parenthetically the fillets, are the region of maximum stress concentration and highest probability of failure.

As noted previously, I misrepresented the tension stress gauge as tensile stress. In fact there are two gauges, 45 degrees tension and compression, whose product is resolved in the torsional shear, plus a minor component of tension, plus a bending gauge. In fact the tensile stress in essence is buried in the data and it is a small value.

One can combine into major and minor principal stresses which are again combined into a mean stress and an alternating stress component which is the common approach. Otherwise the bending and shear stresses can be combined vectorially providing the phase relationships of load versus angle of rotation, providing these are known.

Tensile stresses are a factor at much higher rotational speeds such as occur in large steam turbines. However, they are circumferential, not axial. Here the speed will tend to lift off the shrunk-on disks on the shaft, and tensile stresses will be the principal cause of failure.

Tbe RPMs are much higher than in a crankshaft, usually 3600, so it is a different phenomenon.

End 1

Q. Does that conclude the correction to your statement yesterday, Dr. Bush?

A. Yes.

MR. GODDARD: Judge Brenner, the Staff has nothing more for Dr. Bush on this issue; and to that extent he is available for cross-examination by the parties, if the Board is satisfied with the correction and have no further questions themselves.

JUDGE BRENNER: Mr. Dynner?

MR. DYNNER: No questions.

JUDGE BRENNER: I guess I should have asked LILCO first.

MR. STROUPE: Yes, I have some questions, Judge Brenner.

CROSS-EXAMINATION

XZXZXZX

BY MR. STROUPE:

Q. Dr. Bush, I'm going to hand you a report --

JUDGE BRENNER: Let me tell you, Mr. Stroupe, I'm going to be very careful about limiting you to questions on his clarifications and not using this as an avenue for which other procedural mechanisms need to be employed to introduce yet further evidence.

MR. STROUPE: I understand that, Judge Brenner.

JUDGE BRENNER: Okay. So make it easy on yourself by keeping that in mind in advance.

BY MR. STROUPE:

Q Dr. Bush, I'm going to hand you a document entitled "Field Tests of Emergency Diesel Generator 103 With 13 by 12 Crankshaft", prepared for Shoreham Nuclear Power Station, Long Island Lighting Company, dated April 1984, entitled "LILCO Crankshaft Exhibit No. 16", previously filed in this proceeding; and I direct your attention to Table B-4 at page B-5 thereof.

MR. STROUPE: I do not have extra copies of this because I did not know this was going to happen this morning, Judge Brenner.

JUDGE BRENNER: Well, none of us have copies.

MR. STROUPE: This is the table that he read into the record yesterday in response to Judge Ferguson's question, the answer 29,800 psi for the tensile stresses.

(Exhibiting document to counsel.)

JUDGE BRENNER: Let me put it to you this way: does LILCO disagree with anything Dr. Bush just said this morning?

MR. STROUPE: No, Judge Brenner. However, I believe we should be entitled to some further amplification of what he has said, in view of the fact that part of our rebuttal testimony would have gone to that very subject.

JUDGE BRENNER: That's my problem.

MR. STROUPE: He has admitted on the record, Judge Brenner, that the statement was incorrect, which is the

position I took this morning.

MR. DYNNER: I'll object to handing the witness this document, which I haven't had a chance to look at with any care, or have my consultants read and understand. I think if he wants to cross-examine the witness, he ought to do it on the basis of the statements the witness just made and not hand him new documents.

JUDGE BRENNER: Well, let's let him go a little bit, because I'm not sure it's a new document.

You had better put the foundation in to see if this is what Dr. Bush was using yesterday when he testified.

BY MR. STROUPE:

Q. Dr. Bush, is that, in fact, the document from which you responded to Judge Ferguson's questioning yesterday, and indicated that the tensile stresses were -- the highest figure was 29,800?

(Handing document to the witness.)

A. Yes. And then, I think, I corrected and said that it was the major principle stress, in the testimony.

I would like to clarify, as I said yesterday, I had had approximately 30 minutes to examine this document, which is hardly enough for this number of pages.

Q. Dr. Bush, under the column at 3500 kw, where the figure 29,800 psi is found as a major principle stress, do I understand your statement this morning to say that, in your

opinion, this is not a tensile or axial stress?

A. That's correct.

Q. And did you indeed say that this represents simply the shear and bending stresses relative to a different set of axes?

MR. DYNNER: Objection. Asked and answered. The witness has explained it, and all he is doing is having him regurgitate what he read from his statement.

JUDGE BRENNER: We'd like to make sure it's clear.

Dr. Bush?

THE WITNESS: Yes. These can be combined by use of some things such as sines rule to establish a value. I would comment that sines is cited in the FaAA document. I cannot cite the specific page.

BY MR. STROUPE:

Q. And, to the best of your knowledge, Dr. Bush, these numbers are the result of a strain gauge rosette which was located in the fillet of the crankshaft at crank pin number five?

A. To the best of my knowledge, that is the case, recognizing that I can only read what is here, and have not had an opportunity to digest the document.

Q. And do those strain gauge measurements, Dr. Bush, include all stresses, whether they be tensile, bending or torsional?

A. Yes.

Q. And thus, is it correct that you used all stresses in your fatigue analysis, as a result of utilizing the strain gauge data?

A. That's correct. As I indicated there, the small component of tension is buried in the strain gauge measurements in this instance.

MR. STROUPE: Judge Brenner, that's all of the questions I have on this subject. I would renew my request to be permitted to ask one or two questions of Dr. Bush with reference to the same exhibit, as to torsional stresses set fort in a particular table in that exhibit.

JUDGE BRENNER: Well, wait. I never stopped you from cross-examining Dr. Bush, so I don't know what you're talking about now. Nobody ever stopped you --

MR. STROUPE: I was going to another subject. You said you would be very careful to limit me to specifically the subject matter in this statement; and what I tried to indicate was that I would now like to cross-examine Dr. Bush with regard to torsional stresses as they are set forth in this exhibit, previously filed in this action.

JUDGE BRENNER: Nobody ever stopped you yesterday, while you had your opportunity for cross-examination.

Am I correct?

MR. STROUPE: That's correct.

JUDGE BRENNER: All right.

Dr. Bush, tell me, as simply as you can, how you know of your own knowledge that that figure of 29,800 psi which, I believe, you rounded to 30,000 in your testimony yesterday, is simply a combination of the bending and shear stresses. How do you know that, of your own knowledge?

THE WITNESS: Well, that would be resolved from the strain gauge data. And, as I indicated, since I had essentially no opportunity to read this, I would have to say it is more hearsay because I cannot equate it specifically to the strain gauge measurements shown here, the strain gauge measurements in the Failure Analysis documents and the values here.

JUDGE BRENNER: I'm sorry; I don't understand your answer.

How do you know, of your own knowledge, or what's the basis for your corrective statement this morning, as to just the part that that 29,800 psi represents -- that is, that it's a combination of the bending and shear stresses? What's your basis for knowing that?

THE WITNESS: Only in looking at the way the strain gauges are placed on there. They will be measuring -- there will be a tensile component in there and a compressive component and a bending component; and then, also, it can be resolved into a torsional component. That's from the only one,

and I cannot equate the specific values thereto.

In other words, I would have to go back to the original values, look at the micro-inches of strain, et cetera, and I do not have -- the data may well be in this report, but if it is I haven't had an opportunity to see it.

JUDGE BRENNER: Have you read the proffered testimony of Paul R. Johnston, which is the subject of LILCO's motion dated March 8, 1985?

THE WITNESS: No.

JUDGE BRENNER: And it was your own independent realization, without prompting by anybody else, that that value, for the reasons you just told me, would represent a combination of the bending and shear stresses?

THE WITNESS: Well, I did discuss it yesterday because I realized --

JUDGE BRENNER: Who did you discuss it with?

THE WITNESS: I discussed it with Mr. Johnston. I realized as soon as I stepped down that I had misrepresented the situation; and I wanted to clarify in my own mind, because I suddenly realized that that couldn't possibly be the correct tensile value.

End WRB 2

I would comment: I expected this to come up in cross-examination, frankly, and I would have responded yesterday, but it never did arise.

JUDGE BRENNER: Well, all right. Fine.

Witnesses can say they want to make a correction at any time; and as soon as they know they want to make a correction, that's the better time to do it. I state that as a general observation. You do not have to respond.

B3 As I understand it, Mr. Stroupe, the further questions you were going to ask Dr. Bush are not related to the subject of this correction this morning?

MR. STROUPE: They are, I believe, related in the sense that the questions I would ask him refer to stresses upon the crankshaft that include torsionals, bending, shear -- the very stresses I believe he is talking about this morning. Frankly, all I would want to do is ask him by having him look at one series of exhibits whether he is indeed able to determine that these stresses are linear.

JUDGE BRENNER: I think, as you candidly told me, it's also the same additional information that you would want to get into with your further testimony.

MR. STROUPE: That's correct.

JUDGE BRENNER: Let's take the whole thing up together and, depending on our ruling on your motion for reconsideration, when we all have the exhibits in front of us.

We'll decide what to do at that time. To the extent we rule in your favor, if we do, then Dr. Bush would still be around for you to ask questions of him, too. And we'll decide what to do. I want to see the exhibits. I just don't have -- I'm trying to visualize what those exhibits look like, and I may be confusing them among all the exhibits I've looked at.

MR. STROUPE: I can present them to the Bench right now, if you'd --

JUDGE BRENNER: Well, I'd rather wait and just have -- be more deliberative about it; and then the parties by then will have had an opportunity to have looked at the exhibits, also. So we'll come back to the whole subject.

And we'll excuse Dr. Bush at this time.

(Witness Excused.)

JUDGE BRENNER: Off the record.

(Discussion off the record.)

JUDGE BRENNER: On the record.

MR. GODDARD: Judge Brenner, before we begin the panel on blocks, the Staff would like to state that, pursuant to the Board's direction, we have completely corrected, with all changes made, a copy of the Staff testimony. We have been unable locally to get it reproduced and served to the Board and the parties.

JUDGE BRENNER: We don't need it today. We're putting LILCO witnesses on right now. So you will have further

opportunity to take care of all that at the time the Staff comes on.

MR. STROUPE: We hope so.

JUDGE BRENNER: I want to make sure, Mr. Goddard, that the parties have the marked-up copy in advance, so that if there is any question you can resolve it before we get up here, because I want to avoid wasted effort.

MR. GODDARD: The markup on blocks, Judge Brenner, for the Staff is simply deletion of--

JUDGE BRENNER: Don't tell me now. I just want to make sure that we are all on the same wavelength and that it is all going to be in order.

I understand the theory. You want to take out everything related to cam gallery, but I don't know if you have any other changes. Just mark up the copies completely, including the changes annotated that you made on the crankshaft potion of that, and then we'll take care of it. But you don't have to do it until the Staff witnesses come back. Maybe we will get to them today. I don't know. Anything is possible.

All right. LILCO.

Whereupon,

CHARLES A. RAU,

EDWARD J. YOUNGLING,

MILFORD M. SCHUSTER,

DUANE P. JOHNSON,

and

HARRY F. WACHOB

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

MR. ELLIS: Judge Brenner, the LILCO witness panel has been seated. We had made labels in anticipation of getting on earlier than today, and somehow or other, when we finally got on, the labels are back in the office. We are getting them quickly but if the Board wishes, I would like to proceed to introduce the panel.

JUDGE BRENNER: Off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

DIRECT EXAMINATION

BY MR. ELLIS:

Q Gentlemen, I would like for you please to state for the record your name, your business affiliation, and your business address, beginning, please, with Dr. Wachob.

A (Witness Wachob) My name is Harry Frank Wachob. I work for Failure Analysis Associates. The address is

2225 East Bay Shore Road, Palo Alto, California.

Q Would you also give your business position and affiliation?

A (Witness Wachob) I am manager of the Materials and Testing Laboratory.

Q Thank you.

Dr. Rau?

A (Witness Rau) My name is Charles Alfred Rau, Junior. I am vice president and principal engineer of Failure Analysis Associates. My business address is 2225 East Bay Shore Road, Palo Alto, California.

A (Witness Youngling) My name is Edward J. Youngling. I am the manager of Nuclear Engineering for the Long Island Lighting Company. My business address is Shoreham Nuclear Power Station, Wading River, New York.

A (Witness Johnson) My name is Duane P. Johnson. I am managing engineer at Failure Analysis Associates. My business address is 2225 East Bay Shore Road, Palo Alto, California.

A (Witness Schuster) My name is Milford H. Schuster. I am employed by the Long Island Lighting Company at the Shoreham Nuclear Power site in Wading River, Long Island. And I am currently assigned to the Nuclear Engineering Department.

MR. ELLIS: Judge Brenner, all of these witnesses

I believe -- I did not mention it earlier -- have testified before and have been sworn.

JUDGE BRENNER: That's right, and of course they remain under oath or affirmation. And we can say welcome back to all of them.

BY MR. ELLIS:

Q Gentlemen, do you have before you your prefiled testimony entitled "Additional Cylinder Block Testimony of Dr. Duane P. Johnson, Dr. Charles A. Rau, Milford H. Schuster, Dr. Harry F. Wachob, and Edward J. Youngling on behalf of Long Island Lighting Company," including exhibits?

A (Witness Youngling) Yes, we do.

Q And do you also have before you a letter dated February 7, 1985, to Messrs. Dynner and Perlis from me, setting forth errata to that testimony?

A (Witness Youngling) Yes, we do.

Q All right.

Is the testimony entitled "Additional Cylinder Block Testimony of Dr. Duane P. Johnson, Dr. Charles A. Rau, Milford H. Schuster, Dr. Harry F. Wachob, and Edward J. Youngling on behalf of Long Island Lighting Company," together with the exhibits and as corrected by the errata of the February 7, 1985 letter true and correct to the best of your knowledge and belief?

Would each of you answer individually, please?

A (Witness Wachob) Yes, it is.

