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NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF:

LONG ISLAND LIGHTING COMPANY

(Shoreham Nuclear Power Station)

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the matter of: :

LONG ISLAND LIGHTING COMPANY : Docket No. 50-322-1 (OL)

(Shoreham Nuclear Power Station): :

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State Office Building,

Veterans Memorial Highway,

Hauppauge, New York.

Monday, October 29, 1984.

The hearing in the above-entitled matter was reconvened, pursuant to adjournment, at 10:35 a.m.

BEFORE:

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

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

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

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APPEARANCES:

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On behalf of the Intervenor, Suffolk County:

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On behalf of the Intervenor, New York State:

ADRIAN JOHNSON, Esq.,

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PROCEEDINGS

JUDGE BRENNER: Good morning.

Just a few minutes ago we received something which I at least have not read, entitled "LILCO's Motion to Admit Supplemental Testimony on Suffolk County Contention Regarding Cylinder Blocks."

I don't know, Mr. Farley, if you want to say something about it now, realizing that we have not read it, or defer any discussion of it until after the lunch break.

MR. FARLEY: Judge, I don't believe Mr. Dynner has read it, and I have an indication from Mr. Goddard that he would not be prepared to take a position, as I understand it, until approximately Thursday.

JUDGE BRENNER: Well, we'll be ready to discuss it later today.

MR. FARLEY: Yes, sir.

JUDGE BRENNER: And then if we hear a good reason why we should defer discussing it until tomorrow, we will listen to that reason by any party.

MR. FARLEY: Yes, sir.

MR. GODDARD: Judge Brenner, if I might comment on the statement made by Mr. Farley, what I was referring to is that the Staff would not have a technical position on the testimony itself. We are prepared to speak to the motion at any time.

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JUDGE BRENNER: All right. Thank you.

Mr. Dynner informed me before we went on the record when I saw him at the airport earlier this morning that he did have further cross-examination of this panel, and that he had so informed the other parties.

MR. FARLEY: He informed me, your Honor.

JUDGE BRENNER: You can proceed now, Mr. Dynner, and we'll give you up until a few minutes after twelve if you need it.

Whereupon,

ROGER LEE MC CARTHY,
HARRY FRANK WACHOB,
CHARLES A. RAU,
CLIFFORD H. WELLS,
EDWARD J. YOUNGLING,
CRAIG K. SEAMAN,
DUANE P. JOHNSON
and
MILFORD H. SCHUSTER

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

CROSS-EXAMINATION (Continued)

BY MR. DYNNER:

Q Good morning, gentlemen.

Last week in the morning I again requested

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and Dr. Rau agreed to provide for us information concerning the Exhibits B-49 and B-50, that is, the LILCO diesel exhibits concerning the approximate placement of the asterisks or stars if the Goodman diagrams on those two pages in those two exhibits had been placed with a load of 3,830 kilowatts for EDGs 101 and 102.

And that was specifically concerning the place at which stud-to-stud cracks might be expected to initiate in the presence of -- in a block in which ligament cracks were present.

Dr. Rau, can you now furnish that information?

A (Witness Rau) Yes, Mr. Dynner, except I think again you said that the numbers presented might be related to the condition where cracks might initiate, and I would just caution you again that these numbers, although they can be generated, indicate only the possibility of fatigue crack initiation.

But yes, I am prepared to give you the numbers that would be computed from the strain gage measurements at Position 13 when the power level was 3830.

Q Okay.

My request, just to reiterate, was where the star or the asterisk would be placed. So if you can kindly take those numbers, and you can give them to us but then try to guide us through where the star or asterisk would be

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positioned in that respect, that would be most helpful.

A Okay. With regard to Exhibit B-49, which is the Goodman diagram for low cycle fatigue, in the presence of a pre-existing ligament crack, the mean stress -- that is, the horizontal axis at 3830 -- would be located at 20.8 ksi.

The corresponding vertical axis position -- that is, the one labeled alternating stress -- again in the presence of a pre-existing ligament crack, would be 16.1 ksi.

So those are the coordinates of the star if there is a pre-existing ligament crack and you're looking for the stresses, a conservative upper-bound estimate, that is, of the stresses, at the stud-to-stud crack location, or possible crack location.

Q I think that we can easily plot that ourselves by moving the star to the correct place to show an alternating stress 16.1 ksi and a mean stress of 20.8 ksi on that chart.

I would like, if you could help us, to tell us what are the numbers for mean and alternating stress represented by the asterisk on B-49 as it now appears for stud-to-stud crack, if you know? I mean we can all sort of estimate but I wondered if you had the exact numbers.

A Yes, Mr. Dynner, I think I have the precise numbers if you want them.

I believe the mean stress -- that is, the

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horizontal axis as plotted for the stud-to-stud location with a pre-existing ligament crack -- is 18.0, or 18.1 -- excuse me -- ksi.

The corresponding alternating stress -- that is, the vertical axis at 3500 Kw -- is 13.4 ksi.

Q Thank you.

And can you now go through the similar exercise for Exhibit B-50 which shows the Goodman-Smith diagram for high-cycle fatigue?

A Yes.

Again, the conservative estimate at 3830 Kw for the horizontal axis -- that is, the mean stress axis of Exhibit B-50 -- is computed by the procedures we've talked about, that is, going from the strain gage measurements at position gage 13 at that power level, and going through the series of scale factors leads to 31.8 ksi for the mean.

And the vertical axis, labeled "alternating stress," would be conservatively estimated to be 5.1 ksi.

Q All right.

And those are the numbers for 3830 Kw. Is that right?

A That is correct.

Q Do you have the equivalent numbers for 3500 Kw?

A Mr. Dynner, again they are shown by the points. I have in my notes some numbers, and I'd be pleased to give

WRBeb

them to you.

Q Well, if you don't have them we can certainly get an estimate from looking at the diagram. But if you do have them as you did for B-49, it would be helpful if you could give us the precise numbers.

A My notes show the horizontal axis, that is, the mean stress axis of B-50 for 3500 Kw to be 26.8 ksi. Again that is in the stud-to-stud location when there is a pre-exisitng ligament crack adjacent to it.

The correspondiny vertical axis, that is, the one labeled "alternating stress," is 4.6 ksi.

Q Thank you, Dr. Rau.

I just have another couple of questions about these exhibits in the Block Report of June 1984.

FaAA was able to and in fact did take the Goodman-Smith diagrams which were Figures 3-13 and I believe 3-14 and on page 3-6 of the Block Report, you made a statement that, as I read it, in a block of minimum strength material which had ligament cracks, initiation of stud-to-stud cracks could occur in less than 100 load excursions from 0 to 90 percent power or above if the minimum material properties are assumed.

That statement is at the top of page 3-6.

Now looking for a moment at the equivalent Goodman-Smith diagram --

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MR. FARLEY: Objection. Compound--

JUDGE BRENNER: Let me talk.

Do you want to ask him if he agrees or disagrees with the first part of your proposition, whether the statement that you paraphrased stands for what you stated it stands for?

MR. DYNNER: Certainly. I'll start with that.

BY MR. DYNNER:

Q Do you agree with that parphrase and, in part, quotation from pages 3-5 and 3-6 of the FaAA Block Report?

A (Witness Rau) Well, Mr. Dynner, I don't recall all the words of your paraphrase but the specific words which are actually in the draft report of June, starting at the last sentence at the bottom of 3-5 and proceeding on over to the middle of the paragraph at the top of 3-6, I would not agree with the literal statements that it is predicted, the top two words at the top of 3-6. Maybe I should read it into the record.

"The implication...."

I'm starting at the bottom of 3-5.

"The implication is that the initiation of ligament cracks in minimum stress material is predicted and given the ligament crack initiation, the stud-to-stud cracks is also predicted."

It depends on how you interpret these words, but

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as I said on several occasions, I certainly do agree that the Goodman analyses as presented now did at that time, and still do, suggest that there is a possibility of ligament and also stud-to-stud crack initiation once there is a ligament crack.

However, I do not believe if in fact you interpret those words to mean that you will get crack initiation, I do not agree with that. I think the record probably stands for itself now. Certainly the analysis predicts the possibility of crack initiation in 100 cycles of low-cycle fatigue at 90 percent power, but it certainly does not predict that that will in fact be the case.

Q Yes. Let me try to clarify the question a bit, Dr. Rau.

If you focus for a moment on the first sentence, the first full sentence on the top of page 3-6 of the Block Report, I would read to you that part of the sentence I am asking my question about. It says:

"Initiation could occur in less than 100 load excursions from 0 to 90 percent power or above."

Do you see that part of the sentence?

A Yes.

Q Now isn't it correct that that statement was being made with respect to Figure 3-13 which was your

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original Goodman-Smith diagram for a block of minimum material properties? Isn't that right?

A I think that's basically right. I mean there are other things beside that one figure, but certainly that figure is one of the pieces of information that was utilized to reach that preliminary statement that you've read.

Q Well, isn't that statement-- If you look at the beginning of the paragraph on page 3-5, can you tell me -- because that states that it is talking about Figure 3-13, is there anything else significant beside 3-13 that that statement -- Figure 3-13 -- that the statement that I have quoted refers to?

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A Well, I think the results which would be referenced in making that statement are summarized on 3-13. There were many other things done to generate that but certainly they summarize it.

Q I understand. Thank you.

Now, my question is, isn't it true that LILCO's diesel Exhibit B-49 represents the current Goodman-Smith diagram for low cycle fatigue at 100 percent load for Shoreham Engines EDGs 101 and 102? Is that right?

I have just read you the title; is that the correct title?

A Yes.

Q All right.

Now, is it also true that looking at your Exhibit B-49, that you can make the statement that initiation of stud-to-stud cracks where ligament cracks are present could occur in less than 100 load excursions from zero to 90 percent power or above?

A No, that's not exactly true, Mr. Dynner. Utilizing Exhibit B-49 which is drawn for 100 percent load, you could make the statement that based upon those points the possibility exists for initiation of fatigue cracks in low cycle fatigue. Your portion of the question dealing with me the possibility of initiation at 90 percent cannot be ascertained from the figure directly but I indicated it

WRBpp

was my opinion that that would be the case if you were to generate points from the same analysis for 90 percent load.

Q Okay.

Now, Dr. Rau, looking at Exhibit B-49, can you give us the equivalent information that you did for figure 3-13 in terms of the number of load excursions from zero to 100 percent of power at which initiation could occur based upon this Goodman diagram?

A I think you're misunderstanding how the diagram is used, Mr. Dynner.

From neither the Goodman diagram in the draft report nor from Exhibit B-49 can you infer the number of load excursions. The diagrams are constructed for 100 start or load excursions and indicate only the possiblity that you could get fatigue initiation in the hundred starts to that magnitude.

Q I see. So that Exhibit B-49 does show the Goodman-Smith diagram situation based upon 100 starts or 100 load excursions as you stated in the Block report from zero to 100 percent of power; is that right?

A That is correct. B-49 does that.

Q And if you'll turn for a moment to Exhibit B-50, which is the Goodman-Smith diagram for high cycle fatigue at 100 percent of load for EDGs 101 and 102, is it also true that Exhibit B-50 is based upon operation at 3500 kilowatts

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for about 100 hours?

A No, that's not correct, Mr. Dynner. Exhibit B-50 deals with high frequency fatigue and it deals with the possibility of crack initiation with a very large number of load cycles, in excess of a million load cycles. Under conditions of engine running, normal engine running at 3500 kw, to generate that number of cycles takes in excess of 750 hours of operation, not 100.

Q Dr. Rau, do me a favor and check that answer again. Because if you look at page 3-6 of the Block report you'll see that you appear to be giving information concerning high frequency or high cycle fatigue at 10 to the sixth cycles and in the third line after it says 10 to the sixth cycles you have in parentheses (about 100 hours). And then I note that in the title of LILCO's Diesel Exhibit B-50 after the words "High Cycle Fatigue" it again says with a V on its side (10 to the sixth cycles).

Could you explain what those 10 to the sixth cycles mean and how they differ in those two places, if they do?

MR. FARLEY: Objection to the form of the question. Compound and complex.

JUDGE BRENNER: Objection overruled.

As long as there has been an interruption, the V on its side is the symbol for "greater than."

WRBpp

MR. DYNNER: Thank you.

WITNESS RAU: I misspoke, Mr. Dynner. It is in fact 10 to the sixth, that is ten million -- excuse me; one million cycles as opposed to ten million, and that does occur in somewhat less than 100 hours.

MR. DYNNER: Thank you, Dr. Rau.

BY MR. DYNNER:

Q Dr. Johnson, could you quantify for us how accurate the measurement of the depth of cracks in the EDG blocks is when made by eddy current examination? And when I say "quantify," what I'm getting at is, is the error or envelope plus or minus 5 percent or plus or minus 25 percent or some other figure?

A (Witness Johnson) The answer to that question depends on which block we're dealing with and which material we're dealing with.

Q I'm sorry. I'll interrupt to make my question more specifice.

I am dealing now with EDGs 101 and 102.

A EDGs 101 and 102 and the accuracy of the eddy current measurements I believe would be the order of 0.05, plus or minus 0.05 inches approximately.

Q Can you-- Is it possible to translate that into a percentage of variance whether the accuracy is plus or minus five percent or ten percent or 30 percent?

WRBpp

A No. It depends on the length of the defect or the type of the defect you're attempting to measure.

Q So that is 5/100ths, is that right, of an inch?

A Yes.

Q Now is that your figure whether we're talking about a crack depth that has been measured at a tenth of an inch or at two inches; is it still your testimony that the approximate variance in accuracy would only be 5/100ths of an inch?

A The deepest indication measured on 101 and 102, I believe, was 1.5 inches. And I believe that that accuracy represents -- it corresponds to 1.5 inches as well as to one inch.

Q Or one-tenth of an inch?

A Yes, I believe so.

Q Now can you characterize, Dr. Johnson, in the same way either by a maximum variation or by a percentage plus or minus, how accurate measurement of the depth of a crack might be when made by liquid penetrant. And I realize we're talking here about a crack that would be measured by looking at the inner wall of the counterbore rather than on the inside of the stud holes or in a stud-to-stud crack?

I have asked the question of Dr. Johnson, Mr. Schuster, because he has been put forward as the expert in this matter. So if you have something to add please feel

WRBpp

free to do so after Dr. Johnson answers.

A I believe that the penetrant measurements and specifically on the block top and down the ladder landing area would be accurate to the order of a tenth of an inch with penetrant measurements.

Q Can you tell me how accurate the measurement of a depth of a crack would be made if done with a TSI depth probe?

A With TSI depth probe, we're still referring to the block top measurement?

Q Yes.

A I don't believe we made any such measurements.

Q Are you familiar with that instrument?

A Yes, I am familiar with the instrument.

Q My question is how accurate would a depth -- a crack depth measurement be made using that instrument? Is it plus or minus five percent, plus or minus 20 percent; do you have any knowledge of that?

A Once again, we did not make such measurements on the block top and I really didn't spend time attempting to evaluate how accurately it was.

I believe that it may be accurate to plus or minus 20 percent or so in that case.

JUDGE BRENNER: Dr. Johnson, what is a TSI depth probe?

WRBpp

WITNESS JOHNSON: It's a device, a current injection device where you inject a current across the crack on each side of the crack and monitor the, basically, the resistance. It's an electromagnetic method of determining or estimating the depth of cracks.

BY MR. DYNNER:

Q Would the measurement by a TSI depth probe be -- would the accuracy of that measurement be affected by whether or not the cast iron material had existing Widmanstaetten graphite material in it?

A (Witness Johnson) It could be affected. You need to use a standard for that measurement which is of a similar material to the material which you are testing. And we have not done direct comparisons between the -- on the block top.

Q Were you able to measure the depth of the cam gallery cracks in EDG -- in any of the EDGs by using ultrasonic methods?

A Some measurements were made using ultrasonic tests but we were not able to confirm the presence of cracks. They were not used to measure the depth of cracks.

Q Why not?

A In certain circumstances it was limited by geometry and in other circumstances it was limited by the depth of penetration of the ultrasonic signal.

WRBpp

Q What do you mean by limited by geometry?

A In one case the threads were present which produce -- stud hole threads are present -- which produce reflectors which make it very difficult to interpret the ultrasonic signal.

Q Would ultrasonic measurement, in your judgment, be --

A Excuse me. Are we talking about cam gallery or in general?

Q The cam gallery area.

A Excuse me. I was not speaking of the cam gallery. I was speaking of the studs.

No. Possibly Mil could speak to the ultrasonic tests, if any, that were done on the cam gallery area. My comments were to ultrasonic tests that were done on the block top area.

Q All right. Let me repeat my question for you then.

In the cam gallery area would -- I shouldn't repeat the question. I'm going to give you another one.

In the cam gallery area, would the ultrasonic measurement of crack depth, in your judgment, be a more accurate way of measuring the depth than by a TSI depth probe?

A The geometry of the cam gallery precludes the use

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of ultrasonic methods to measure the depth of the cracks.

Q Can you explain what you mean by that, by the geometry of the area making it impossible to use ultrasonics?

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A I would like Mil to expand on the answer but you simply cannot get appropriate beam -- placement of the probe and beam direction so that you can get to the tip of the crack and thus make a measurement of it.

Q You cannot do that because of the configuration of the block itself, is that what you mean?

A Yes.

Q All right.

A (Witness Schuster) There are several things that I could add to that and one is the curvature of the fillet area, that's one part of the geometry that is a problem. Also, we looked at doing ultrasonics internally and there are -- there is a web on internally that reinforces the back section which does not allow you to send an ultrasonic beam through to provide an accurate description of what the crack depth is.