A (Witness Rau) Yes, it is.

A (Witness Youngling) Yes, it is.

A (Witness Johnson) Yes, it is.

A (Witness Schuster) Yes, it is.

Q And do each of you adopt it as your testimony in this proceeding?

A (Witness Wachob) I do.

A (Witness Rau) Yes, I do.

A (Witness Youngling) Yes, I do.

A (Witness Johnson) Yes, I do.

A (Witness Schuster) I do.

JUDGE BRENNER: Help me out, Mr. Ellis. Weren't you going to delete portions of this testimony?

MR. ELLIS: The cam gallery portions?

JUDGE BRENNER: Yes.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: All the exhibits relate to that, and I can see why you may want to separate out the stipulation and get it in, although I am not sure it's essential. That's why when you started talking about all the exhibits and everything I was confused.

MR. ELLIS: That's right, Judge Brenner. In the portions that were prepared for the Reporter, we have not yet gone through and lined out all of that testimony, and

I apologize to the Board for that.

JUDGE BRENNER: All right.

Were you going to identify what we are not going to enter into evidence?

MR. ELLIS: Yes, sir.

JUDGE BRENNER: I think the best thing is for you to do that, and then for somebody to perform those deletions very promptly so that the copy bound into the record matches what in fact is being moved into evidence.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: It's the same message I gave the Staff about saving time.

MR. ELLIS: Question and answer Number 3 on page 4, Number 3 running over to page 5;

Page 13, starting with IV and extending through page 25.

In addition, Exhibits B-65, 66 and 68 would no longer be necessary in view of the resolution of the cam gallery monitoring matter and the cam gallery itself.

There will also be I think a reference to the cam gallery on page 2 in the final paragraph that appears in the answer on page 2.

I believe with those deletions, Judge Brenner, the remainder of the testimony will be moved into evidence.

JUDGE BRENNER: All right.

On page 2 you are deleting the entire last paragraph, beginning with the word "Finally...."

MR. ELLIS: Yes, sir.

MR. GODDARD: The Staff requests a clarification, Mr. Ellis. What was the first deletion which you made prior to the--

MR. ELLIS: The first deletion would be on page 4.

JUDGE BRENNER: It was answer 3 on page 4, and carrying over to page 5 I believe.

MR. GODDARD: Thank you.

MR. ELLIS: And there will of course be an associated deletion in the table of contents that I don't think is terribly important.

We have copies for the Reporter but we will line those out with black ink and give them to the Reporter by the first break.

JUDGE BRENNER: Fine.

MR. DYNNER: May I make an inquiry, please?

On page 12 is it intended to leave in the third sentence?

MR. ELLIS: I'm sorry, which sentence is being referred to there?

MR. DYNNER: The third sentence that refers to the cam gallery cracks on page 12 of the testimony.

JUDGE BRENNER: It begins: "The original EDG 103 block experience...."

MR. ELLIS: I think that is not intended to be struck, Judge Brenner.

JUDGE BRENNER: Here again this is why these things should be done in advance. I don't mean to seem unreasonable, but you could have talked about it and I believe probably done some editing on that sentence. I'm making some guesses here, but LILCO could keep in what it wanted to keep in and nevertheless delete the reference to the cam gallery.

Do you want to leave the hours of operation in? Is that your problem, Mr. Ellis?

MR. ELLIS: May I have a moment, Judge Brenner, please?

(Pause.)

JUDGE BRENNER: If I can interrupt you for a moment, Mr. Ellis, and then I will give you a moment, perhaps what you might want to do -- I'm guessing, so I may be wrong on this -- is to say the original EDG 103 block experience included 30 hours at or above 110 percent of nameplate load, and leave it like that.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: All right, sir. We will delete the "which" for the sake of language; and then, for the sake of substance, delete "demonstrated that cam gallery cracks will not propagate", which is the last clause of the sentence.

MR. DYNNER: I have another question, and that is that there are numerous references to cam gallery cracks on pages 5 and 6 and 7. And it's out opinion that perhaps those pages ought to be looked at, too, because the cam gallery issue has been -- is no longer part of this litigation, and I don't see what the use of all that testimony about the cam gallery cracks would be.

JUDGE BRENNER: Recall that yesterday we accepted both parties' positions in approving the agreement on the cam gallery; and part of the County's position was that no findings would be made regarding the cam gallery cracks.

That remains the approved position, and perhaps we could resolve it by reiterating that statement. It is

cleaner if we can get everything out instead of taking of time now. And I haven't reread it, but you have, if they are just passing references, you know we are not going to be making any finding on the cam gallery cracks.

Would that solve your problem?

MR. DYNNER: Yes. In fact, I would not care if you leave it in or take everything out. It is just that you started -- they started with the procedure of taking out the testimony, and I thought, if you're going to go that way, for the sake of consistency it should all be out. But I don't think you have to take anything out as long as nobody is going to refer to it in any of the findings.

JUDGE BRENNER: Well, there is an aphorism about foolish consistency, which maybe we will adopt here: It's cleaner to have taken it out, and when it's easy to do so -- but I think we can live with where it is now.

MR. ELLIS: All right, sir.

I think there's also another issue to which it may be relevant, and that is the County's contention that the new 103 block is inadequately tested or approved.

JUDGE BRENNER: With respect to cam gallery cracks, it's no longer an issue.

MR. ELLIS: That's correct, Judge Brenner.

MR. DYNNER: That's correct; and, at this time, if you would like, before we start cross-examination I will

make the statement for the record, with respect to the blocks, as I had with respect to the crankshafts.

JUDGE BRENNER: All right. Give me one moment.

MR. DYNNER: Certainly.

JUDGE BRENNER: Off the record.

(Discussion off the record.)

JUDGE BRENNER: On the record.

What we will do at this point is admit the testimony of the LILCO panel of witnesses on the subject of additional cylinder block testimony, with the corrections and deletions that have been discussed on the record, and with the limitation we have identified to the extent there may still be some passing references to the cam gallery cracks.

And we will immediately, at the same point in the transcript, immediately follow the testimony with the two-page stipulation dated January 14, 1985, and signed by counsel for all the parties, on the subject of the cam gallery cracks. Of course, that stipulation is led to and is referenced in the settlement of the cam gallery contention that we approved yesterday, and bound into the record yesterday.

(The documents follow.)

HUNTON & WILLIAMS
2000 PENNSYLVANIA AVENUE, N.W.
P.O. BOX 19230
WASHINGTON, D.C. 20036
TELEPHONE 202-955-1500

707 EAST MAIN STREET P.O. BOX 1535
RICHMOND, VIRGINIA 23212
TELEPHONE 804-788-8200
TWX 710-956-0081

FIRST VIRGINIA BANK TOWER
P.O. BOX 3889
NORFOLK, VIRGINIA 23514
TELEPHONE 804-625-5501
TELEX 755628

4011 CHAIN BRIDGE ROAD
FAIRFAX, VIRGINIA 22030
TELEPHONE 703-352-2200

299 PARK AVENUE
NEW YORK, NEW YORK 10171
TELEPHONE 212-980-8200
TELEX 754708

B B & T BUILDING P.O. BOX 109
RALEIGH, NORTH CAROLINA 27602
TELEPHONE 919-828-9371

FIRST TENNESSEE BANK BUILDING
P.O. BOX 951
KNOXVILLE, TENNESSEE 37901
TELEPHONE 615-637-4311

FILE NO.

DIRECT DIAL NO. 202 955-

February 7, 1985

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

Robert G. Perlis, Esq.
U.S. Nuclear Regulatory
Commission
Washington, D.C. 20555

Dear Alan and Bob:

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

I. Errata Regarding Additional Crankshaft Testimony

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

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

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

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

II. Errata Regarding Additional Block Testimony

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

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

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

III. Errata Regarding Diesel Generator Qualified Load Testimony

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Best wishes.

Sincerely,

T. S. Ellis, III

75/403

cc: Service List

LILCO, January 15, 1985

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

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

ADDITIONAL CYLINDER BLOCK TESTIMONY OF DR. DUANE P. JOHNSON, DR. CHARLES A. RAU, JR., MILFORD H. SCHUSTER, DR. HARRY F. WACHOB AND EDWARD J. YOUNGLING ON BEHALF OF LONG ISLAND LIGHTING COMPANY

Testimony and Exhibits

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I. Introduction

1. Please state your names and summarize your professional qualifications.

A. (Johnson) My name is Dr. Duane P. Johnson. My professional qualifications are set forth in my previous testimony during this proceeding.

(Rau) My name is Dr. Charles A. Rau, Jr. My professional qualifications are set forth in my previous testimony during this proceeding.

(Schuster) My name is Milford H. Schuster. My professional qualifications are set forth in my previous testimony in this proceeding.

(Wachob) My name is Dr. Harry F. Wachob. My professional qualifications are set forth in my previous testimony in this proceeding.

(Youngling) My name is Edward J. Youngling. My professional qualifications are set forth in my previous testimony in this proceeding.

2. What issues are addressed by this testimony?

A. (All) Among the topics addressed are the EDG 103 endurance run, the results of inspections on the block following the endurance run, and the effect of these inspections on Lilco's previous evaluations and conclusions.

Also addressed are the effect of operating the EDGs at the qualified load of 3300 KW, including the margins between demonstrated performance and that cumulative damage which a postulated LOOP/LOCA might involve.

~~Finally, the County has stipulated that it does not seek to disqualify the blocks on the basis of the cam gallery cracks. However, it still contends that the cracks in the EDG 101 and 102 blocks should be monitored by placing wire strain gages across the cracks and by measuring the depths of the cracks before operation and at the first refueling outage. This testimony addresses whether there is any need to monitor the cam gallery cracks in the EDG 101 and 102 blocks in light of the high magnification photomicrographs, the x-ray crystallography and the strain gage test results.~~

3. Please briefly summarize the conclusions reached in your testimony.

A. (All) Our conclusions are as follows:

1. Fluorescent magnetic particle inspections of the block top and eddy current inspections of stud holes on the block top of the EDG 103 replacement block at the conclusion of the endurance run detected no reportable indications. The absence of ligament or stud-to-stud cracks in the block top confirms our opinion that the design enhancements introduced in the EDG 103 replacement block are beneficial and that they have reduced the possibility of fatigue crack initiation. Furthermore, the additional operation of the replacement block at 3300 KW for more than 500 hours during the endurance run confirms that the replacement block has been adequately designed and tested. Clearly, it has proven its capacity to perform its intended function of providing emergency power during postulated accident conditions at Shoreham.

2. Operating the EDGs at the qualified load of 3300 KW produces lower cyclic stress in the block top and in the cam gallery than at higher loads. This reduces the possibility of fatigue crack initiation in the block top, and reduces the rate of any crack propagation should crack initiation occur. Further, cumulative damage analysis shows that, if a postulated LOOP/LOCA occurs, the EDGs will perform their intended function with even greater margin at the qualified load than at the higher loads previously analyzed.

3. It is not necessary to monitor the cam gallery cracks in the EDG 101 and 102 blocks by placing wire strain gages across the repair welds or by measuring the depth of the cracks with the TSI depth gage at any time prior to the first refueling outage because:

a. The 550x magnification photomicrographs and the x-ray crystallography, combined with previous fractographic and metallographic examinations, demonstrate that cam gallery cracks up to 0.91 inch deep in the original EDG 103 block did not propagate in more than 1200 hours of operation, despite the severely degraded fatigue and fracture properties of that block material and the presence of cracked repair welds. Accordingly, the cracks in the EDG 101 and 102 blocks, which have superior fatigue and fracture properties and smaller repair welds, will not propagate.

b. Strain gage measurements made on the cam gallery of the EDG 103 replacement block prior to the endurance run demonstrate that the stresses perpendicular to the cam gallery crack indications (i.e., vertical) are fully compressive during EDG operation, including quick starts to 3300 KW and continuous operation at 3300 KW. Extrapolation of this data shows that the stresses remain fully compressive at 3500 and 3900 KW. Since fatigue cracks do not grow in fully compressive stress fields, the strain gage data confirms our prior opinion, based on physical examinations, calculations and fracture mechanics analyses, that regardless of the presence of any residual stresses, the cam gallery cracks in the EDGs have not propagated and will not propagate in the future.

c. Since the strain gage measurements on the ~~replacement~~ EDG 103 replacement block are directly applicable to fracture mechanics analyses of the cam gallery cracks in EDGs 101 and 102, they confirm that the cam gallery cracks in the EDG 101 and 102 blocks will not propagate even at loads up to and including 3900 KW. Further, the presence of any residual stresses will not affect the validity of the strain gage results. Residual stresses at the tip of any

cracks in the EDG 101 or 102 blocks which are assumed hypothetically for purposes of analysis to extend substantially below the repair welds would be very small and compressive.

II. Confirmatory Testing and Post Endurance Run Block Inspections

4. What is the operating history of the EDG 103 replacement block?

A. (Rau, Schuster, Wachob, Youngling) The EDG 103 replacement block was installed in June 1984. Since June, EDG 103 has been operated for more than 849 hours. Of these hours, 70 hours were at or above 3500 KW and more than 507 hours were at or about 3300 KW as indicated on the main control room kilowatt meter. A substantial portion of the hours placed on the EDG 103 replacement block occurred as a result of a 745 hour (10^7 loading cycles) confirmatory test. The endurance run portion of the confirmatory test was performed at the load level of 3300 KW, which is the qualified load for the Shoreham EDGs.

5. Was tne EDG 103 replacement block inspected after the 745 hour confirmatory test?

A. (Johnson, Rau, Schuster, Wachob) Yes, the cam gallery area and the block top region of the EDG 103 replacement block were inspected at the conclusion of the endurance run portion of the 745 hour confirmatory test. In accordance with the program approved by the NRC Staff, which is outlined in SNRC 1094, the block top region was examined using fluorescent magnetic particle and eddy current inspection techniques. The

inspection showed no ligament or stud-to-stud cracks. In addition, eddy current examination of the four stud holes between cylinders no. 4 and 5 confirmed that neither ligament cracks nor stud-to-stud cracks initiated at the block top or at any location on the stud hole surface between the block top and the bottom thread in the stud hole.