The thicknesses also vary at that point, they vary from an inch and a quarter to some value thicker than that and this thicker section is the web section that goes back into the cylinder block.

Also the matreial itself, the cast iron, does not lend itself to that accurate a measurement in that area because of the signal noise that you see on the screen.

Q Would it have been possible, Dr. Johnson, to have measured the depth of the cracks in the cam gallery area by

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X-ray techniques?

A (Witness Johnson) No, I do not believe it would be possible.

Q Why not?

A X-ray techniques are not an appropriate technique for measuring the depth of cracks. It will detect the presence of cracks if they are sufficiently open but the method does not permit you to measure the depth of a crack.

A (Witness Schuster) Again the geometry would not allow for appropriate film placement to give you a good overview of that area, and something that would be representative of the crack depth in that area.

Q Dr. Wachob, have you had an opportunity to review the supplemental testimony of the County's witnesses concerning cam gallery cracks?

A (Witness Wachob) Yes, I have.

Q Would you agree, Dr. Wachob, that crack indications have been found in the cam gallery bearing saddles areas numbers 2 and 8 of the replacement block for EDG 103?

A There have been indications found in the --

Q Will you answer the question yes or no and then you can give your recommendation?

A No, I don't believe that there are cracks of any ignificance or --

WRBagb

Q That's not the question, the question is is it true that crack indications have been found in the cam gallery areas of saddles 2 and 8 of the replacement block for EDG 103, yes or no?

MR. FARLEY: Object to the form of the question, asked and answered.

JUDGE BRENNER: The objection is overruled and it wasn't answered.

WITNESS WACHOB: The answer to the question is not a simple yes or no.

BY MR. DYNNER:

Q Let me put it to you another way:

Mr. Youngling, will you look for a moment at the County's Diesel Exhibit S-7, which is bound in with the County's supplemental testimony?

Do you have that, Mr. Youngling?

A (Witness Youngling) Yes, I do.

Q Now the first page of Exhibit S-7 is a LILCO deficiency report, LDR No. 2507, signed and dated, isn't that correct?

A The deficiency report --

Q Isn't that correct, yes or no?

A The deficiency report has been signed and dated, however it is not a completely dispositioned deficiency report.

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MR. DYNNER: I didn't ask that question. I am identifying the document and I am entitled to a yes or no answer I believe, Judge Brenner.

JUDGE BRENNER: I think he is entitled to explain what it is, Mr. Dynner.

Why don't you finish the explanation, Mr. Youngling?

WITNESS YOUNGLING: The deficiency report merely states the problem description, acknowledges the description by the quality assurance personnel and assigns the responsibility for disposition to Stone and Webster Engineering by the block number 7.

BY MR. DYNNER:

Q Now can you answer my question?

A (Witness Youngling) I believe I have.

Q No, you haven't.

My question was isn't it true that the first page of County's Exhibit S-7 is a LILCO deficiency report bearing an LDR number 2507 and signed and dated?

A Yes, Mr. Dynner, it is a LILCO deficiency report No. 2507 and it has been signed and dated as I have previously testified.

Q And looking through the balance of Exhibit S-7, which includes a magnetic particle examination report dated October 1, 1984 and a liquid penetrant examination report

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starting on page six dated October 1, 1984 and another magnetic particle examination report on page nine dated September 30th and another liquid penetrant examination report dated September 30 starting on page 12, are those documents true and correct LILCO examination reports for examination of the cam gallery areas of the replacement block on EDG 103?

A Yes, they are.

Q And do they relate to the cam gallery saddle areas Nos. 2 and 8?

A Yes, they do.

Q Has LILCO or any of its consultants or agents conducted any examinations of other cam gallery areas of the replacement block for EDG 103 by non-destructive examination?

A Yes, Mr. Dynner, LILCO has performed inspections of the entire cam gallery area as part of the inspections of the block at the factory, and I will ask Mr. Schuster to explain in detail those inspections.

Q Well before -- Let me try to clarify my question for you because I don't want to mislead you.

My question really is has LILCO, since September 30, 1984, conducted a non-destructive examination of any other cam gallery saddle areas besides Nos. 2 and 8 to look for indications since September 30th?

WRBagb

A No, we have not.

Q Do you intend to conduct such an examination in the future; that is to say, do you have any plans to do so before that engine goes into operation?

A At the conclusion of the 740-hour run, we will go into the cam gallery area at the No. 2 and 8 bearing saddles and reperform the examinations that we performed prior to the start of the run.

Q Can you now answer my question?

A That is the extent of the examination that we plan to perform and we feel that is an adequate examination.

JUDGE BRENNER: Mr. Youngling, you may think you are answering his question but he is entitled to get the answer in his terms.

Ask the question again and you're going to have to pick up the pace, Mr. Dynner.

MR. DYNNER: I'm trying, Judge Brenner.

JUDGE BRENNER: Let me finish.

You can focus a little more sharply on where you're going, as I have observed the progression and I made my statement to Mr. Youngling so now together you and the witnesses should make better progress.

MR. DYNNER: Thank you.

BY MR. DYNNER:

Q Mr. Youngling, my question was does LILCO plan to

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conduct any non-destructive examinations in the future of any of the cam gallery saddle areas of EDG 103's replacement block other than the saddle areas Nos. 2 and 8?

MR. DYNNER: Ongoing now, so the record can show, it has been a lengthy conference between Mr. Seaman and Mr. Youngling.

BY MR. DYNNER:

Q I hope you are now prepared to answer.

A (Witness Youngling) Yes, Mr. Dynner.

In the future, as part of the inspections required under the preventive maintenance program, we will go into the cam gallery area to inspect for wear of various components in there, in particular the camshaft. At that time we will be looking for general concerns in that area in a visual manner. However, there will be no further non-destructive examinations.

As we have testified here, these indications that we are seeing in 2 and 8 are surface indications and we feel confident that there are no problems in that area and --

MR. DYNNER: I move to strike this portion of the answer. There is no such testimony --

JUDGE BRENNER: I was going to ask where is such testimony.

MR. DYNNER: In fact there is testimony by Mr. Youngling on page 75 that says:

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"The replacement EDG 103 block, which obviously has no cracks, will undergo sufficient pre-operational testing to insure that its performance is satisfactory for providing emergency standby power."

JUDGE BRENNER: All right. We have stopped him right there. You used up more of your time by repeating their testimony.

Go ahead.

BY MR. DYNNER:

Q When would you look for these other -- this inspection, not the non-destructive examination, when would that take place, Mr. Youngling?

A (Witness Youngling) That would be done at the specified interval in the preventive maintenance program. I don't know what that interval is. I could look it up.

Q That's after the engine though has gone into operation at the plant?

A Yes.

Q Thank you.

Dr. Wachob and Dr. Rau, as I believe you two gentlemen worked on this, can you tell us which portions of the block for EDG 102 were examined for the presence of Widmanstaetten graphite?

A (Witness Wachob) As was discussed before,

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samples for observation of the presence or non-presence of Widmanstaetten graphite were taken from the No. 4 and the No. 5 block top positions at the exhaust manifold support base. We have taken a small sample from the crotch of the block top between cylinders No. 4 and 5 and we have replicated a portion of the block top adjacent to the cylinder No. 1 position.

Q Now to help me and the Board better understand what the location of these areas is, can you tell me whether you can point these areas out by referring to the, as an example, the drawing of the block top or the representative drawing of the block top as Exhibit B-16? That is LILCO's Diesel Exhibit B-16.

JUDGE BRENNER: Except you are asking about 102, but it doesn't matter.

MR. DYNNER: Yes, it doesn't matter, they are the exact same drawings.

BY MR. DYNNER:

Q Now first of all, Dr. Wachob, the first item you mentioned, No. 4 and No. 5 area -- between No. 4 and No. 5 areas of the exhaust manifold support, do they show on this drawing?

A (Witness Wachob) Their position is not shown in the drawing, however, they are physical extensions of the block top at the 4 and 5 cylinder positions, and it would be

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basically at the 12:00 position for the cylinders.

A (Witness Rau) If I might add to that just for clarity, I think if you refer to B-8 you have an enlarged view, plan view looking down on the top of the block top. And although both Exhibit B-17 and B-8 are schematic in that they are not accurately reflecting all of the detail of the block top, you see on the intake side that the block top is not round as you come off to the bottom of the figure B-8.

Similarly on the exhaust side at the top, although it is not shown explicitly, the block top is not exactly round at that location. It comes out and forms a corner which is not 90-degree but a corner nevertheless and it is a fact from the protrusion of the corner, which is an extension beyond the top, the 12:00 position on B-8, that this corner is drilled out for the metallurgical and metallographic examination.

Q Thank you, Dr. Rau.

And when you drilled out that corner, you took a specimen approximately how large?

A (Witness Wachob) The corner that was removed was approximately pyramidal in shape on the order of a half to three-quarters of an inch in height and with leg size or leg length of about an inch.

Q Thank you.

Now what about the -- Can you identify for us

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on either Exhibit B-8 or B-16 the crotch of the block top between Nos. 4 and 5 that you referred to earlier?

A If we stay again with Exhibit B-8 and with the cylinder in the center, being cylinder No. 5 in that drawing, and then the one to the right, being cylinder No. 4, if you go to the exhaust side, you will see that there is a line vertically indicated as the center line and where the geometry of one cylinder blends in and turns around and becomes the next cylinder, that is what I would call the crotch area of the block top.

Q And was material drilled out from that area also, We're talking now about EDG 102, in your quest for examination for Widmanstaetten graphite?

A LILCO removed specimens from the crotch of that cylinder position. I believe that they were drilled out.

Q Can anyone from LILCO tell us if you know or if anyone on the panel knows the size of the area, if it was drilled out, that was taken?

A The size of the piece that was removed was something on the order of a quarter of an inch cube, three-eighths of an inch cube, something on that order.

Q And was it taken, looking again at Exhibit B-8, was it taken from the edge of the crotch rather than in toward the two stud holes, if you know?

A (Witness Rau) Well Mr. Dynner, it certainly was

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not taken on the block top inboard of the edge, so it was at the intersection of the block top and where it starts to come down and become the side, the outside of the block. So it certainly is on the perimeter of the intersection of the block top and the outside of the block.

Q Now, thirdly, gentlemen, can you tell me what you meant when you said you replicated a portion adjacent to Cylinder No. 1?

First, can you show us what portion adjacent to Cylinder No. 1 that you're talking about?

A (Witness Wachob) If we go to B-17 and look at the first cylinder, the bolt hole that is at approximately the four o'clock position, the replication procedure was performed on that area near that bolt hole. What it involved was successive grinding at finer and finer grits with a metallurgical polish of the block top. Then replicas were taken of the polished microstructure.

A (Witness Rau) If I could just add one clarification.

I don't think we have explained what these replicas are, and people might get confused.

Q That was my next question, so you have again anticipated me.

Go ahead, please.

A As Dr. Wachob has indicated, we go through

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successive polishing operations. He said "grinding." It's a rather fine grind, but not taking off very much material. But we go through progressive grits of sand until we get basically a mirror polish on the surface. And then the replica is-- It's basically a plastic which is moistened, placed down, and then after it drys peeled off. It's a special kind of plastic which is designed to very accurately replicate, or reproduce all the surface features.

Q How large, approximately, was the area that was polished and replicated?

A The replicas themselves are between a half and an inch square. They are not exactly square. But they vary in size somewhat depending on the precise size of the tape.

Perhaps Dr. Wachob can say more precisely how large an area was polished before the replicas were taken.

A (Witness Wachob) The area polished was approximately two to three times that size of the replica. The replica was taken in the center portion of the polished area.

Q Was there more than one replica taken of the polished area, on the area adjacent to Cylinder No. 1?

A Good metallurgical practice requires that you pull more than one replica from that area, yes.

Q How many were taken?

A (Witness Rau) I can't give you a precise number.

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But I recall looking at twenty-five or thirty for perhaps three separate engines. So, of the order of ten per region. On one engine it would have been of the order of ten.

Q Is the area from which the replica was taken, Dr. Wachob -- looking at the stud in the four o'clock position on Cylinder No. 1, was it on the block top, the top of the block itself, or on the side, or can you more precisely show us where that area is located1?

A (Witness Wachob) The region polished was on the block top, and was within several inches of that stud hole.

Q So was it outboard of the stud hole, going toward the front of the block?

A It was outboard of the stud hole.

Q Now, can you tell me what you did with the-- We now have the three areas and -- if I can use the word "samples," or the replicas you've taken. What specifically did you do to examine each of these for Widmanstaetten graphite? Take them, please, one at a time, and briefly describe what you did.

A Sections of the corner, sections taken off of the exhaust manifold support base positions, were mounted and then metallographically polished. Several polishing procedures were used for, one, just standard gray cast iron procedures but then we varied that procedure to include many

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etch-polishing duplications such that we would etch, polish, etch, polish.

We would then also perform a polishing technique whereby you would not etch between successive polishing steps. We have done this in three or four different manners to assure that the microstructure that we were observing had nothing to do with artifacts produced during the polishing stage, that we were indeed looking at the true microstructure of the cast iron block.

A (Witness Rau) If I might just amplify a tad on this, the normal procedures for metallographically polishing cast iron are more complex than those which are required for steel and many other materials, and that results from the brittleness, if you like, of the graphite and the difficulty or the desire, both as a matter of fact, to keep that graphite in the surface as you're polishing for your subsequent microscope examination.

So there are various procedures utilized but what Dr. Wachob is talking about with the polish, etch, polish, etch is one of the methods used to keep the graphite from falling out when it is lined up parallel to the surface you are attempting to polish.

Basically we utilized numerous variations on the standard polishing procedures and demonstrated that the results, when we examined them in the microscope -- that is,

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the optical microscope and the scanning electron microscope -- were consistent and reproduceable independent of the particular detailed metallographic procedures utilized. And that was in fact the result.

We basically prepared them by numerous procedures and numerous sections, examined them in the microscope, photographed them, and compared the results.

Q Now did you do precisely the same thing from precisely the same areas of the EDG 101 block as you have just described that you did in looking for Widmanstaetten graphite in the EDG 102 block?

A (Witness Wachob) Yes, sir.

Q Did you-- Am I correct then that you did not use this methodology in looking for Widmanstaetten graphite in the cam gallery areas of those two blocks? That is, EDGs 101 and 102?

A (Witness Rau) We basically did use the same procedures to examine the cam gallery regions but we did not repeat all the variations on the etching and polishing. Once we had verified that the results were not dependent upon the details of the etch-polish procedure, we then standardized on a single one and used that one to examine other regions as well as the block top and including the cam gallery.

A (Witness Wachob) I would like to clarify that a

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a bit in that the 101 and 102 cam gallery areas were not polished metallographically. The sectioning that Dr. Rau was talking about and the variations on looking at things was done only on the original 103 block.

Q Well, am I correct, Dr. Wachob, that if you didn't polish areas of the cam gallery region on EDGs 101 and 102 that you would not be able to examine them under the microscope for the presence of Widmanstaetten graphite?

A Not having polished the cam gallery areas in 101 and 102, we cannot at this point in time say that we looked at that microstructure. However, in looking at the microstructure that was in the original 103 block, there was no significant difference between the cam gallery areas and the block top regions, the block top regions that were sectioned, the block top regions that were sampled in agreement with 101 and 102 positions.

So we feel very confident that the sectioning that we've done in the examination of the microstructure that was performed on 103 justifies our not having to go back and look at the replicas of areas that would be polished in 101 and 102.

Q And just to make sure that I understand, with respect to the block top only and the three areas that you either sampled or replicated and that you did on 101 and 102, did you do the same tning on the original 103 block?

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A Four areas were sampled in each of the blocks. 101, 102 and 103 had four identical regions. Those were the exhaust manifold support basis, the crotch, and the replica that was taken of the block top. So that in all three blocks we have identical regions to make direct microstructural comparisons with.

Q And did you do the same thing with the replacement block for EDG 103 as you did for EDGs 101 and 102 in looking for Widmanstaetten graphite?

A With respect to the original -- I mean the replacement 103, we have gone back and removed one corner from the exhaust manifold. In addition, we had a three-inch diameter cast bar that was associated with the original block casting and metallographic preparation of areas within that smaller chunk of casting have been performed.

Q With respect to this one corner of the exhaust manifold of the replacement 103 block, did you take any photomicrographs of the section of that that you had examined?

A Several photomicrographs were taken of the section removed from the exhaust manifold support base block top area.

Q What did your examination of the area from the one corner of the exhaust manifold of EDGs replacement block show with regard to the presence or absence of

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Widmanstaetten graphite?

A The metallurgical microstructure of the replacement block is that of a typical gray cast iron. There is no evidence of Widmanstaetten graphite or other abnormalities associated with that block.

Q Has the replacement block for EDG 103, since it left the Delaval plant and was installed at Shoreham, been examined by non-destructive means for ligament cracks in the block top?

Anyone?

A (Witness Schuster) The original 103?

Q The replacement block.

A The replacement block has not been examined at Shoreham. The base line inspection was done at TDI prior to shipment.

MR. DYNNER: No further questions at this time, Judge Brenner.

JUDGE BRENNER: Staff? Could you give me an estimate of how much you have, Mr. Goddard?

MR. GODDARD: Probably one to two hours, Judge Brenner.

JUDGE BRENNER: Mr. Farley, are you prepared to give us an estimate?

MR. FARLEY: Yes, sir. I would say approximately a half a day.

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JUDGE BRENNER: The Board has questions also.