The cam gallery area of the EDG 103 replacement block was inspected at cam bearing saddles no. 2 and 8 using visual, magnifying glass, liquid penetrant and magnetic particle examination techniques. Small, discontinuous linear indications detected by liquid penetrant examination were evaluated with the TSI crack depth gage to measure their depth. The deepest indication recorded after the endurance run was 0.010 inch deep. The remaining indications were all 0.004 inch deep or less.

6. Will any of the cam gallery indications impair the ability of the EDG 103 replacement block to perform its intended function?

A. (Rau, Wachob, Schuster, Youngling) Absolutely not. The indications evaluated after the completion of the endurance run showed no significant change from their condition at the time they were initially detected prior to the endurance run in October 1984. These indications are still not detectable visually without a magnifying glass, and they have been measured both ~~before~~ during and after the endurance run to have no significant

depth. Furthermore, casting shrinkage cracks as deep as 0.91 inch in the original EDG 103 block did not propagate during more than 1200 hours of operation, including more than 400 hours of operation at or above 3500 KW, despite the severely degraded fatigue properties of the block material. Consequently, the very shallow indications in the EDG 103 replacement block, with its superior fracture and fatigue properties, will not impair the ability of EDG 103 to provide emergency power at Shoreham.

7. If the cam gallery indications in the EDG 103 replacement block have not changed, why are there some differences in the inspection reports before and after the endurance run?

A. (Johnson, Rau, Schuster, Wachob) None of the cam gallery inspection reports show significantly different indications after the endurance run. Minor differences in mapping of the surface indications revealed by magnetic particle and liquid penetrant techniques before and after the endurance run are not significant. The insignificant differences result from the very shallow nature of the indications, minor differences in surface cleaning and preparation, and test techniques.

Similarly, minor variations in the depth of indications measured by the TSI crack depth gage are not significant. Some slight variation is expected in reported depths because they are within the accuracy of the TSI crack depth gage. In our opinion, when the visual, magnetic particle, liquid penetrant

and TSI depth gage inspections are analyzed as a whole, they indicate that no propagation of these indications has occurred during more than 500 hours of endurance testing on the EDG 103 replacement block.

8. What effect, if any, do the results of the inspections of the EDG 103 replacement block following the endurance run have on your opinion regarding the adequacy of its design and testing?

A. (Rau, Wachob) The product enhancements incorporated into the EDG 103 replacement block have now been further tested by actual operation at Shoreham. The absence of any detectable ligament or stud-to-stud cracks in the block top after the endurance run confirms our opinion that the design enhancements introduced in the EDG 103 replacement block are beneficial. Since the EDG 101, 102 and original 103 blocks had initiated ligament cracks at approximately an equivalent number of operating hours as have now been placed on the EDG 103 replacement block without block top cracking, the design enhancements have reduced the possibility of fatigue crack initiation. Thus, the endurance run confirms our previous testimony, which was based on our review of the replacement block design and on our review of the R-5 test engine experience, that the replacement block has been adequately designed and tested.

9. Should the replacement block have been tested for 745 hours at or above 3300 KW to confirm its adequacy for nuclear service?

A. (Rau, Youngling) No. The 745 hour confirmatory test (10^7 loading cycles) was performed primarily to evaluate the adequacy of the modified crankshaft. The County's contention with regard to the replacement block, and our testimony with respect to the replacement block, addressed whether it was an unproven design that was inadequately tested. Operation of the engine since block replacement for more than 849 hours, of which more than 577 hours were at or above 3300 KW, further substantiates the extensive R-5 test experience. This confirms our opinion that the design enhancements incorporated into the block are beneficial, and that the design is both proven and adequately tested.

Furthermore, testing the [redacted] EDG 103 replacement block for 10^7 loading cycles was not necessary in light of our cumulative damage analyses of the EDG 101 and 102 blocks. These prior analyses demonstrate that the blocks are capable of performing their intended function even though they have ligament cracks. Thus, testing the EDG 103 replacement block for more than 577 hours at or above 3300 KW without developing any detectable ligament or stud-to-stud cracks further demonstrates that the block is qualified for nuclear service.

10. Since the EDG 103 replacement block has no ligament cracks, does it need to be inspected on the same basis as the EDG 101 and 102 blocks for stud-to-stud cracks?

A. (Rau, Wachob) No. In our original testimony, we stated that the EDG 103 replacement block should be inspected on the same basis as the EDG 101 and 102 blocks until sufficient operating service without ligament cracks had been obtained to increase the inspection intervals. The endurance run has placed enough hours on the replacement block without the development of ligament cracks to justify extending the inspection interval for that block.

The EDG 103 replacement block can now be operated without additional inspections for stud-to-stud cracks for combinations of load and time that produce less than the allowable fatigue damage index. In other words, operation may continue without further block top inspections until the fatigue damage index accrued is equal to one-third of the fatigue damage index demonstrated for the original EDG 103 benchmark period minus the fatigue damage index that would be required for one postulated LOOP/LOCA. Since it is anticipated that the EDG 103 replacement block will experience less than 100 hours of further operation before the end of the first fuel cycle, no additional block top inspections are necessary until the refueling outage.

III. Effect of the 3300 KW Qualified Load

11. What is the effect on the EDG blocks of operation at up to the qualified load of 3300 KW?

A. (Rau, Wachob) Operation of the EDGs at a maximum

load of 3300 KW rather than a maximum load of 3500 or 3900 KW will produce lower cyclic stresses in the block top and in the cam gallery. Specifically, operation of the engine at the lower load levels reduces the cylinder firing pressures, thermal strains, and vertical loads imposed on the head during cylinder firing. This results in a corresponding reduction in the loads transmitted to the block through the head studs and through contact with the liner and block top. As a result, the possibility of fatigue crack initiation in the block top is reduced, and, should crack initiation occur, the rate of any crack propagation will be slower.

12. The County contends that the qualified load might be exceeded for brief periods of time during EDG operation. If brief load excursions occur over 3300 KW, what effect, if any, will they have on the blocks?

A. (Rau) We have previously testified about the effect of engine operation at 3500 and 3900 KW. Our cumulative damage analysis of the block tops demonstrated that the blocks would withstand with sufficient margin a LOOP/LOCA with a postulated load profile that included 0.2 hours at 3900 KW and 0.8 hours at 3500 KW.

Further, stresses in the cam gallery area will not increase significantly at power levels above 3300 KW. These stresses have been verified by the strain gage testing, which demonstrates that the vertical stresses remain fully compressive even when extrapolated to loading as high as 3900 KW.

Reliable operation at loads in excess of 3300 KW has also been verified by the operating experience of the EDGs. Despite hundreds of hours of operation above 3500 KW, including more than 25 hours each at or above 110% of nameplate load, EDG 101 and 102 have not developed stud-to-stud cracks. The original EDG 103 block experience, which included 30 hours at or above 110% of nameplate load, demonstrated that cam gallery cracks will not propagate. In addition, the EDG 103 replacement block has already experienced 70 hours of operation at or above 3500 KW. These are direct demonstrations of the blocks' ability to perform reliably at loads up to and including their overload rating for brief periods of time. Thus, both the analytical and the empirical evidence demonstrates that brief excursions over 3300 KW, should any occur, will not impair the ability of the EDGs to perform their intended function.

13. What is the load profile that the EDGs at Shoreham will experience should a LOOP/LOCA occur?

A. (Youngling) The maximum emergency service load on any EDG is bounded by 3300 KW. A conservative LOOP/LOCA load profile would be 0.2 hours at 3300 KW, 0.8 hours at 3200 KW, and up to 167 hours at 2617 KW.

14. What effect, if any, does the reduced load profile have on the results or the conclusions of the cumulative damage analysis?

A. (Rau) A postulated LOOP/LOCA resulting in a load profile of 0.2 hours at 3300 KW, 0.8 hours at 3200 KW and 167

hours at 2617 KW will produce less fatigue damage than the LOOP/LOCA load profile previously analyzed. Analyses of the damage accumulated by the original EDG 103 block during the test period from March 11 through April 14, 1984 demonstrates that at the actual load profile of the EDG 101, 102 and 103 engines, the blocks will withstand a postulated LOOP/LOCA with even greater margin.

15. Has FaAA performed additional cumulative damage analyses of the block top since the conclusion of the previous hearings?

A. (Rau) Yes. As part of the preparation of the final generic block report, which was issued in December 1984, cumulative damage calculations were performed employing a refined determination of stresses from the strain gage testing. The additional cumulative damage calculations set forth in the final block report confirm our conclusion that the Shoreham blocks will perform their intended function with sufficient margin during a postulated LOOP/LOCA.

~~IV. Monitoring of the Cam Gallery Cracks in~~ the EDG 101 and 102 Blocks is Unnecessary

16. Is monitoring of the cam gallery cracks in ~~the EDG~~ 101 and 102 blocks necessary or justified?

A. (Rau, Wachob) No. ~~There~~ is no need to monitor the cam gallery cracks ~~prior~~ to the scheduled maintenance interval at the ~~first~~ refueling outage. In addition to our previous calculations, and fractographic and metallographic

examinations, we now have additional data which establishes that monitoring is not necessary or justified. First, photomicrographs taken of the weld shrinkage crack at 550x confirmed Lilco's previous testimony that the cam gallery cracks in the original EDG 103 block were fabrication cracks that had not propagated during EDG operation. Second, x-ray crystallographic analyses were performed on the oxide present on the cam gallery cracks in the original EDG 103 block which established that the oxide was primarily (85 percent) magnetite. As a result of these tests, the County has stipulated that the cracks in the EDG 101, 102 and original EDG 103 blocks have not propagated during or as a result of EDG operation. Finally, strain gage measurements made on the EDG 103 replacement block, which are applicable to fracture mechanics analyses of cracks in the EDG 101 and 102 blocks, establish that the cam gallery cracks will not propagate beneath the repair weld depth even considering the presence of residual stresses.

A. High Magnification Photomicrographs

17. Please explain in greater detail how the high magnification photomicrographs support your conclusion that monitoring is unnecessary.

A. (Rau, Wachob) In our previous testimony, at Tr. 26525-26, we discussed a series of photomicrographs taken from a metallographic cross-section of cam gallery bearing support no. 7 of the original EDG 103 block. Two of these

photomicrographs, which are shown in Lilco Exhibit B-63, depict, what we have called the casting shrinkage crack. As shown in Exhibit B-63, these photomicrographs were taken at 100x and 500x magnification. Two more photomicrographs, depicted in County Exhibit S-4, were taken at 50x and 100x magnification of what we have called the weld shrinkage crack, which, as shown in Lilco Exhibit B-61, is directly adjacent to the casting shrinkage crack. However, as was discussed at Tr. 26525-26, no 500x photomicrograph was originally taken of the weld shrinkage crack.

At the meeting of the parties on November 20, 1984, Lilco agreed to take additional photomicrographs of the weld shrinkage crack at 500x magnification. (See Tr. 26990-91). Accordingly, two additional photomicrographs at 550x were taken of representative areas of the weld shrinkage crack in cam gallery bearing support no. 7. These photomicrographs are attached as Exhibit B-65. The locations where these photomicrographs were taken are shown in Lilco Exhibit B-66, which is a marked-up version of County Exhibit S-4.

The 550x photomicrographs confirm what the 100x photomicrograph in County Exhibit S-4 depicted, namely that the weld shrinkage crack surface has a very thin oxide which is markedly different from the uniformly thick (0.2 to 0.5 mils), dark oxide on the contiguous casting shrinkage crack depicted

in Lilco Exhibit B-63. Comparison of the 500x photomicrograph of the casting shrinkage crack in Lilco Exhibit B-63 with the 550x photomicrographs in Lilco Exhibit B-65 shows the difference between the oxides present on the casting shrinkage crack and the weld shrinkage crack. The light gray appearance of the crack surface on the casting shrinkage crack is due to the presence of the thick oxide. The absence of a light gray layer on the weld shrinkage crack reveals that no thick oxide is present.

The significant differences between the photomicrographs confirms the opinion we expressed at Tr. 26469 that the casting shrinkage crack must have been formed before the weld shrinkage crack formed. The clear and pronounced difference between the thick, dark oxide on the casting shrinkage crack and the very thin oxide layer on the weld shrinkage crack indicates that the casting shrinkage crack formed during the fabrication process and did not propagate during EDG operation.

B. The Stipulation

18. Please describe in greater detail how the x-ray crystallography and the Stipulation support your conclusion that monitoring is unnecessary.

A. (Rau, Wachob, Youngling) As a result of the x-ray crystallography performed on a section of the cam gallery crack from bearing support no. 7 of the original EDG 103 block, which determined that the oxide layer on the crack was primarily (85

percent) magnetite, the parties have stipulated that the oxide layer was formed at high temperatures at the time of the casting process and that the layer was not due to fretting corrosion or graphitic corrosion. The parties have also stipulated that this evidence supports the conclusion that the cam gallery cracks in the original EDG 103 block did not propagate during or as a result of EDG operation. Further, the parties have stipulated that the evidence justifies the conclusion that the cracks in the cam gallery areas of EDGs 101 and 102 formed during the casting process, and that this supports the conclusion that the cam gallery cracks in EDGs 101 and 102 did not propagate during or as a result of EDG operation. A copy of the Stipulation stating that Suffolk County and the State of New York do not seek to disqualify the use of the EDG 101, 102 or replacement EDG 103 blocks on the basis of the cam gallery cracks is attached as Exhibit B-67.