All right, Mr. Goddard, why don't you begin, and pick a convenient time to stop at around noon.

MR. GODDARD: Since it is ten to 12:00, this may be a convenient time to break if you have no objection.

JUDGE BRENNER: All right.

Let me raise one or two matters unrelated to the direct examination so the parties can consider them.

Number one, a minor housekeeping matter, the transcript of October 22nd. LILCO had its errata to the direct testimony of these witnesses and the exhibits of these witnesses bound in, and attached certain of the changes to the errata. One of the attachments was supposedly the new replacement Exhibit B-44 which is the linear regression fit for the original 103 block based on the various specimens plotted.

Our quick comparison leads us to believe that what is in fact bound in is not the replacement but the old diagram. And of course Counsel had explained the replacement at the time we admitted it into evidence, that some of the blocks were not fully darkened in, and so on.

In any event we are going to rely on the official exhibit file for that exhibit, but we would like a word one way or the other when it is convenient from LILCO's Counsel as to whether our observation is correct or not.

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Last week also the parties provided us with the final signed resolution of Suffolk County Diesel Generator Contention Regarding Cylinder Heads. We can take that up whenever it is convenient to the parties, but I have one question that I would like the parties to consider and give us an answer to at a time prior to actually taking up the whole agreement, so that we then have time to consider the answer.

There is a footnote, the only footnote in the agreement, at page 5 regarding the loads at which the diesel engine would be run. I would like to get an understanding of what the significance is of that footnote from the point of view of the parties' posture in the context of are there cylinder heads or anything beyond that. And we can take that up whenever it is convenient, the sooner the better.

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MR. FARLEY: I have had nothing to do with the cylinder heads.

JUDGE BRENNER: I understand. I don't expect an immediate answer. That's why I'm giving you this question in advance so you can get the footnote experts in.

Let me ask one question to check what was said on the transcript at some point also and then we'll break for lunch.

Dr. Wells, do you have a copy of the transcript of October 22 handy?

WITNESS WELLS: I don't have one with me.

JUDGE BRENNER: Can somebody lend him one?

When you get it, I'm going to ask you to turn to page 24,459, particularly line 4. In the beginning of that answer you were responding and you said, "Mr. Dynner, if the crack progressed below" and the transcript says, "23 1/2 inches on the liner side" --

WITNESS WELLS: Yes, sir.

JUDGE BRENNER: I recall that as you were giving the testimony -- what happened was you started giving a dimension, you stopped yourself in the middle then gave another dimension. And I want to make sure that my recollection of what you stated is correct. Can you help me out?

WITNESS WELLS: Yes. The intended dimension was

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2 1/2 inches.

JUDGE BRENNER: In any event, that would be your testimony at this time, 2 1/2 inches?

WITNESS WELLS: Yes, sir, that's correct.

JUDGE BRENNER: Do you want to follow this up now, Mr. Dynner?

MR. DYNNER: No, I have a separate matter.

JUDGE BRENNER: I'm done. Thank you, Dr. Wells.

MR. DYNNER: I wanted to bring to the Board's attention the fact that the County again in the light of the cross examination on the block portion of the case, has deleted some portions of its direct testimony on the block that is the original direct testimony. I notified Mssrs. Farley and Goddard that we would be making these deletions last Friday and gave both of them a general statement of the nature of the deletions. They are nowhere near as extensive, of course, as the deletions that were made in the piston testimony. But we are prepared to distribute the revised -- the portions showing the deletions of that testimony. If the Board would like we can do that at this point so that everyone can have it and have some time to look at it.

JUDGE BRENNER: All right. Why don't you do that as soon as we break?

If there is nothing further we can recess now and

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return after the lunch break at 1:30.

(Whereupon, at 12:00 p.m., the hearing was recessed for lunch, to reconvene again at 1:30 p.m., this same day.)

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AFTERNOON SESSION

(1:35 p.m.)

JUDGE BRENNER: Good afternoon. We're back on the record.

Whereupon,

ROGER LEE MC CARTHY
HARRY FRANK WACHOB
CHARLES A. RAU
CLIFFORD H. WELLS
EDWARD J. YOUNGLING
CRAIG K. SEAMAN
DUANE P. JOHNSON
and
MILFORD H. SCHUSTER

were called as witnesses and, having been previously duly sworn, were examined and testified on their oath as follows:

JUDGE BRENNER: Is this a convenient time to discuss LILCO's motion to admit supplemental testimony?

Let me ask Mr. Goddard. Is that acceptable to you?

MR. GODDARD: Yes, it is .

JUDGE BRENNER: Mr. Dynner? We could come back to it later if you like.

MR. DYNNER: I would rather come back to it after I've had some more time.

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JUDGE BRENNER: I'd like to do it today if you think you could after the next break?

MR. DYNNER: Yes, sir.

JUDGE BRENNER: Mr. Goddard, why don't we pick up your cross examination of this Panel?

MR. GODDARD: Thank you, Judge Brenner.

CROSS EXAMINATION

BY MR. GODDARD:

Q Dr. Rau or Dr. Wachob, could you give me the basis for your conclusion at page 5 of the supplemental testimony that the cracked section from cam gallery number 7 was covered with an oxide?

A (Witness Wachob) The evidence that we have observed associated with the cam gallery cracks are that, one, the metallography that has been done on cam saddle positions in number 7 and in number 6, when they are done and when they are polished metallographically in cross section, one sees oxide which funnels the shrinkage crack from the outside portion of the -- or the bottom of the -- the root of the weld from there down to the tip of the shrinkage crack. This oxide is relatively uniform throughout its length and that's one piece of evidence.

The second piece of evidence is fractographically, when you look at the fracture surface of a piece of the cam gallery number 7 which was broken open,

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the surface has an appearance typical of that of an oxidized surface.

The third fact is once the County's supplemental testimony was given to us, additional testing was performed to measure whether or not there was an oxide on the surface of the fracture surface and, indeed, the microprobe analysis did reveal an oxide.

MR. DYNNER: Objection. I move to strike the last part of his answer. The County -- none of that so-called evidence has been made available to the Board or any of the parties and I think -- I mean we have seen this time and time again. We started out with an FaAA Block report that was presumably the basis for their testimony. Now we're talking about additional tests that we haven't seen. The record is replete with the fact that we are having to shoot at a moving target and it's a moving target that we often are not in a position to be able to even take aim at, let alone find mark on. We don't know anything about additional tests, sir.

JUDGE BRENNER: Mr. Farley?

MR. FARLEY: Judge Brenner, I believe the answer is entirely appropriate for these reasons: First, no schedule was prescribed for response by LILCO to the supplemental testimony filed by the County. To say that the Board and the parties have not been provided with that

WRBpp

supplemental testimony I think is, to say the least, a misnomer.

Thirdly --

JUDGE BRENNER: Wait. I don't understand your second point.

MR. FARLEY: I thought Mr. Dynner represented that we had not been provided -- that the Board had not been provided with that supplemental testimony.

JUDGE BRENNER: You said it was a misnomer. I don't understand why you say that.

MR. FARLEY: Because we have been provided with it. Maybe misnomer is the wrong word.

JUDGE BRENNER: Where have you provided evidence that testing done subsequent to the receipt of Suffolk County Supplemental testimony to show that, in fact, there was an oxide present?

MR. FARLEY: No, I have not done that but that is in the County's Supplemental testimony, and this Panel should be given an opportunity to respond to it.

JUDGE BRENNER: On cross examination for the first time?

MR. FARLEY: Yes, sir. Mr. Dynner can redirect.

JUDGE BRENNER: All right. I cut you off. You had some other points.

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MR. FARLEY: The third point was that during the cross examination of the LILCO Panel by the County, there were several instances where inquiries were made about the County's Supplemental testimony and responses were given by the witnesses. So at least Mr. Dynner recognized even this morning that it was appropriate to cross examine in those areas.

JUDGE BRENNER: Mr. Goddard?

MR. GODDARD: The Staff does not support the motion to strike the testimony. We feel that it is relevant, albeit --

JUDGE BRENNER: That wasn't the objection. The objection was not relevance. The objection was surprise, hearing it for the first time.

MR. GODDARD: That is correct, but the Staff position is that it is highly relevant and we do not take the position it should be struck on the basis of surprise. However, we would request that the documentary results of any such examination be forwarded -- furnished to the Staff and to the County at the earliest opportunity.

JUDGE BRENNER: Well, what good will that do, we're questioning the witnesses now not next week. Did the Staff have information that LILCO or its agents had performed further tests to confirm whether or not the layer was in oxide subsequent to the receipt of the County's

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Supplemental testimony?

MR. GODDARD: No, we did not. However, we still would not join the motion to strike on the basis of surprise.

JUDGE BRENNER: But you want more information?

MR. GODDARD: We would want any information that is available at this time.

JUDGE BRENNER: Isn't that not fully consistent? I'm trying to understand what good the further information would do for the record of this proceeding?

MR. GODDARD: I'm sorry, Judge Brenner, would you repeat your last question?

JUDGE BRENNER: I had asked you whether your two points were, perhaps, not fully consistent. On the one hand you disagree with the County's objection that it is hearing some new information for the first time. Whereas, on the other hand on behalf of the Staff, you agree that the Staff is also hearing it now for the first time and you want documentation and support and so on, with respect to any such further work performed by LILCO or its agents. Yes, nevertheless, you see no reason to be concerned with it in terms of evidence on the record of this hearing?

MR. GODDARD: The Staff is in the position where it is interested in developing the most accurate factual record with regard to the nature of these cracks. We have

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no particular side in this issue whereby we would wish to include or exclude specific evidence. Rather, we would like to have as full a development of this portion of the record as possible. We feel we would get that by allowing this testimony and further obtaining from FaAA the results of any and all testing which was performed, albeit, that the Staff as well was unaware of testing subsequent of the filing of Suffolk County Supplemental testimony.

(Board conferring.)

JUDGE BRENNER: We are not going to strike the testimony. However, we, too, are becoming concerned that that much of this information has indeed become a moving target with LILCO either not being prepared early enough in terms of the schedule of this proceeding, or not bringing information to the attention of the Board and the parties as soon as feasible, even where the information might be preliminarily developed as this proceeding has gone on.

It is true we have not provided formal rules for rebuttal. However, the Board has flexibility to control rebuttal-type testimony. Backing up for a moment, nevertheless, LILCO did not even seek permission to present this as rebuttal. LILCO was just sitting back and happenened to be asked the right question, I assume by coincidence, since the Staff assures us it, too, did not know about it. And then out pops the information for the

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first time.

Even if there are no rules for rebuttal, it's clear -- formal rules for rebuttal -- it's clear that's not the way to get information to us, that is, to sit back and wait for only the right questions to be asked.

Number two, now that we've got the information out or at least the beginnings of it, we will allow the subject to be pursued and if after it is pursued by examination of these witnesses, we will be flexible in allowing questions to be put, for example, by Suffolk County's own counsel to its witnesses as a type of supplement to Suffolk County's supplementary testimony or surrebuttal to this rebuttal if LILCO wishes us to consider it somewhat analogous to rebuttal. Although, I've already pointed out the important difference in terms of motivation towards notification. We will permit that including such questions as to what Suffolk County's experts do know and do not know and why they cannot know certain things. And we'll take that into account into giving weight or not giving weight to the testimony and also in entertaining any motions which a party deems appropriate after we've heard all the evidence from all the witnesses as to whether any further remedies or redress are necessary.

In agreeing with the County's complaint that some of this has become a moving target, we agree with it not

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only as to this one circumstance, but we've seen it in other circumstances and we may see it again when we discuss the pending motion.

MR. DYNNER: Judge Brenner, I would like to state for the record that having heard what you have said the County is also interested in a full and complete record but only if it is consistent with the Administrative Procedure Act and the regulations which govern these proceedings. And our view, with all respect not having seen documentation or having had any opportunity for discovery or analysis by our experts on whatever these new tests or examinations may have shown or not shown, I respectfully submit that the ability to ask further questions about it of my witnesses or of LILCO's witnesses does not rise to the level of the kind of preparation and litigation standards provided by the Act whereby the regulations --

JUDGE BRENNER: Well, there is nothing explicit in the Act or the regulations, Mr. Dynner. That's why we have flexibility to control it with due process being our guide. And I did not mean that the further opportunity for you to ask questions both of these witnesses and of your own witnesses would be to end all of the remedies. What I'm saying is you do that to the full extent feasible and then use the answers you get including from your own witnesses in support of whatever further remedies you may seek from us.

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It is a matter of degree. The witnesses on both sides already know quite a bit about this oxide layer or non-oxide layer in the cam shaft gallery cracks. And I cannot tell at this point whether this is just one other further detail which no discovery or further inquiry in preparation for questions is necessary or whether it is complex enough to give rise to further remedies.

And I want to go forward with the record at this time to the fullest extent feasible. And I'm telling you that you need to make your best attempt at going forward in those circumstances and then we'll see where the record stands after we've completed the evidence of all witnesses on the subject of blocks. And at that point we may well agree with you, that some further remedies are required. Or we may take it into account in the weight we'll assign.

In other words, we may say to you at that point, well, we're not going to have any further discovery or whatever else you might want to ask for. But on the other hand we won't credit any of that testimony.

But I want to do it in a particular context after we've learned what facts we can learn and after we've heard testimony from your witnesses or Staff witnesses as to perhaps why they can't reach certain conclusions based on what they've heard because they need to know A, B, and C. And then we'll be able to put the arguments in the context

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of specifics.

But we don't think it's proper for us to have heard this because the right question happened to be asked by another party -- and I've stated that already -- unless what we've heard turns out to be almost an unimportant detail. But I don't know that yet.

Mr. Goddard?

MR. GODDARD: Thank you.

BY MR. GODDARD:

Q Following up, Dr. Wachob, you stated that the dark surface layer appeared to be an oxide. Do you know in fact that it was an oxide?

A (Witness Wachob) The appearance both fractographically and metallographically were totally consistent. With that knowledge or belief that that was an oxide, obviously the third item that we just mentioned supports that and the microprobe analysis was only for the fact of confirmation. We already believed heavily that that oxide existed. We had factual evidence for it.

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Q Excuse me, you said the third item you mentioned. Would you restate the third item which you mentioned?

A The third item was in the first question you asked me the fact that we did do a microprobe analysis to determine that there was an oxide associated with the fracture surface.

Q What is the nature of such an analysis?

A A superprobe was looked at the fracture surface. And out of that fracture surface, an electronic signal comes out, a portion of which is related to the iron and oxygen species on the surface.

JUDGE BRENNER: What was used, you said some sort of probe?

WITNESS WACHOB: It is a superprobe. JEOL is the manufacturer of it. It is a microprobe analysis.

Dr. Rau might have an additional comment, though.

WITNESS RAU: I just wanted to add, with regard to your last comment, your most recent one, was that having examined in cross-section the detailed metallography of the cam gallery cracks in the oxide which is on the surface, it was my opinion that that can only be an oxide. There is really only one other corrosion product which could even, in your wildest imagination, be and that would be a sulfide. In my opinion, it would not take the character which that

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continuous oxide uniform thickness took. And I was completely convinced from the detailed metallography that it was in fact an oxide. And I think Dr. Wachob has already indicated that confirmatory microprobe work was done only when we were surprised by what we thought was an -- well a completely untenable position taken by the County's expert.

WITNESS WACHOB: May I add something?

In addition to that, we had performed an EDAX or Energy Dispersive X-ray Analysis of the fracture surface. And in that instance we did not see large amounts of sulfur or any other compound on it to indicate that there was any other corrosion product and that was strong evidence to us, in addition to the fractography and metallography, that there was an oxide associated with that fracture surface.

BY MR. GODDARD:

Q Dr. Rau, you stated that the oxide layer was uniform in thickness.

Is that consistent with how you would expect an oxide layer to form during the casting process?

A (Witness Rau) Generally yes, Mr. Goddard. The uniformity of the oxide thickness is consistent with the solidification shrinkage cracks because the cracks are formed on the cool-down during the solidification process and, in our opinion, form at a relatively high temperature and then are -- the crack, excuse me, forms at a relatively

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high temperature -- and the entirety of the crack is generally then exposed to a gradually decreasing temperature over a period of days while this fairly large casting cools down.

As contrasted to a situation where only a small crack might be present and to grow during surface over a period of -- an extended period of time. Under those circumstances the early portion of the crack would be exposed much longer than the subsequent portions and of course, the ones, the most recent portions of a growing crack would be exposed for a very short period of time. For those reasons the uniformity, or the relative uniformity of the oxide over the entirety of the shrinkage crack is indicative to me that it formed during the solidification process.

Q The County's expert, Dr. Anderson, testified that he would expect thicker layers of oxide to occur at the mouth of the crack and lower down because of exposure to larger quantities of oxygen during the cooling process at the mouth than would appear at the bottom of the crack.

Do you agree with that statement?

A No, and let me explain.

It is a matter of degree. Maybe I shouldn't answer yes or no to that.

Any differences between the mouth and further on

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down in the shrinkage crack, which is basically open, would in my opinion be small compared to the thickness which is seen. There is in fact some small difference in the thickness as you progress from the mouth or the surface of the cam gallery crack indication down to the tip. But it is not a large difference. We are talking about less than a factor of two in the thickness between the very tip and the mouth.

Perhaps Dr. McCarthy or Dr. Wachob would add to that.

A (Witness McCarthy) There are two time constants involved in getting a different thickness of oxide from the front to the back of the crack: one is the time constant involved in the mollecular diffusion of oxygen down the crack and second is the time constant involved with the oxidation process.