The Stipulation, which was based on the results of the x-ray crystallography, establishes that the cam gallery cracks in the EDG 101, 102 and original EDG 103 blocks have not propagated during more than a thousand hours of operation on each engine, including hundreds of hours of operation at or above 3500 KW. Specifically, with respect to the original EDG 103 block, the x-ray crystallography and the Stipulation establishes that more then 1200 hours of operation, including more

than 400 hours of operation over 3500 KW, did not cause crack propagation despite the severely degraded material of that block and the presence of large weld repairs with weld shrinkage cracks.

Based on this extensive operating experience, there is no reasonable engineering basis for concluding that cracks measured to be much smaller and shallower in the EDG 101 and 102 blocks will ever propagate, let alone propagate during the 100 hours or less of operation that the EDGs are anticipated to experience prior to the first refueling outage. Accordingly, there is no need to perform any monitoring or measuring of the cam gallery cracks prior to the first refueling outage. Mapping of the cracks at the maintenance interval scheduled during the first refueling outage is more than sufficient to confirm that there is no crack growth.

C. Strain Gage Measurements

19. Please describe the strain gage testing that was performed on the cam gallery of the EDG 103 replacement block.

A. (Rau, Wachob, Schuster) Prior to the endurance run, strain gage measurements were made on the cam gallery of the EDG 103 replacement block at locations where cracks had been observed on the EDG 101, 102 and the original EDG 103 blocks. Prior to the installation of the strain gages on the EDG 103 replacement block, magnetic particle and liquid penetrant

examinations were performed. These inspections revealed the fine, discontinuous linear indications that were reported by Lilco during its oral testimony.

Before installing the strain gages, through-bolts numbered 1, 2, 3, 7, 8 and 9, which are in the vicinity of cam bearing support saddles no. 2 and 8, were loosened. Then, strain gages, which included four full rectangular rosettes and two biaxial gages, were attached at six block locations as shown in Exhibit B-68, pages 1 and 5. After calibrating and zeroing the gages, the strain data were recorded as the through-bolts were tightened (torqued) in five increments up to the specified torque.

The strain gage data were recorded while the engine was brought to hot standby condition and quick started to 3300 KW. The EDG was run continuously at 3300 KW for approximately one hour, and then at lower load levels which were subsequently achieved by unloading the engine incrementally. At each power level, strain gage data was recorded after allowing a steady state operation.

20. Please describe the results of the strain gage testing.

A. (Rau, Wachob) The strain gage measurements demonstrate that the stresses perpendicular to the crack indications (i.e., vertical) remain fully compressive at all operating conditions, including both fast starts to 3300 KW and steady state

operation at 3300 KW. This results from the large steady compressive stress that is introduced due to tightening of the through-bolts. Engine operation at load superimposes cyclic stresses on this steady compressive stress. However, the magnitudes of the cyclic stresses are less than the steady compressive stress. Therefore, the stresses remain fully compressive, thereby preventing crack propagation. The measured stresses perpendicular to the cam gallery indications are shown as a function of bolt torque and engine load in Exhibit B-68, pages 2-4 and 6-8.

21. Do the test results indicate whether the stresses perpendicular to the crack indications would remain compressive at higher engine loads?

A. (Rau, Wachob) Yes. The test results have been extrapolated conservatively to engine operation at 3500 and at 3900 KW. The results indicate that the stresses remain fully compressive even at these loads.

22. Would the stresses remain fully compressive even during fast starts to 3900 KW?

A. (Rau, Wachob) Yes. Fast starts do not introduce a significantly higher transient stress into the cam gallery as compared to steady operation at the same power levels. This is consistent with engineering analyses which indicate that transient thermal stresses introduced during fast starts will be insignificant in this region.

23. Are the strain gage tests performed on the EDG 103 replacement block applicable to the cam gallery regions of the EDG 101 and 102 blocks?

A. (Rau, Wachob) Yes. The geometry of the cam gallery is identical for each of the EDGs. Similarly, the compressive load imposed by the through-bolts is the same for each of the EDGs since the bolt torque specified is the same for each engine. Accordingly, in the absence of the repair welds and shrinkage cracks, strain gage measurements on the EDG 101 and 102 blocks would have been virtually identical to the measurements on the EDG 103 replacement block.

Although the EDG 101 and 102 blocks have repair welds and weld shrinkage cracks, the results of the strain gage measurements on the replacement block of EDG 103 are directly applicable to fracture mechanics analyses of cracks in the cam gallery regions of EDG 101 and 102. There is no indication that casting shrinkage cracks extend below the depth of the weld repairs in the EDG 101 or 102 blocks. Indeed, the evidence from the TSI depth gage is that no crack extends below the weld shrinkage crack. But if a casting shrinkage crack were present below the repair welds in the EDG 101 or 102 blocks, the strain gage measurements made on the replacement block of EDG 103 are directly applicable to the fracture mechanics analyses which show that such cracks would not propagate in operation. Accordingly, the conclusion drawn from the EDG 103 strain gage data that

~~the cam gallery cracks are nonpropagating applies to the EDG~~ 101 and 102 blocks.

24. Based on the strain gage test results, would the presence of residual stresses affect your conclusion that cam gallery cracks will not propagate?

A. (Rau, Wachob) No. Before the crack formed, any residual stresses that were present would have been tensile stresses at the cam gallery surface. These tensile stresses would have been balanced by compressive residual stresses beneath the cam gallery surface. The repair welding process and the formation of weld shrinkage cracks has eliminated or reduced markedly the magnitude of any tensile residual stresses near the cam gallery surface. Correspondingly, it has reduced the magnitude of the balancing, subsurface compressive residual stresses. Consequently, if a crack was hypothetically assumed to be present to a depth beyond the repair weld, the residual stresses near the crack tip would be negligibly small and compressive. Thus, any residual stresses existing at the present time will not enable crack extension during operation.

This analysis has been confirmed by physical observations of the original EDG 103 block after extensive operation. In the original EDG 103 block cam gallery, casting shrinkage cracks extended substantially beyond the repair weld depth. They did not propagate, however, during more than 1200 hours of ~~operation, including more than 400 hours at or above 3500 KW~~

~~despite the degraded fatigue and fracture properties of that~~ block material and the presence of even larger repair welds.

25. Can tightening and loosening of the through-bolts cause sudden crack extension?

A. (Rau, Wachob) No. During the course of the strain gage testing, the through-bolts in the vicinity of cam bearing supports no. 2 and 8 were fully loosened and subsequently retightened to the specified torque. No significant change in the surface crack indications resulted. In addition, the through-bolts on the EDG 101, 102 and the original EDG 103 blocks have also been loosened and retightened several times for required maintenance, with no indication of cam gallery crack extension. Since each of the existing Shoreham EDG blocks has already experienced through-bolt loosening and retightening, subsequent loosening and retightening will not produce crack extension, including "pop-in," of any cam gallery cracks.

26. The County contends that the EDG 101 and 102 cam gallery cracks should be monitored with wire gages because there is no reliable depth measurements of the cracks in these blocks. Do you agree?

A. (Rau, Wachob) No. Cam gallery cracks in the EDG 101 and 102 blocks have been inspected visually and with fluorescent magnetic particle and liquid penetrant. These inspections revealed that the repair welds are smaller and the weld ~~shrinkage cracks shorter and tighter on the surface than in the~~

original EDG 103 block. This observation is consistent with the metallurgical analysis and mechanical testing which have shown superior mechanical properties in the EDG 101 and 102 blocks compared with the original EDG 103 block. Thus, all other factors being equal, both casting shrinkage and weld shrinkage cracks, if they form, will be shallower in the EDG 101 and 102 blocks than in the original EDG 103 block.

Crack depth measurements using the TSI depth gage have also indicated that the cracks in the EDG 101 block are much shallower than in the original EDG 103 block. The deepest crack in the EDG 101 block was measured to be 0.164 inch as compared to 0.91 inch in the original EDG 103 block. Thus, it is our opinion that the original casting shrinkage cracks were much shallower in the EDG 101 and 102 blocks and were completely ground out at the time of the repair weld.

Nevertheless, even if it is unrealistically assumed that casting shrinkage cracks in the EDG 101 and 102 blocks are as deep as those in the original EDG 103 block, there is no necessity to monitor the cracks because they will not grow. The evidence demonstrates clearly that the relatively large cracks in the original EDG 103 block with severely degraded material did not propagate. Similar cracks in the EDG 101 and 102 blocks, if they existed, would not propagate in the superior material of those blocks.

27. The County also contends that the cracks in the cam galleries of EDG 101 and 102 should be monitored because the repair welds are inadequate. Do you agree?

A. (Rau, Wachob) No. The operating experience of the original EDG 103 block makes clear that the cracked weld repairs do not cause cam gallery crack propagation even in material with severely degraded fatigue resistance. Thus, the operating experience of the original EDG 103 block for over 1200 hours with cracked welds and without any cam gallery crack propagation shows that the presence of weld shrinkage cracks in the cam galleries of the EDG 101 and 102 blocks will not cause crack propagation.

Furthermore, since the strain gage measurements establish that the stresses in the cam gallery area of the EDGs remain fully compressive under load conditions up to the EDGs' overload design rating, it is clear that no crack propagation will occur in the future as a result of any anticipated operation regardless of the presence of cracked repair welds. Consequently, it is not necessary to conduct wire gage monitoring of the repair welds on the EDG 101 and 102 blocks or to measure the depth of the cracks in the EDG 101 and 102 blocks prior to the scheduled maintenance interval at the first refueling outage.

LILCO, January 15, 1985

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

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

CYLINDER BLOCK EXHIBITS

ADDITIONAL CYLINDER BLOCK TESTIMONY OF DR. DUANE P. JOHNSON, DR. CHARLES A. RAU, JR., MILFORD H. SCHUSTER, DR. HARRY F. WACHOB AND EDWARD J. YOUNGLING ON BEHALF OF LONG ISLAND LIGHTING COMPANY

B-65	550x magnification photomicrographs of the weld shrinkage crack at face 1 of cam saddle no. 7 of the original EDG 103 block.
B-66	Mark-up of 100x magnification photomicrograph of the weld shrinkage crack at face 1 of cam saddle no. 7 of the original EDG 103 block.
B-67	Stipulation of the parties regarding cam gallery crack contention.
B-68	Strain gage measurements on cam gallery of replacement EDG 103 block.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

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

STIPULATION

The parties to this proceeding, by counsel, stipulate as follows:

1. On Motion of Suffolk County, the Licensing Board ordered that a cam gallery crack from the original EDG 103 block be produced for analysis. As a result, analyses utilizing x-ray diffraction techniques have been performed on a cam gallery crack from the original EDG 103 block by a laboratory on behalf of Suffolk County. The test results confirm that the oxide layer on the cam gallery crack surface consists primarily of magnetite oxides (approximately 85%). This indicates that the oxide layer was formed at high temperatures during the time of the casting process and that these layers were not due to fretting corrosion or graphitic corrosion. This evidence supports the conclusion that the cam gallery cracks in the original EDG 103 block did not propagate during or as a result of operation.

2. The evidence of record indicates that the cracks in the cam gallery areas of EDGs 101 and 102 formed through the same process as the cam gallery cracks in the original EDG 103 block. Accordingly, the test results support the conclusion that the cam gallery cracks in EDGs 101 and 102 did not propagate during or as a result of EDG operation.

3. Accordingly, Suffolk County does not seek to disqualify the use of the blocks of EDGs 101 and 102 and the new block of EDG 103 on the basis of the existence of cam gallery cracks. However, Suffolk County reserves the right to contend and to litigate that the cracks should be monitored continuously using wire strain gages and that depth measurements should be taken prior to operation and at the first refueling outage, if Shoreham is licensed to operate.

Fabian G. Palomino (JJB)
Counsel for State of New York

Joseph J. Brigati
Counsel for Suffolk County

Counsel for Long Island Lighting Company

Counsel for Nuclear Regulatory Commission

MR. ELLIS: The panel is now ready for cross-examination. I believe Mr. Dynner has a statement to preface that.

JUDGE BRENNER: Mr. Dynner?

MR. DYNNER: Thank you.

Based upon the qualification test of EDG-103 at a nominal load of 3300 kilowatts, the County and the State do not challenge the adequacy of the replacement block for EDG-103, if loads do not exceed 3230 kilowatts, which assumes a maximum instrument error of plus or minus 70 kilowatts.

MR. ELLIS: I note, for the record, that it's LILCO's view that that assumes an instrument error of minus 70 kw, not plus or minus 70 kw.

JUDGE BRENNER: All right. It doesn't matter. He's just stating his position; and we encourage that because it helps us and, presumably, helps the other parties to understand what the latest position is of the parties. And you don't have to agree with his position.

MR. ELLIS: Yes, sir.

CROSS-EXAMINATION

BY MR. DYNNER:

Q Good morning, gentlemen. Please turn to page 5 of your prefiled testimony.

You have the statement in Answer 4 that, with

respect to EDG-103, it was operated 70 hours at or above 3500 kilowatts, and more than 507 hours were at or about 3300 kilowatts, as indicated on the main control room kilowatt meter.

Am.I correct that the main control room kilowatt meter had a potential instrument error of plus or minus 70 kilowatts?

A (Witness Youngling): Mr. Dynner, your statement is not correct.

Q All right. Let me ask the next question.

JUDGE BRENNER: He's entitled to explain his answer. Are you going to ask him to explain it in your next question?

MR. DYNNER: Exactly. I was trying to keep this short so that I can avoid some speeches.

JUDGE BRENNER: Go ahead.

BY MR. DYNNER:

Q Can you tell me, if that is not correct, what was the potential instrument error of the main control room kilowatt meter?

A (Witness Youngling): First of all, the total hours on that engine -- the 507 hours: some of those hours were accumulated during the preoperational test program. And, as I testified earlier, during the pre-op program the instrument of record was the watt-hour test loop, which had

an instrument accuracy of 0.6 percent.

MR. DYNNER: I object, Judge, because my question is: what was the potential instrument error on the main control room kilowatt meter and he is not being responsive at all.

JUDGE BRENNER: No, I think he is, because it's part of the explanation; and if he doesn't make that explanation then there will be the ambiguity that he is talking about everything related to the --

MR. DYNNER: I was going to follow up by asking him which hours were which. But I don't think he's being responsive to my specific question at all.

JUDGE BRENNER: Let him make the explanation. I think we'll get there faster in this case. If you're going to get there anyway, I could not be assured, and neither could the witness, that you were going to get there. And it would have been potentially misleading, I think.

Go ahead.

WITNESS YOUNGLING: The remaining portion of those hours which were taken during the endurance run on diesel engine 103, were accumulated during the endurance run, which utilized the main control room watt-hour meter as the primary source of data accumulation.

As we testified earlier, that particular instrument loop had an accuracy of 2.5 percent. That

accuracy does correspond to a worst-case instrument loop error of plus or minus 70 kw.

In addition, as I testified earlier, some of the data on the 103 engine was taken off the watt-hour test loop by the operators; so a portion of that data is also reflected by that instrument loop, which has a higher degree of accuracy than the watt-hour loop.

BY MR. DYNNER:

Q You said 2.5 percent: 2.5 percent of what, Mr. Youngling?

A (Witness Youngling): Of full scale.

Q And full scale is how many kilowatts? 5600?

A (Witness Youngling): Full scale on that particular instrument loop is 5600 kilowatts.

Q And 2.5 percent of 5600 kilowatts does not equal 70, does it?

A (Witness Youngling): Full scale of 560 kilowatts is 112 kw.

However, our calibration history on that instrument has shown that the worst-case accuracy before and after the endurance run was plus or minus 70 kw, which means that the loop is performing better than its intended accuracy, which is not uncommon in a powerhouse.

Q All right.

So it is correct that your testimony is that the

potential instrument error for the main control room kilowatt meter during this test was plus or minus 70 kilowatts; is that right?

A (Witness Youngling): I'm saying that the recorder loop accuracy is plus or minus 70 kw. But, as we have previously testified, it is our feeling that the instrument spends as much time above as below; and we feel that the mean value, as indicated by the kilowatt meter, is representative of the loop load -- of the diesel generator load.

Q Now, of the 507 hours that are referred to in that sentence, how many of those hours were run at 3300 kilowatts, as indicated by the main control room kilowatt meter?

A (Witness Youngling): Mr. Dynner, I don't have that number with me now. I'll have to get it for you at the break.

Q In the next sentence, you refer to "A substantial portion of the hours placed on the EDG-103 replacement block occurred as the result of a 745-hour 10 to the 7th loading cycle confirmatory test."

How many hours are you referring to in your term "a substantial portion"?

JUDGE BRENNER: Mr. Dynner, maybe I don't understand the question. Are you asking them what portion of 849 hours is 745 hours?

MR. DYNNER: I'm asking them specifically what they're talking about when they say a substantial portion of the hours; how many hours is a substantial portion in that sentence.

JUDGE BRENNER: I'm sorry, I don't understand.

MR. DYNNER: Well, I think the Board is aware that there were two blocks involved, the old block and the new block. A 745 hour run, as I think testimony shows, goes with respect to the crankshaft, which was run in two different blocks.

I want to know what he's talking about by "a substantial portion."

JUDGE BRENNER: I think you're misunderstanding what is in the testimony. All I know is what I'm reading, and maybe I'm reading it wrong.

I don't now what is taking the panel so long, though.

MR. DYNNER: It does raise questions about whether my question is a good one or not.

JUDGE BRENNER: Maybe it's a question as to whether your question is comprehendable or not.

MR. DYNNER: Or the testimony, for that matter,

since all I'm talking about is the written testimony.

JUDGE BRENNER: Let me try something.

Gentlemen, as I read your answer four, you are saying that the new replacement block has been operated for more than 849 hours, correct?

WITNESS YOUNGLING: That's a true statement, Judge.

JUDGE BRENNER: And are you also saying by your phrase, "a substantial portion," that of the 849 hours 745 of them occurred as a result of the 10-to-the-seven loading cycles confirmatory test?

WITNESS YOUNGLING: Judge, let me try to clarify it in this manner:

The confirmatory -- the endurance test, the 745 endurance test consisted of 525 hours which were clearly on the new 103 block. In addition there were 220 hours which had been accumulated prior to that endurance run. I do not have the exact proportion of those 220 hours that were on the new block versus the old block, and that's the difficulty that I'm having.

JUDGE BRENNER: Mr. Dynner, you are correct and I apologize.

That's the number you want, is that right, Mr. Dynner?

MR. DYNNER: That's what I was looking for. And

I think the answer is that they don't know.

WITNESS YOUNGLING: I can get you the number at the break.

BY MR. DYNNER:

Q When you refer in the next sentence to the endurance run portion of the confirmatory test, are you referring to the 525 hours that you just mentioned?

A (Witness Youngling) Yes, I am.

Q And were those 525 hours, was the load level during that confirmatory test indicated by the main control room kilowatt meter?

A (Witness Youngling) As I previously testified this morning, the majority of the data points were taken off the control room meter. But there were some data points that were read off the watt hour test loop after confirmation of load on the watt hour meter. So some of the data was recorded off the more accurate loop.

Q Can you quantify that in terms of the number of hours that were read off the data meter?

A (Witness Youngling) No, I don't have that number.

MR. DYNNER: I have no further questions.

JUDGE BRENNER: That's why I was trying to get to the witnesses this morning; I knew what the approximate length of your cross plan was. I don't know if the other

parties realized that we might be able to go through several witness panels.

MR. DYNNER: I informed the parties that I would have very short cross-examination; I think what I told them was about a half hour or even less.

JUDGE BRENNER: All right.

Staff.

MR. GODDARD: The Staff has no cross-examination for this panel.

JUDGE BRENNER: We're going to take a break and get organized ourselves to see if we can shorten up our questions.

MR. ELLIS: Judge Brenner, may I make an inquiry of the Board? With respect to my examination, I'm not sure whether the Board has ruled in this connection before but let me tell the Board what I had intended to do by way of redirect examination.

I'm not sure whether the Board has ruled in this connection before, but I had intended to go to the County's examination on pages two and three and --

JUDGE BRENNER: You mean the County's testimony?

MR. ELLIS: The County's testimony, I'm sorry, on pages two and three and ask this panel whether they agreed, and if not why not, and if so why.

The reason for that, of course, is, of course,

that their testimony was filed after ours and we did not get a chance to respond.

JUDGE BRENNER: We will allow that type of inquiry. We have allowed it before.

MR. ELLIS: Thank you.

JUDGE BRENNER: Maybe we should let you do that now to the extent it might affect our questions.

MR. ELLIS: All right, sir. I'll be glad to go to it now.

JUDGE BRENNER: All right.

REDIRECT EXAMINATION

BY MR. ELLIS:

Q Gentlemen, turn, if you will, please, to the testimony of Mr. Bridenbaugh, dated January 25, 1985, on page two. Question four, Dr. Rau, states:

"Do you believe that the cylindar blocks in EDG 101 and 102 are suitable for use at a reduced load of 3300 KW?"

And the first paragraph of the answer states:

"No. First, both of those blocks have ligament cracks. FaAA's own analysis predicts that both ligament and stud to stud cracks may initiate in those blocks even at the reduced load level of 3300 KW."

Dr. Rau, do you agree with that portion of answer

number four?

A (Witness Rau) No, Mr. Ellis, I do not. Mr. Bridenbaugh has answered no to the question of whether or not blocks of 101 and 102 are suitable for their intended purpose at a reduced load of 3300. I disagree with his statement, his answer no. I believe they are. And I believe they are for a number of reasons.

In particular the cumulative damage analysis of fatigue crack propagation of the block tops has indicated that, independent of whether or not stud to stud cracks would initiate at any power level -- whether it be 33 or 35 or any combination duty -- that there is a very substantial margin which would prevent a crack, even if it were initiated, from extending to a size of concern.

And in particular I previously testified that the EDG 101 and 102 blocks, even based on the very conservative cumulative damage analysis of crack propagation that we've done, could withstand 50 consecutive LOOP/LOCAs even at the 35-, 39-, 2600 design load profile which was addressed in the proceedings of last fall.

For that reason I disagree that initiation has any relationship to the adequacy of the 101 or 102 blocks with regard to the functionability or ability to perform their intended function at 3300.

Q In your opinion, Dr. Rau, do you agree that

stud to stud cracks are likely to initiate in those blocks at load levels of 3300?

A (Witness Rau) No, Mr. Ellis, I do not believe that stud to stud crack initiation is likely in those blocks.

The analyses that have been done of the possibility of fatigue crack initiation are very conservative, as I have testified quite extensively previously. And although they indicate the possibility that stud to stud cracks might initiate, the conservatism in that analysis leads me to believe that it is not likely that they will.

I think further that the extensive operation that the 101 and 102 blocks have seen at power levels at and above 3500 KW, when converted, if you like, to an equivalent number of hours at 3300 KW, suggests that these blocks have already demonstrated a very substantial number of cycles -- again of the order of five-times-ten-to-the-sixth cycles -- an equivalent of 3300 KW without initiating stud to stud cracks even after ligament cracks have been shown to be present in the 101 and the 102 blocks.

So for that reason I don't believe it is likely that we are going to initiate stud to stud cracks in those block tops.

Q All right.

Gentlemen, the second paragraph of that answer states with respect to circumferential cracks -- and I quote:

"No tests have been performed which conclusively establish that the EDG 101 and 102 locks do not have circumferential cracks, and we are aware of no analysis that demonstrates that such cracks will not initiate at 3300."

Do you gentlemen agree with that statement, and if so why, or if not, why not?

A (Witness Rau) Mr. Ellis, I disagree with that second paragraph. I believe that the inspection experts on this panel will want to comment in more detail.

But I would simply like to indicate that, again Mr. Bridenbaugh is inferring that the initiation of circumferential cracks invalidates the suitability of the block for its intended use at 3300 KW.

And based on the extensive analysis and the testimony we previously have given last fall, it's clear that even if cracks were to initiate at the circumferential location the analyses that have been done indicate that the mean stresses will become compressive at very short distances away from that sharp fillet where the cracks might initiate and that the cyclic stresses will decrease very

rapidly with distance from that sharp corner.

And for both reasons, that even if a crack were to initiate in a circumferential area it would slow down and it would arrest. And for that reason the implication that initiation has any relevance whatsoever to the suitability of the blocks, should it occur, I take disagreement with.

I also disagree with the statement that there have been no tests which conclusively establish the absence of cracks in either 101 or 102. I believe that there are inspections -- in particular the ultrasonic inspections -- which do conclusively indicate that there are no cracks in 101.

And I believe Dr. Johnson would like to comment on that.

A (Witness Schuster) Long Island Lighting Company has performed in excess of 100 examinations of the liner landing and the block top areas of 101, 102 and 103 engines.

Specifically EDG 101 early in November of 1983, we performed a penetrant examination on cylindar number eight. At that point in time some industry experience was provided to us in regard to the possibility of circumferential indications in the cylindar block. So we performed a penetrant baseline on cylindar number eight on DG 101.

Subsequent to that, early in February of 1984, we performed another penetrant baseline examination on cylindar number seven.

Subsequent to that we performed penetrant examinations as part of the DRQR program on cylindars one through eight, which included the liner landing area, the circumferential area we're discussing at this point.

In addition to that we repeated these penetrant examinations and performed ultrasonic examinations on selected areas of DG 101.

In addition to that we provided some baseline inspections on DG 103 and did penetrant examinations in February on all eight cylindars, which included the liner landing area and the circumferential area under discussion. We did eddy current inspections also in the study areas of that block. And we did some additional penetrants after the 100 hour endurance run.

We also did penetrant examinations on the 103 engine and did confirmatory ultrasonic examinations and mag particle and penetrant examinations on the old DG 103 block after it had been cut up. And further verification was then done by -- of our examinations by FaAA in California.

Q Mr. Schuster, before you -- before Dr. Johnson comments about the FaAA inspections, you referred to a number of liquid penetrant inspections of the diesel

generators, but you did not refer to the results. Will you tell us what these inspections disclosed with respect to circumferential cracks?

A (Witness Schuster) DG 102, no circumferential cracks were evident as a result of our examinations.

DG 101, we had some background indications due to the geometry, including the area in question. It's a sharp corner, and debris and carbon collects in that area and it makes it very difficult to do penetrant in that area. So additional cleaning, a redo of the penetrant and specific examination of the areas where the background was high was done by ultrasonic examination.

Incidentally, all the procedures that were utilized were qualified in accordance with MB-5000 of ASME Section Three with backup qualification done in accordance with Section Five of that code.

All of these procedures were done by qualified personnel with a minimum level two certification for the baseline inspection, and the additional examinations and scrutinization was done by a level three who had level three examination certification in UT, MT, PT and RT, and had extensive casting industry experience.

Q You omitted, though, from your answer, Mr. Schuster, what was the result of the additional work on the 101, DG 101. You mentioned ultrasonic that was done as

a result of the background.

A (Witness Schuster) The results of the ultrasonic examination were that there were no indications in that area of the block, in the land area of the block, specifically that notch where the liner landing face and ledge meet each other.

Incidentally, we also verified this procedure again on DG 103 with a different inspector to verify the original inspection because of questions that were raised as a result of some of what is going on here, and verified that that procedure was in fact valid.

Q Have any of the inspections, then, that you have described, Mr. Schuster, revealed any circumferential cracks on DG 101 and 102?

A (Witness Schuster) No, sir.

Q Dr. Johnson, do you agree with that second paragraph of answer four? And give a basis for your answer, please.

A (Witness Johnson) No, I do not agree with that statement.

I do not believe there is any evidence that there are circumferential cracks in DG 101 and 102. We performed extensive UTs -- ultrasonic tests -- directed at detection of circumferential cracks in March of '84 after the 100 hour endurance run test on DG 101, and no circumferential cracks

were detected.