Unless you get extremely favorable geometry -- in other words, early oxidation at the front managed to almost clog the crack as a porous plug, which is unusual to say the least -- the time constant of mollecular diffusion is very much faster than the time constants associated with corrosion. And to a first order you would expect the diffusion of oxygen to be uniform and the whole rate controlling thing will be the rate of oxidation.

JUDGE BRENNER: Let me just understand: What you

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just described, Dr. McCarthy, is your view of what would happen during the casting and cooling process?

WITNESS MC CARTHY: Yes, during the casting and cooling process where the crack came about more -- especially from these two time constant point of view more or less at the same point in time, you would not have a blocking oxide at the front of the crack and therefore oxygen would quickly diffuse the width of the crack if it had any measurable opening. Compared to the mollecular mean free path, the crack is a huge space, so you would have oxygen present there.

And unless just some incredible fortuitous event happens so that you had a mollecular plug, effectively oxygen would be present over the full width of the crack and thus the diffusion of oxygen to the crack for oxidation would be a much faster process than the rate of consumption of oxygen by that crack.

WITNESS RAU: Is that clear, your Honor?

JUDGE BRENNER: No, I have got some questions about it, but I don't want to --

WITNESS RAU: It is a very technical subject. Let me just try to restate it very simply.

There's two things that have to happen for oxidation to occur at the tip of the crack -- not at the surface, but at the tip: the oxygen must diffuse or get

WRBagb

down in the crack and then the oxygen must get through the oxide or the metal must come out through the oxide in order for the metal to react with the oxygen to form the oxide layer.

And what Dr. McCarthy has very simply said is that the diffusion of the oxygen down to the crack tip occurs very, very quickly compared to the rate at which the oxygen and the metal get through the oxide to actually form the oxide. And therefore you wouldn't necessarily expect any significant difference in the thickness of the oxide from the tip to the surface based on the fact that the oxygen is more slowly -- or more difficult to get to the tip.

So very simply it gets all along the crack almost instantaneously and then how quickly it grows and how thick it gets depend upon the kinetics of the oxide growth itself all along the crack surface simultaneously.

MR. GODDARD: Thank you, Dr. Rau.

BY MR. GODDARD:

Q Dr. Rau, in response to an earlier question, I have discerned that you do not believe that this dark colored layer could in fact be graphitic corrosion as testified to by Dr. Anderson.

Can you confirm that my opinion of your opinion was correct and will you give us the basis for your opinion?

WRBagb

A (Witness Rau) You are correct, Mr. Goddard, I do not believe that this dark oxide is graphitic corrosion. The basis for my opinion is that graphitic corrosion is nothing more, quite frankly, than oxidation of gray iron. However, it normally occurs in an aqueous, a water-based type solution, typically in soils, it typically occurs over long periods of time and most important it occurs by eating away all the steel portion of the cast iron and leaving only this network of graphite remaining.

The metallography that has been performed is completely inconsistent with that observation about graphitic corrosion. The oxide is uniform in thickness and there is no indication that it is selectively attacking the steel in-between the graphite, it just looks nothing like graphitic corrosion. And quite frankly that statement is just absurd.

Q At page five of your testimony you indicate that the presence of high concentrations of calcium on the surface of the crack are indicative of crack formation when the block was exposed to elevated temperature during the casting process.

Can you explain that statement?

A Are you asking me in particular or anybody?

Q Either you or Dr. Wachob, since that is testimony sponsored by the two of you jointly.

WRBagb

A Let me ask Dr. Wachob to handle it. I think he is more familiar with it than I am.

Q Thank you.

A (Witness Wachob) The calcium that we see on the surface is not typical of other surfaces that we have looked at in the cast iron, nor is it an anticipated element to be there. Our belief is that the calcium is somehow deposited during the fabrication process, let's say from the welding in particular of the cast iron block.

In that instance the electrode coverings are calcium fluoride and calcium carbonates and that happens to be a source of calcium which we believe is consistent with what we have seen.

Q Dr. Wachob, at page five of your testimony --

JUDGE BRENNER: Could I follow up, Mr. Goddard? I wonder if I can interrupt.

MR. GODDARD: Yes.

JUDGE BRENNER: Based on what you said, Dr. Wachob, it occurs to me that the presence of calcium would not be indicative one way or the other of whether the crack was pre-existent during the casting and cooling process or whether it propagated later after the weld was already made.

In either case, if you are correct about the source of the calcium, you would still find it to be

WRBagb

present, is that not correct?

WITNESS WACHOB: For the calcium to be present on the shrinkage crack, one would have to have the shrinkage crack first in existence. Once that crack is in existence, and they begin to try and weld repair that material, you now have an opportunity for any calcium deposits that would be associated with the weld rod to actually deposit on that crack surface.

JUDGE BRENNER: Why could it not be the case that the crack initiated prior to the welding during the casting process and then it continued to propagate after and you would still find the calcium present, would you not?

Is there something about the distribution of the calcium in what you looked at that would be inconsistent with my hypothesis to you?

WITNESS WACHOB: The fact that it is associated only with the pre-existent dark oxide of the shrinkage crack I think is helpful in suggesting that it has occurred at one time.

The other fact is that the mobility of the calcium itself on the surface is quite low and the only opportunity one would have to get it would be during an initial deposition of it being laid down on that surface.

WITNESS RAU: In other words -- it's not clear from that -- if the crack were to extend hypothetically

WRBagb

after the calcium were deposited over that portion which existed at one time, due to the limited mobility, you would not expect the calcium to move onto the surfaces which are further away, at least it is not very easy for it to move. And the compositions or, let's say, the magnitudes of the calcium which were measured with the EDAX, Electron Dispersive Energy Analysis, were consistent along the entire oxidized portion of the cam gallery crack indication.

JUDGE BRENNER: I guess I wanted to ask this eventually and maybe this is a good time:

Were there any cam gallery cracks or indications, if you want to call them that, that did not have weld repairs on the old 103 block?

WITNESS RAU: No.

JUDGE BRENNER: There were no portion of any crack that did not have a weld repair?

WITNESS RAU: Well there are no cam gallery saddles which did not have a weld repair.

JUDGE BRENNER: I understood that from your testimony.

WITNESS RAU: And of course all of the cracks which you see on the surface are at the edge of the weld repair and the cast iron.

As you recall, of course, at the base of the weld repair there was a shrinkage crack which, before the weld

WRBwrb

repair was made, ran and emerged out at the surface.

For that reason, at one time there were shrinkage cracks that were not associated with weld repairs.

JUDGE BRENNER: Would you run that last part by me again? I lost the train.

WITNESS RAU: Our opinion is there certainly were shrinkage cracks before the weld repair. So at one time they existed.

JUDGE BRENNER: Right. I know that.

WITNESS RAU: And in those regions where there had been weld repairs, the cracks had emerged at the surface throughout the interface. There may well be other regions where shrinkage could produce surface tears or cracks which have not been weld repaired. But in the cam gallery saddle region they all had been weld repaired, in 103, the original 103, in 101, and those in 102 which we examined.

JUDGE BRENNER: I thought, perhaps -- and correct me: I can't find my notes now -- that there were some cam gallery cracks on either 101 or 102 that had not been welded. Am I incorrect in that belief?

WITNESS RAU: Yes, sir, I believe you are. It's on the replacement 103 block where there are not the weld repairs present.

JUDGE BRENNER: Mr. Goddard.

BY MR. GODDARD:

WRBwrb

Q Dr. Wachob, I would like to read to you a sentence from your answer to Question 8 at page 5 of your testimony. It states that,

> "The dark oxide, the presence of high concentrations of calcium, and the absence of a rust-colored oxide indicate that the entire surface of a crack was introduced during casting and exposed to elevated temperatures at that time."

Will you please reconcile that sentence with your statement with regard to the possible source of the calcium as occurring during the welding process?

A (Witness Wachob) The statement that it was exposed as a result of the casting process is meant to focus more on the originality of the crack itself. The dark oxide, the fact that you have a shrinkage crack, and the absence of this rust-colored oxide are indicative of the fact that it was a fabrication defect.

Unfortunately, the calcium that is there, and the discussion we're talking about there, is associated with the fabrication process, and that has gotten interweaved into that discussion and sentence.

Q Thank you.

Dr. Anderson also stated in his testimony that in all samples where calcium was detected, sulfur was also detected in proportionate amounts.

WRBwrb

Did FaAA find that sulfur was present with calcium on the crack surface?

A Amounts of sulfur were found on the fracture surface as well when we analyzed them using an energy dispersive technique. There is sulfur itself associated with the cast iron in that the magnesium sulfite particles do end up making up a portion of the material itself.

There is no correlation that we have been able to determine between the calcium and the sulfur indications.

WRBeb

Q I thought I understood your answer, but let me try this again.

How do you explain the presence of sulfur along the crack surface?