We have also performed penetrant tests directed at circumferential cracks. They were conducted both on DG 101 and 102 after the 100 hour endurance runs. And no circumferential cracks were detected.

Q Gentlemen, let's turn to the third paragraph of Answer 4, and let me ask you, without reading it -- you may read it for yourself -- whether you agree or disagree with that.

Any member of the panel may answer.

A (Rau) Others may wish to answer, too, Mr. Ellis, but I, for one, certainly strongly disagree with the statements made by Mr. Bridenbaugh in his testimony, the third paragraph in his answer to Question No. 4.

He states that Failure Analysis has not undertaken any detailed crack propagation analyses, and I have testified previously and will state again here that Failure Analysis Associates has in fact done an analysis of crack propagation in the block top.

The cumulative damage analysis, which we have testified about extensively, is in fact an analysis of fatigue crack propagation in the block top, and it does in fact show with a reasonable degree of scientific certainty that the block top cracks cannot and will not extend during a LOOP/LOCA to a size of concern, with a very substantial margin.

With regard to the circumferential crack area, which Mr. Bridenbaugh suggests we haven't done a crack propagation analysis of, we have in fact done all that analysis which is necessary to reach with a reasonable

degree of scientific certainty a conclusion that those circumferential cracks are of no concern because they will not and cannot extend to a size to affect the function of the EDG blocks.

In particular, the finite element stress analyses which we have done have indicated convincingly that the stresses which are very high right at that sharp corner between the counterbore, the cylinder, and the liner land where circumferential cracks were detected in the original 103 block with the degenerate Widmanstaetten graphite, those very high stresses very quickly drop off with distance away from that sharp corner; and through analyses of postulated hypothetical cracks which might extend in various directions from that sharp corner, our analyses have shown that the maximum stress will become compressive at depths less than four-tenths of an inch beneath that surface, and once the maximum stresses become compressive in conjunction with a reduced magnitude in the cyclic stresses any crack, should it initiate at that sharp corner, will slow down and will arrest.

There is absolutely no reason to do any specific, if you like, fracture mechanics analyses of crack progression beyond that point because it is simply going to show no crack progression.

A (Schuster) I would like to add that the results

of the inspections on the block top, specifically for stud-to-stud indications, the penetrant examinations, and other examinations that were done on DG-101 and 102 indicated no stud-to-stud cracks, and those engine blocks have over some 1200 hours of operation at all loads.

A (Rau) Could I add one more thing?

I noticed that Mr. Bridenbaugh in that same paragraph you referenced also makes reference to ligament crack area, which I don't think I have responded to specifically.

I think it is appropriate to note that the finite element stress analyses that have been done at the block top region indicate that in the ligament area as well as in the stud-to-stud area that the steady stresses, the mean stresses also decrease very rapidly with distance beneath the top surface of the block, and in fact they become compressive on the ligament side of the stud as you progress down towards the thread area from the block top surface.

Similarly, to the stud-to-stud side of the stud hole and the block top, the cyclic stresses introduced by the cylinder firing also decrease in magnitude as you progress in distance from the block top down towards the threads, and in fact the magnitude of the cyclic stresses decreases very substantially as you move from the block top down to the inch and a half depth where the first thread

appears on EDG-101 and 102 block tops.

For both those reasons, the ligament cracks are also going to slow down and arrest, as in fact -- and this in fact confirms the observations that have been made on the EDG-101 and 102 that in fact the ligament cracks do slow down and arrest at the liner land area.

Q What is your opinion with respect to whether subsurface ligament cracks would initiate at the first loaded thread in the stud hole?

MR. DYNNER: Objection. There is nothing about initiation. The question is about propagation.

MR. ELLIS: That is correct, Judge Brenner. What I was doing is the implication of the statement concerning ligament cracks. I was simply taking the full implication of that statement.

JUDGE BRENNER: Well, I think I will overrule the objection. I know we will overrule the objection for Mr. Ellis' reason, and in addition, maybe we don't understand what Mr. Bridenbaugh means by "develop," as he uses that word in that paragraph, that the witnesses have been focused on as a lead-up to this.

So for completeness, because we might not learn fully what he means, and for conservatism's sake I assume he means initiation, also, for now.

Do you need the question again?

WITNESS RAU: I think I remember it, your Honor.

As I understand the question, you are asking me, in addition to my comments about crack progression in the ligament and stud-to-stud areas, with regard to the ligament side itself, do I believe that ligament cracks could initiate subsurface; that is, below the block top, in particular at the first thread of the stud?

I do have an opinion on that, and my opinion is that ligament cracks will not initiate at any position below the actual top, physical top, of the block top surface. They will not initiate there for the same two reasons that the cracks will slow down and arrest as they progress from the block top down towards the first thread of the stud. That is, the steady stress which is opposed by the preload and the thermal stresses will decrease with distance from the block top and in fact actually become compressive down at the inch and a half depth or even before the inch and a half depth, and simultaneously with that decrease in mean or steady stress there is a very substantial decrease in the cyclic stress as computed by our finite element analysis, such that there is an enormously reduced driving force for initiation of fatigue crack beneath the block top.

And although I haven't made a specific calculation of it, we are talking about hundreds and thousands of times more difficult to initiate a crack down

to the first thread than it would be to initiate the crack at the block top, where in fact the physical evidence indicates the ligament cracks have initiated.

Q Gentlemen, let's turn to page 3 of Mr. Bridenbaugh's testimony, and let me direct your attention to Answer 5. In the body of Answer 5, Mr. Bridenbaugh makes the statement -- and I am paraphrasing -- that FaAA's cumulative damage analysis in (i) was based on imprecise crack measurements.

Do you gentlemen agree with that?

A (Johnson) No, I do not agree that the crack measurements performed were too inaccurate for our accumulated damage analysis. Specifically, the stud-to-stud crack between Stud Hole No. 7 in Cylinder 4 and Stud Hole No. 2 in Cylinder 5 detected in the original DG-103 block immediately after the 100-hour endurance run were at least 1.4 inches deep and not more than approximately 1.6 inches deep.

As the records of the eddy current examination I performed in the stud holes after the 100-hour endurance run show, there were large unmistakable crack indications down at least to 1.4 inches in both stud holes.

After the load excursion in the old DG-103, we have laboratory destructive tests, laboratory magnetic particle tests, penetrant tests, eddy current examination

results, which all agree that the stud-to-stud crack in this area after the load excursion do not extend to more than approximately three inches in this area.

Q Dr. Johnson, did you review some specific data to support or confirm your opinion that you have just given me?

A (Johnson) The specific inspection report. Well, the DRQR report, Q-220, which clearly describes the magnitude of the signal, which is approximately five times the reference level down to the first thread, which is approximately 1.5 inches in both stud holes.

A (Witness Schuster) Just for clarification, the 100-hour endurance run is the DRQR testing that we did, because we use the term "endurance run" interchangeably.

I think we should add that.

JUDGE BRENNER: Could you give me the approximate date for that? I ask only so that I can catalogue that in my own mind.

WITNESS JOHNSON: The date of the inspection is 3/14/84.

JUDGE BRENNER: And the endurance run ended right around that date?

WITNESS JOHNSON: Shorely before that.

WITNESS RAU: Can I add something, too, for clarity?

The answer that Mr. Bridenbaugh was addressing is, in fact, the adequacy of the cumulative damage analysis, and, in particular the input -- that is, the crack measurement input.

Dr. Johnson has addressed the quantification of the size of the crack prior to the demonstration period, which we sometimes call the benchmark period, with the original 103 block. That is the operation which occurred between about 3/11 1984 and 4/14 1984.

The inspection done prior to that demonstration period, or benchmark period, operation is the one in which

Dr. Johnson has testified that he has reviewed the inspection reports and knows precisely that the depth of the stud-to-stud crack between cylinders 4 and 5 was in fact between 1.4 and 1.6 inches deep. That's the initial crack size upon which our cumulative damage analysis is in part based.

In addition to that crack measurement there is also the measurement of the crack depth after the demonstration run -- that is, about 4/14 1984 -- when the original 103 block, or after which it was taken out of service.

The quantification of the crack depth in the stud-to-stud region at that time was made by a number of methods, including destructive metallurgical examination which confirmed that the depth after that demonstration period run was, in fact, 3 inches, maybe as little as 2.8 inches, but between 2.8 and 3 inches deep. That is below the block top surface.

That depth was confirmed by visual examination through the metallography -- that is, the visual examination. It was also measured by eddy current to be the same depth. It was measured by magnetic particle inspection to be the same depth. It was measured by liquid penetrant to be the same depth.

So there were four independent non-destructive and

destructive examinations which confirmed the depth of the crack after the demonstration period on the original 103 block. And, in fact, the eddy current inspections of the crack depth prior to the demonstration period, I believe also confirmed by some ultrasonic inspections which were consistent with that 1.5 or 1.4 to 1.6 inch crack depth prior to the period.

And it is those two crack sizes which form, in part, the input to the cumulative damage analysis of crack progression which is benchmarked against the performance of the original 103 block during that test period, 3/11 through 4/14 1984.

Q Well, Dr. Rau, is it your opinion that the cumulative damage analysis-- Or, what is your opinion with respect to whether the cumulative damage analysis was based on adequately precise crack measurements? Was it or wasn't it?

A (Witness Rau) It very definitely was, Mr. Ellis, for the reasons I have just indicated. The crack size after the endurance run was confirmed to be within 2.8 to 3 inches deep by four independent methods, and the measurement before has been confirmed by the eddy current and ultrasonics to be within 1.4 to 1.6 inches deep. And there's absolutely no concern whatsoever for the validity of either one of those numbers within those ranges quoted.

Q Gentlemen, in that same answer Mr. Bridenbaugh states, and I'm paraphrasing, that the original analysis was inadequate -- referring to the cumulative damage analysis -- at 35, 39 and the same weaknesses exist at 33, because it was based on inadequate -- in part, based on inadequate crack propagation data.

Do you agree with that, gentlemen?

A (Witness Rau) No, Mr. Ellis; I strongly disagree with Mr. Bridenbaugh's testimony in that regard. He is implying that we do not have adequate fatigue crack propagation data upon which to perform our cumulative damage analysis of fatigue crack propagation. I disagree with his statement because it's clear that we do.

With regard to the original 103 material -- that is, the benchmarked testing upon which the analysis in in part based -- we actually cut physical samples from the block top region of the original 103 block. It contained the same microstructure, the same degenerate Widmanstaetten graphite that was throughout the original 103 block. We made fatigue crack propagation measurements on that material cut from the same original 103 block. We measured the effect of variable cyclic stress amplitude, we measured the effect of variable steady, or mean stress on the rate of fatigue crack propagation on the original material cut from the old 103 block.

For that reason we have done a direct and precise measurement of the rate of fatigue crack propagation in the original 103 block material.

Now, to perform the cumulative damage analysis we also have measured, directly measured, the fatigue crack propagation rates in conventional gray cast iron without degenerate Widmanstaetten graphite.

Short of completely destroying the 101 and 102 blocks, and cutting material directly from them, we have done the best that anybody could possibly do with regard to quantifying the rate of fatigue crack propagation in typical gray cast iron of the ASTM A48-64 gray cast iron Class 40. We did that by cutting samples from a large casting made by TDI in an area where the wall thickness was approximately three inches, where the microstructure was confirmed to be conventional, or typical gray cast iron. We fabricated a laboratory specimen, we went to the laboratory and we measured on those specimens cut from the typical gray cast iron the effect of variable cyclic stress, of variable steady, or mean stress, and we did it on exactly the same basis we made the measurements of fatigue crack propagation on the original 103 block material with degenerate Widmanstaetten graphite.

So, as I said previously, short of literally cutting material actually precisely from 101 or 102, we have

gotten as close as we can with regard to the same class of material, large castings, same manufacturer, same thickness of material. And, in fact, it is those direct measurements which we have used on both the original 103 and also on typical cast iron that formed the basis, in part, of our cumulative damage analysis of fatigue crack progression.

Maybe Dr. Wachob, who did the testing, would like to add something to it.

A (Witness Wachob) No.

Q Dr. Rau or Dr. Wachob, I'm not sure I got-- You may have said this, but did the examination of the microstructure of 101 and 102 reveal the same microstructure as that typical of Class 40 gray cast iron?

A (Witness Wachob) Yes; in all cases where we examined the microstructure in 101 and 102 we found that it is typical of that which you would observe in an ASTM Class 40 gray cast iron. So, therefore, the applicability of the exemplar material that we have to the testing, in comparison to the 101 and 102, is direct, and, therefore, quite appropriate.

JUDGE BRENNER: Dr. Wachob, you're talking about everything you looked at before you testified previously; correct?

WITNESS WACHOB: That's correct.

JUDGE BRENNER: We're starting to get too

repetitious.

MR. ELLIS: Yes, sir.

BY MR. ELLIS:

Q Gentlemen, finally, Mr. Bridenbaugh states that the original analysis was inadequate at 35 and 39, and the same weaknesses exist at 33, because it failed to account for possible variations in the rate of crack growth at various points in time.

Do you agree with that, Dr. Rau?

A (Witness Rau) No, Mr. Ellis, I do not.

It's quite clear, once you understand the details of the cumulative damage analysis of fatigue crack propagation that it does, in fact, consider in a conservative fashion the variation in crack growth rate at various points in time.

The original 103 block and the progression of the stud-to-stud crack during the demonstration test period between 3/11 and 4/14 1984 in fact undergoes progression of the stud-to-stud crack during that period over the crack size range which is the one used to benchmark the cumulative damage analysis. And to the extent there are any significant variations in crack progression over that time period, or over that distance of crack progression, that's incorporated, if you like, automatically through the behavior of the original 103 testing.

I've indicated that in addition to that the analysis which we've performed is conservative, and it incorporates any possible variations in a conservative way. And what I mean by that is the following:

The analysis which we did, the cumulative damage analysis of fatigue crack propagation in the block top, has not incorporated any effects of fatigue crack retardation that sometimes result as the result of variations in the load amplitude and sequencing of loads. And in particular, what happens -- I think Dr. Bush may have testified about this already: if there's a high load or stress which is subsequently followed by a lower load or stress, the fatigue crack progression at the lower load of stress will be retarded or slowed down if in fact it is preceded by a high load first, compared to what it would have been without that high load preceding the operation at the lower load.

The reason for which our cumulative damage analysis is conservative, it is that the postulated LOOP/LOCA load profile involved the highest demands, or loads, and therefore corresponding stresses in the block top area early in the LOOP/LOCA load profile, followed with subsequent operation at lower load levels.

So that if in fact the effects of variations in crack progression due to this high load followed by low load were to be incorporated explicitly in the cumulative damage

analysis, that would have resulted in even slower crack progression, or postulated crack progression during the LOOP/LOCA event, and therefore even larger margins than those which have been demonstrated by the conservative analysis which we've done.

In addition to that, the demonstration test period -- that is, the 3/11 to 4/14 testing done on the original 103 block involved the largest, or highest stresses and loads occurring late in the demonstration test period. So, if you like, there would be no retardation during the demonstration period, and there might be retardation during the LOOP/LOCA load profile. And if you think about that for a minute, the combination of those two is the most conservative it can be.

In other words, had we incorporated any crack growth retardation phenomena into the model, it would have resulted in even a larger predicted demonstrated margin between the original 103 and the requirements of the 101 and 102 during a LOOP/LOCA.

So the fifty consecutive LOOP/LOCAs that have been demonstrated would be even larger if, in fact, any variation in crack progression beyond those which are automatically included by the demonstration, or comparison with the original 103, had been included in our analysis.

MR. ELLIS: Judge Brenner, that's all the

questions we have. This might be an appropriate time for a break.

I think Mr. Stroupe has those exhibits for the Board at this time.

JUDGE BRENNER: All right.

I don't know what your concern is for finishing with this panel today also. You have got competing tensions. Do you want us to take the time to take care of Dr. Johnston -- you know, depending on our ruling -- and then at the same time you want us to presumably not take too long a break because we might finish this panel.

Do you want to help me out on that, Mr. Ellis, so I can decide how long a break to take?

I'm trying to accommodate your witnesses, but I don't know if you have competing considerations. You and Mr. Stroupe might have disagreement as to priorities; I don't know.

MR. ELLIS: I think Mr. Stroupe and I would be happy to do it in whatever way the Board would find it appropriate.

I would imagine that getting the crankshafts entirely behind us would have some priority over-- It is one against five, but, nonetheless-- Either way; it doesn't make any difference to us. Whatever the Board wishes.

JUDGE BRENNER: This will take another moment or

time of time, but I wanted to inquire at some point today, and I'm afraid in the rush to get out of here at the end of the morning session there might not be time.

I know that LILCO said they still want to raise further settlement possibilities before the Board. The Staff had no objection, as I recall; I don't know if they favored it, but at least they had no objection. The County -- and the County also represented the State's point of view -- I guess thought nothing further would be gained on it, to state it as moderately as I can.

Were you opposed to it?

MR. DYNNER: Yes, we're opposed to it, because we don't think there are any settlement discussions going on.

JUDGE BRENNER:. That was going to be my next question.

Should there not be further settlement discussions, however long or short the parties mutually think is appropriate before we even consider bringing it back before the Board again?

MR. ELLIS: Well, I think-- Yes, sir, we are certainly happy to continue to discuss with the County. But I think what we have is a position taken by the County from which there is no movement.

I'm the author of the last communication.

JUDGE BRENNER: I don't even know if I've seen the

last communication. But that doesn't matter.

I'll see if one or two questions will help solve it; and, if not, I'll abandon the whole subject in favor of the break.

We can let the witnesses take a break now while we keep talking. This won't relate directly to their testimony.

JUDGE BRENNER: Mr. Dynner, am I correct that as long as LILCO is not proposing anything with respect to further testing of the 101 or 102 engine the County sees nothing further to be gained by further discussion? Is that right?

MR. DYNNER: Well, I wouldn't characterize the County's position at all that way. The County's position is that settlement discussions have not taken place, that we received a proposal, we responded to that, and we received another letter -- and you have seen the correspondence -- and nothing further has occurred.

So we have rejected the initial proposal. We have not heard any response to our settlement proposal other than their proposal, and there haven't been any discussions and there aren't any negotiations, and as far as I am concerned, settlement has to be among the parties.

And if the parties mutually -- as you said on the record previously, if the parties mutually agree that it would be helpful for the Board to intervene and to assist the parties in getting over some kind of a hump, then that might be appropriate, but we are nowhere near that stage.

JUDGE BRENNER: Are you willing to have settlement discussions between now and early next week, Mr. Dynner, without the Board, just the parties?

Maybe I misunderstood. You see, I thought you

were opposed to that. But something you just said now leads me to believe that --

MR. DYNNER: We are always willing to believe, to listen to, to have communications with LILCO and the Staff about their positions in respect to possibilities for settling the issues. We haven't had those discussions. We have had an exchange of correspondence, and we have had litigation.

JUDGE BRENNER: All right. During this break, talk about when you can have further discussion. I am not talking about when you finish them or -- well, I can't take it too far, obviously.

What I really want to know is whether you can have further discussions between now and very early next week, and then we could get a further oral status report, and I am hoping to complete the hearing possibly on Monday, but we will hold over for that subject until Tuesday morning, or something of that nature.

MR. DYNNER: My own feeling is that we ought to go forward and complete this hearing. We are very close to the end, and whatever discussions and negotiations are possible to be carried out either will or will not happen. It just seems to me I can't be in a position to say that I can do anything between now and Monday or now and Tuesday, and hopefully we will be able to continue -- or to begin,

I should say -- discussions after we conclude this hearing and keep the Board apprised if anything happens as a result of those discussions, if they occur.

JUDGE BRENNER: Well, I think it would be reasonable -- unless you point out why it would be unreasonable from your point of view -- for us to require the parties to have -- to begin the discussions that you have said have not occurred between now and early next week so that we could at least get a status report and then make a more informed decision as to anything we might -- whether there was anything we might say or do that could stimulate anything further.

Now, we might agree with you that at that point there is still nothing further for us to do, and we might well decide to do nothing, but I want to have that other opportunity, and it will be very convenient, since we are all going to be here next week, to work it out so that we can have the opportunity then.

MR. DYNNER: I would respectfully suggest that if the Board requires the parties to have discussions, that those discussions are probably not going to go anywhere. Discussions on settlement go someplace if the parties mutually decide that they have something to discuss and that there is movement on either side, but I don't think it will be appropriate for the Board to require discussion to take

place.

I would hope discussions would take place if people's positions are such that they could have discussions.

JUDGE BRENNER: I am confused again. You will forgive me.

I thought you said you would be willing to undertake discussions. That was my starting point. So my only question is for us to force the timing a little better than leaving the timing wide open, and that is all I thought I was speaking to because you corrected my previous misimpression and told me you were certainly willing to have discussions.

MR. DYNNER: I said we are willing to talk if LILCO has something they want to talk to us about. I don't think that discussions ought to be imposed by the Board, and I don't think a timeframe for those discussions ought to be imposed by the Board.

I think at this stage in particular settlement negotiations and discussions ought to be left to the parties.

JUDGE BRENNER: You are not communicating any substantive thoughts to me, Mr. Dynner. I am not receiving any, let's put it that way.

All right. Let's take a break. We will see if

we can do what we need to do by 11:15, and if we are not ready then, we will let you know.

(Recess.)

JUDGE BRENNER: Back on the record.

We have reconsidered, at LILCO's request, and now supported by their written proffer, whether to allow LILCO to put in the "Proffered Testimony of Paul R. Johnston," dated March 8, 1985.

On reconsideration, we hold to our original ruling, for the reasons we gave on the record yesterday, not to admit the testimony. There is no need to repeat that.

I will further point out the obvious, that to the extent there is information already existing in the record that the parties want to bring together in their proposed findings, they are entitled to do that.

MR. ELLIS: Judge Brenner, maybe before the Board begins its questions --

JUDGE BRENNER: I have one other subject.

Your subject was related to the testimony?

MR. ELLIS: Yes, sir.

JUDGE BRENNER: I am sorry. I had one other subject.

With respect to settlement discussions, it is the Board's view that we would seek to require further discussions to take place as a follow-up to what has

already taken place. Some of it we have seen in the exchange of letters, some of it we may not have seen.

But we want further discussions to take place, and we want to be able to establish a timeframe for the parties to report back to us to communicate the status to us. Those are the goals that we can and will require be implemented.

However, for now; that is, between now and Monday, we want to leave it up to the parties both as to what an appropriate timeframe should be for requiring the parties to have further discussions and communicate back to us.

But we want a finite timeframe and what form that communication back to us should take, whether it should be a written report, a conference of counsel, probably in Bethesda with the Board, or both, or maybe no written report.

So the parties at least are required to talk about that much. Label that the "shape of the table" discussions, to take place between now and Monday, and then let us know, and I am sure the parties, with those goals in mind, can come up with something.

Obviously, when the time comes for the parties to report back to us, the report may be that no further progress has been made, but....I am talking about the

ultimate report back to us.

We think that is consistent, or at least not inconsistent, with anything the parties express so far. We are at least not discouraged by the fact that no party has said absolutely there is no point in any further discussions to take place, and having been through lengthy proceedings already and having seen the parties' very successful results in at least holding discussions even when they do not reach fruition, we would have been surprised if any party had taken that position.

So the parties that the parties -- at least we have confidence that the parties will continue to approach this matter as they have approached settlement matters in the past, and if no progress is made, that will be the result. But nevertheless, we are going to require that you try, and you tell us how best -- what type of framework that that could be done to best suit your mutual purposes.

Since we are not going to -- well, I don't think we will finish with this panel. If it looks like we are not going to finish with the panel, anyway, we probably would like to adjourn at about 11:50 to give us a little more time, but if it makes a difference between finishing and not finishing we have some flexibility.

Mr. Ellis, you wanted to raise a matter?

MR. ELLIS: Yes, sir, two things. With respect

to the Board's ruling, the proffered testimony, is it the Board's practice to bind that in as offered but exclude it? And if so, I would ask that that be done.

JUDGE BRENNER: Yes. We will make it an exhibit so as not to confuse the parties here to thinking it is in evidence.

Thank you. I should have offered that. I guess I did yesterday and forgot to renew the offer today.

I suppose we will give it a C exhibit number.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: We believe, taking two lists, which may not be accurate, that we are up to C-43 for LILCO.

Do you know?

MR. ELLIS: I don't know, Judge. I will check that. I think that is correct, and we will supply four copies to the reporter marked as C-43.

JUDGE BRENNER: All right. The "Proffered Testimony of Paul R. Johnston," dated March 8, 1985, which consists of three typewritten -- a cover page and three typewritten pages will be marked for identification as LILCO Exhibit C-43, and it has been rejected by the Board for the reasons indicated.

(LILCO Exhibit C-43 identified and rejected.)

MR. ELLIS: The second point, Judge Brenner, is that Mr. Dynner had asked for some figures that Mr. Youngling said he would obtain at the break. He has those figures now and is prepared to give them if the Board considers this to be an appropriate time.

JUDGE BRENNER: Fine.

Mr. Youngling.

WITNESS YOUNGLING: Judge Brenner, on page 5 of our testimony, Mr. Dynner asked me how many -- what percentage of the hours of the 745 hours that were accumulated during the 10-to-the-7 test were on the replacement 103 block.

Of those 745 hours, 596 hours were on the replacement block.

He also asked me, of the 507 hours cited in the fourth line of my testimony, how many of those hours were at 3300 kw, and there were approximately 426 hours at 3300 kw.

JUDGE BRENNER: Is that 426 of the 596?

WITNESS YOUNGLING: Of the 507.

MR. DYNNER: May I ask a question, Judge Brenner, of Mr. Youngling, with respect to the remainder? He said that 426 hours were at 3300, and I was going to ask him about the remainder between 426 and 507.

WITNESS YOUNGLING: The remainder of those hours were at greater than 3300.

JUDGE BRENNER: We will let you come back to it as part of your follow-up questions if you want, Mr. Dynner, if you think it is necessary to ask a question or two now so you can contemplate the answers, I will let you do that also.

MR. DYNNER: Either way. I am confused now more than I was before. And I could ask some questions about this discrete area.

JUDGE BRENNER: Go ahead.

MR. DYNNER: Thank you, Judge.

BY MR. DYNNER:

Q Mr. Youngling, your testimony says more than 507 hours were at or about 3300 kilowatts as indicated on the main control room kilowatt meter. You now said that 426 hours were at 3300 kilowatts.

Were those 426 at 3300 kilowatts as indicated on the main control room kilowatt meter?

A (Witness Youngling) As I testified this morning, those 426 hours out of those 507 were accumulated during the endurance run, the 525-hour endurance run, and a portion of those were off the main control room kilowatt meter, but there also was a portion that were taken off the watt hour test loop, the more accurate measurement loop.

Q Yes.

And were these 426 that you're talking about all as indicated on the main control room kilowatt meter, or were some of those also recorded by the other device?

A (Witness Youngling) I don't have a precise breakdown but more than likely, a portion of them were off the more accurate loop. But I don't have an exact breakdown.

Q Then you said the difference between the 426 and the 507 hours that appears in your written testimony were at loads in excess of 3300. Precisely what were those loads, if you know?

A (Witness Youngling) As we testified in our earlier testimony on the load contention, a portion of the hours during the 525-hour run were at greater than 3300 up to 3400 kw, as indicated on the watt hour meter.

Q So this 81 hours were somewhere between 3300 and 3400 but you don't know precisely where. Is that right?

A (Witness Youngling) I don't have the precise

breakdown with me, no.

Q My statement is correct then; is that correct?

A (Witness Youngling) No, I know where they are. I don't have the breakdown with me.

Q But my question is--

A (Witness Youngling) I'm sorry, Mr. Dynner.

Q The 81 hours were somewhere between 33 and 34 hundred. Is that right?

A (Witness Youngling) Yes.

Q Thank you.

MR. DYNNER: I think that clears it up for me. Thank you, Judge.

EXAMINATION BY THE BOARD

BY JUDGE MORRIS:

Q Dr. Rau, I have some questions. Mr. Ellis started you through Mr. Bridenbaugh's testimony, but he stopped before getting to question and answer 6. I will give you a minute to refresh your memory on what that answer was.

(Pause.)

Mr. Bridenbaugh states that:

"The results of the endurance test do not disclose anything about the endurance limits of 101 and 102 blocks for a number of reasons, one that the cast iron of 103 has a tensile

strength substantially higher than that of EDGs 101 and 102."

Would you comment on the validity of Mr. Bridenbaugh's reason there?

A (Witness Rau) I'm sorry, Judge Morris. You asked me to comment on the entire answer, or just that portion?

Q I'm going to try to take you through it a part at a time, starting with (i) on page 4.

A (Witness Rau) Okay.

I think I would generally agree with Mr. Bridenbaugh with regard to that particular subitem in the sense that although "anything" is a very strong word, I certainly would have concurred that the cast iron used for the replacement 103 block is of a different specification and is in fact of higher strength than that in 101 and 102. That's a true statement.

And to the extent that that therefore prevents direct applicability of any testing done on the replacement 103, I would concur with that subpoint.

Q The next subpoint which is (ii) has to do with the design changes between 103 and 101 and 102. Will you comment on that?

A (Witness Rau) Yes, Judge Morris.

As I think we have testified extensively

previously, it is my opinion that the design modifications or improvements that were incorporated in the replacement 103 block, one of which is made reference to in Mr. Bridenbaugh's testimony, would have the effect of reducing the stresses and increasing the margin. And to that extent I would expect the replacement 103 block top to be even more reliable than the 101 and the 102 are.

Q It is my understanding, and correct me if I'm wrong, that LILCO chose to run the endurance test on 103 so that they could monitor the cracks in the cam gallery which they felt was not a feasible thing to do on 101 and 102. Is that correct?

A (Witness Youngling) Yes, Judge, that was certainly one of the reasons that we chose the 103 engine, yes.

In addition, of course the major emphasis for the test was to approve the crankshaft. And we also wanted to put some hours on this new 103 block to give us reassurance of its reliability.

A (Witness Rau) Judge Morris, I would just add that it certainly was my recommendation to LILCO that in fact the replacement 103 block was much more appropriate for the cam gallery strain gage testing. And in fact, the 101 and 102 would have been very difficult to accomplish that task and I recommended the testing be done on the

replacement 103 block for that reason.

Q Was there any consideration that running an endurance test on either 101 or 102 might be damaging to those engines?

A (Witness Rau) Well, as I have indicated, Judge Morris, the reasons for selecting the replacement 103 were primarily with the cam gallery testing.

I think with regard to whether it would be damaging or not, I don't think that issue was even part of the consideration. It's my opinion that the testing with regard to the crankshaft wouldn't have mattered, whether they had done it on 101, 102 or 103.

I also am of the opinion that there wouldn't have been anything gained by -- with regard to the block top reliability by doing the 10 to the 7 testing on 101 or 102, the reason being that 101 and 102 already have ligament cracks and the endurance testing is a test with regard to crack initiation. And once you have cracks, obviously you cannot confirm -- you are not going to get cracks by doing the endurance test. And I really felt there would be nothing gained by subsequent testing on 101 or 102 even if in fact the cam gallery were not a dominant issue with regard to which block to utilize.

BY JUDGE BRENNER:

Q Dr. Rau, wouldn't there have been information

to have been gained as to the validity of your prediction of the extent of crack propagation of the 101 or 102 block to have tested them further from the point of last baseline measurement, or is that not the case?

A (Witness Rau) No, Judge Brenner, I don't think it is the case for the following reason:

There are no stud-to-stud cracks in the 101 or 102. The cumulative damage analysis of crack propagation in the stud-to-stud region is based upon -- conservatively based upon crack progression once you have a crack that reaches the depth of 1.5 inches.

Because neither 101 nor 102 had stud-to-stud cracks, additional testing would not serve to demonstrate anything with regard to the rates of subsequent crack propagation until such time as those cracks developed, if in fact they were ever to develop.

Q Is there a significant level of cycles of operation applicable to the blocks above which you would end up past a knee in the-- Let me back up.

Is there an S-N shaped curve applicable to the blocks that is expressed in stress levels and cycles which would be the same as the shape of the S-N curve that we have previously discussed with respect to the crankshaft?

A (Witness Rau) I don't know what you discussed with regard to the crankshaft, but we have in fact produced

in one of our prior exhibits -- I don't remember the number now -- but the actual S-N data measured for the original 103 cast iron material, and also representative S-N data for the A4864 gray cast iron with typical microstructure.

Those were the most appropriate S-N curves.

If your question means to ask if there is a certain number of cycles you can acquire on the block top which would give you some information about whether you're going to get stud-to-stud cracks initiated -- maybe I'm misinterpreting--

Q That's a good question.

A (Witness Rau) Surely there is information gained as you produce -- put cycles on the block top. Based on the knee to which we have actually measured and seen in the literature, I am not prepared to say that there is any magical number at 10 to the 7 or 3 x 10 to the 6 or 5 x 10 to the 6.

But certainly as you get more and more cycles on without initiation of the stud-to-stud cracks and you already have ligament cracks, you do gain some information with regard to the conservatism that was in our analyses of the block top once it contains ligament cracks.

And there is no question that the 101 and the 102 block tops have experienced a substantial amount of duty at a range of power levels much of which is up in the 3500 kw

regime, which are equivalent to hundreds of hours at 35 and even larger hundreds of hours at 3300 kw. And these, as you know, are equivalent to 5 x 10 to the 6.

They are less than the 740 that is required for 10 to the 7, but they are certainly well in excess of a million cycles which those two blocks, that is, 101 and 102, have experienced without initiating stud-to-stud cracks, but already having ligament cracks.

However, I don't think you can draw definitive conclusions from additional testing of 101 and 102 on this basis because there is another mechanism of potential crack initiation in the stud-to-stud region which we've testified about previously.

Although you do gain some information with regard to the high-cycle fatigue mode or potential mode of crack initiation, you don't gain -- unless you run a lot of starts and stops, you don't gain specific information with regard to the potential low-cycle fatigue load of initiation of stud-to-stud cracks.

And for that reason, even if you were to run 5 x 10 to the 6, which we have done already, or to run 10 to the 7 cycles on 101 or 102 and show there is no stud-to-stud cracks, you could not be convinced that you might not get a stud-to-stud crack initiated on subsequent cycling or testing of either of those engines.

For that reason we have conservatively relied upon the crack propagation to demonstrate the margin to meet its intended function during a LOOP/LOCA and although I believe that there is additional margin associated with crack initiation which might in fact preclude us ever initiating cracks in the stud-to-stud region, I don't rely upon that, nor do I rely upon the time it might take for a crack to grow from initiation up to a depth of 1.5 inches.

These are additional conservatisms which we don't take credit for, which would further expand the margin which has been demonstrated by the cumulative damage analysis of fatigue crack propagation.

Q I know -- Well, let me ask to make sure:

Your analysis from your point of view has conservatively assumed initiation of stud to stud cracks where a block already has ligament cracks, correct?

A (Witness Rau) That is correct. It also assumes, your Honor, that those cracks extended to a depth of an inch and a half.

Q Given the substantial number of hours already on the 101 and the 102 block, in your view why do you not believe you can point to that experience as a reasonable assurance, in your professional opinion, that in fact stud to stud cracks would not initiate in the 101 or the 102 blocks?

A (Witness Rau) I'm not sure, Judge Brenner, that I couldn't. I just haven't attempted to do so because it's not really necessary to do so, in my opinion, given the enormous margins already demonstrated.

I think I have indicated that I do believe that it is in fact an indication that our initiation analyses, given the presence of a stud to stud crack, are in fact conservative. But in fact it is not so many cycles, and also given the possibility of the thermal stresses and the low cycle fatigue initiation, I don't choose to rely upon that evidence as definitive evidence that we will never get stud to stud cracks initiated.

Q All right.

Changing subjects slightly -- and this might be you, Mr. Youngling, or perhaps you, Mr. Schuster, but anybody can answer:

I can't locate the page right now, but I believe in your testimony -- however by reference to another document -- you talk about matters relating to future surveillance or inspection of the blocks if operation is permitted. That is, after an operating license.

Could you tell me precisely what LILCO is committing to do in that regard? I believe you reference an FaAA report rather than spelling it out.

A (Witness Youngling) Yes, Judge. The major documents which will put in place the future testing on the block consist of the commitments made through the DRQR program and as implemented into the TDI owner's group -- the TDI operating manual, which defines the preventive maintenance program to be adopted by LILCO.

In addition, the Staff in their December SER on the Shoreham engines has identified additional block inspections that they are contemplating.

Now in detail, our commitment through the DRQR program is to perform an eddy current inspection of the block top between adjacent cylindars whenever the engine is operated at 50 percent load or greater. If an indication is

found, the indication would be evaluated and depths down to 1.5 inches would be acceptable whereas depths below that would not be acceptable.

In addition, as we discussed yesterday, we will be performing the cam gallery monitoring, as we have agreed to with the other parties.

Q Yes. I meant everything but the cam gallery. But thank you for mentioning that.

A (Witness Youngling) Now in the Staff SER the PNL consultants and the NRC Staff has asked us to supplement these inspections by visually inspecting daily during any operating period in the area on the block top to look for any adverse situations.

In addition they have asked us at each refueling outage to inspect the top surface of the block by removing two adjacent cylindar heads.

Those are the major thrusts of the inspections to be done in the future.

Q Are you telling me that LILCO is agreed -- has agreed to do those?

A (Witness Youngling) We have not made our full evaluation on the Staff SER recommendations, but we are strongly considering the item number one on the visual inspection. We have not finalized our thoughts on the inspection between two adjacent cylindar heads, although at

this time we don't find that to be unreasonable.

Let me add, Judge Brenner, LILCO does have confidence that the eddy current probe inspection, which is to be done between two adjacent cylindar heads, will provide us the same kind of information that this further NRC inspection would provide. And that is our major reason in not fully committing to it at this time.

Q Have you finished?

A (Witness Youngling) Just one other point:

The eddy current inspection, of course, has to be done between all cylindar heads whenever we run the engine at greater than 50 percent load, whereas the Staff recommendation would just be looking at two adjacent heads.

Q Does the eddy current inspection frequency, then, include at least monthly -- or let me state it differently: Would it be performed every time the one hour run would be performed?

A (Witness Youngling) Yes, it would, Judge. Since the engine would be operated at greater than 50 percent load during that one hour run, yes, the test would be performed, the inspection would be performed.

JUDGE BRENNER: That's all the questions I have.

What happened -- I should have stated it expressly -- Judge Morris is not finished with his questioning. He allowed me to ask some questions on a

subject he was in the middle of, so we are not going to be able to finish today in any event. And we might as well adjourn.

Give us one moment.

(The Board conferring.)

MR. ELLIS: Judge Brenner, is the Board considering finishing everybody today, because we would certainly be willing to do that.

JUDGE BRENNER: No, because it would not terminate the hearing in any event.

I might have been willing to go that far if we could have finished the entire hearing today, but I have no hope of being able to do that.

If Mr. Dynner's cross plan is still reasonably applicable -- that is, his cross plan of the Staff witnesses.

MR. DYNNER: Of course I'm going to have some follow up on the basis of the examination by Mr. Ellis.

JUDGE BRENNER: But am I right that you have -- Well, how much cross-examination would you have of the Staff witnesses?

MR. DYNNER: I think of the Staff witnesses my cross plan would still indicate that that would be a relatively short time.

I don't expect, in other words, to have to

examine the Staff witnesses on the block for more than an hour, and possibly less than an hour.

MR. ELLIS: I would have even less than that, far less.

JUDGE BRENNER: All right. I'm telling you what Mr. Dynner tells me is he still intends to pursue the written cross plan that I have; and I have my own estimate as to how long that will take. So now we're going to adjourn.

I did want to say one thing as a follow up to the last testimony regarding inspections:

I suppose it's understandable that LILCO may still be thinking about certain matters. But to the extent those matters may be pertinent to our findings on issues in controversy, the time has come because we're going to close the record next week.

MR. ELLIS: Yes, sir, we'll be prepared to give you a direct answer and a conclusive answer on those points next week.

JUDGE BRENNER: All right.

I think it might be helpful if we could get in writing -- no testimony, no explanation as to why it's a good idea or a bad idea, just in writing; I understand it's another document, but we're asking it to be pulled together -- precisely what the conditions for the inspection of the

blocks would be -- and not including the cam gallery; you've already given us that -- that LILCO would agree to, is agreeing to.

And then I suppose we would like to get, also in writing, those further recommendations of the Staff very precisely that LILCO is not agreeing to. And either the Staff can supply that part or LILCO can also supply that part, or both of you, both parties can put that together. And we just want to be able to identify it.

I know I said earlier that we wanted to see that in proposed findings -- and that's still true, and that was a general statement. But as to this particular situation we want to see what the present posture is as of next week. We're not requiring that you be definitive, but I'm just pointing out the obvious trade-offs.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: In addition, that, among other things, is obviously a possible subject in the negotiations among the parties.

All right. We will adjourn now. We wish all of you a pleasant weekend, and we will reconvene at one-thirty on Monday afternoon.

(Whereupon, at 12:00 noon, the hearing in the above-entitled matter was recessed, to reconvene at 1:30 p.m., Monday, 11 March 1985.)

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: FRIDAY, MARCH 8, 1985

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
(TYPED)
WILLIAM R. BLOOM
Official Reporter
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