A Again I believe that a portion of what we have seen is the result of the manganese sulfide that is associated with the iron -- the gray cast iron itself. There is the possibility that sulfur does become involved from the point of view that it is in the oils, the lubricating oils itself, but it is not present as a calcium sulfide, not at all.

Q And did your chemical analysis of the let's call it an oxide layer reveal which sulfur or sulfide compounds were in fact present?

A No, neither the energy dispersive nor microprobe analysis was used to determine that.

A (Witness Rau) Let me just add, Mr. Goddard, keep in mind the percentages of sulfur are very, very low. They are not high enough to have any significant fraction of the oxide layer. We're talking about, you know, down in the percent or less I believe Dr. Wachob has said.

So even if we could identify a sulfur compound and its source precisely, we are dealing with less than one percent of the dark oxide which we're looking at on the surface.

WRBeb

Q Dr. Rau, is the size of that or the percentage of that overall oxide layer makeup significant if in fact there is sulfur present? Isn't it more important to know what the source of that sulfur or sulfide was as opposed to the amount that is deposited there?

A I don't understand your question.

Q I say-- Strike the question.

Dr. Wachob, I believe you stated that calcium sulfide was not found to be present. Is that correct? Am I characterizing your testimony correctly?

A (Witness Wachob) No. From the point of view that yes, we had seen some calcium, yes, we do see some sulfur, the conclusion that it is not calcium sulfide comes from the fact of I don't believe there is a reason for nor a source of calcium sulfide to be deposited on that surface.

Q Do you know whether calcium sulfide is present in the diesel oil, in the lubricating oil that was used at Shoreham?

A No. However, Dr. McCarthy may be able to address that issue better than I.

Q Dr. McCarthy?

A (Witness McCarthy) There is not calcium sulfate present in the diesel oil -- calcium sulfide present in the diesel oil. There is calcium present as an antifoaming and detergent agent, and there is an extreme pressure additive

WRBeb

which is zinc diphosphate as opposed to a disulfide which is sometimes used as an extreme pressure additive in oils.

There is not a disulfide extreme pressure lubricant. It is a diphosphate in this particular type of oil.

Q Dr. McCarthy, there would be sulfur present in the lubricating oil in one form or another, would there not?

A There would be trace elements, yes, sir. It is impossible to get all the sulfur out of any crude, but it would be trace elements, especially in the lubricating oil, the reason being that free radicals of sulfur pose problems for any lubricating oil. As soon as they get oxidized and find water, then you've got sulfuric acid, so great effort is spent to keep the sulfur content in lubricating oils as low as possible.

Q I guess I should address this question to Dr. Johnson, but anyone else on the panel is free to take a shot at the answer.

Are calcium or sulfur present in the liquid dye penetrants that were used to examine these crack surfaces?

A (Witness Schuster) Very, very small amounts, sir. We traditionally order our penetrant materials--

JUDGE BRENNER: You've got to repeat what you said.

WITNESS SCHUSTER: I said we traditionally order

WRBeb

our penetrant materials to a standard for stainless steel co-class 1, reactor piping. That requirement is that we have very low sulfur amounts in the penetrant materials.

I think Dr. Johnson can elaborate a little bit more because he has had a chance to review the analysis of the materials.

JUDGE BRENNER: Mr. Schuster, before you pass the microphone over,--

WITNESS SCHUSTER: Yes?

JUDGE BRENNER: -- when you answered "Yes" to Mr. Goddard's question, I'm not sure if you were answering Yes to calcium sulfide or just to sulfur or sulfur and calcium.

MR. GODDARD: Judge Brenner, if I may, the question now was phrased--

JUDGE BRENNER: Well, let me make sure I understand what he's saying.

MR. GODDARD: I did not use calcium sulfide in the question. I used calcium or sulfur. With that, I apologize for interrupting you.

JUDGE BRENNER: That's okay. I wasn't criticizing the question. I just want to ascertain what he has in mind.

WITNESS SCHUSTER: The calcium and the sulfur, sir.

WRBeb

JUDGE BRENNER: Okay.

WITNESS JOHNSON: The penetrants used are below -- a very low sulfur, a very low sulfur and halite content. I don't remember the exact percentages but they are specified in the ASME code.

BY MR. GODDARD:

Q Dr. Johnson, what about the calcium content?

A (Witness Johnson) I don't know the answer to that.

JUDGE BRENNER: Mr. Goddard, I guess I am going to interrupt again because I don't know how important it is in terms of how far we go with these questions as to where the calcium might be or where the sulfur might be until I get some other information.

Anybody on the panel can answer.

If I postulated, contrary to your belief, that whatever traces you found of calcium and sulfur are attributable to either the lubricating oil or the liquid dye penetrant, would that mean that some of the cracks propagated after operation?

WITNESS RAU: Definitely not, your Honor.

JUDGE BRENNER: And why not?

WITNESS RAU: Again hypothetically assume that the calcium is there because the crack is extended--

JUDGE BRENNER: I'm asking you to assume that the

WRBeb

calcium and sulfur that you found in your chemical analyses are there because they were present in either the lubricating oil or the liquid dye penetrant.

WITNESS RAU: Okay. The answer is, as I indicated, definitely not.

The major reason, amongst the various ones that have been listed for the conclusion that these cam gallery cracks were there since fabrication, is the uniformity of the oxide thickness and in fact, its thickness, if you make computations of what temperatures and times are required to generate the thickness of oxide which is in fact observed on that crack, you conclude that there is absolutely no way that oxide could form at the running temperatures or even close to it.

The formation of those oxides requires temperatures up in the 1,000 to 500 degrees Fahrenheit range for days, and you can run at 150 or even 200 degrees Fahrenheit forever. That's a very long time but I mean for many, many years and you would not--

JUDGE BRENNER: Almost as long as this hearing.

WITNESS RAU: Almost.

-- and you would never generate the thickness of oxide which has been observed on those cam gallery cracks.

JUDGE BRENNER: Let me stop you. You may be finished.

WRBeb

I wasn't very clear. I understand that you have various reasons, you know, that you've given for your conclusion. I want you to set everything else aside except that Aha, Eureka, you found calcium and sulfur present.

And I further want you to assume hypothetically, at least from your point of view hypothetically, that the calcium and sulfur that you found when you were examining the camshaft gallery cracks are there because of the presence of those elements in either the lubricating oil or the liquid dye penetrant.

Does that presence from that source ipso facto mean that the cracks propagated after operation of the diesels?

WITNESS RAU: No, definitely not, your Honor. Even if that were the case, the pre-existing shrinkage crack could of course become contaminated or covered with the calcium and sulfur from the oil during operation. It would not necessarily imply anything with regard to the extension of that crack during service.

JUDGE BRENNER: Would that be true even taking into consideration the weld repairs to those cracks?

WITNESS RAU: Yes, sir.

WITNESS MC CARTHY: Just a little footnote on the deposition mechanism of the calcium.

There is only about a thousand parts per million

of calcium in the oil even as a dispersant whereas the concentration of calcium measured in the oxide is far higher. And we would also, if the calcium came from the oil, have to come up with a hithertofor unknown concentrating mechanism to get the calcium content up to what we observe.

BY MR. GODDARD:

Q Dr. McCarthy, what is the quantitative -- what did the quantitative analysis of that oxide for calcium content show? You indicated it was quite a bit higher than would be caused by deposition from the lubricating oil.

A (Witness McCarthy) According to analyses that have been done on samples of new oil not run in the engine, we see a calcium content of about a thousand parts per million. That would be a tenth of a percent approximately for calcium.

The EDAX results of the oxide itself show concentrations of one to three percent, so 10 to 30 times higher.

Q Do you have a comparable figure for the sulfur content in that oxide layer?

A The sulfur concentration in the oxide is roughly comparable. I do not have a trace indication of the sulfur content in the oil. It would be a huge difference, on the order of a factor of a thousand.

1 WRBeb

Q Well, I'm not referring to the content in the oil, Dr. McCarthy. I would like to know what the sulfur content of the oxide layer was.

A Approximately one to three percent also for the sulfur in the oxide layer.

Q Which is roughly proportional then to the amount of calcium in the oxide layer?

A I will let Dr. Wachob speak to that.

A (Witness Wachob) It is roughly comparable, yes.

Q Thank you.

Dr. Rau and Dr. Wachob, your testimony states that this oxide can only have formed in elevated temperatures and in the presence of an air environment.

Dr. Anderson's supplemental testimony stated that:

"The block casting is formed under strong reducing conditions where air cannot enter."

Could either of you explain this apparent contradiction between the two testimonies?

A (Witness Rau) Mr. Goddard, I don't think there is necessarily a contradiction. In this particular instance, I don't know the precise conditions at the very beginning of the casting process but what Mr. Anderson may be talking about is in the very beginning having a reducing environment.

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However, during the time where -- arter which the shrinkage crack is formed which we believe to be down in the below 1300 and probably in the order of 1000 degrees Fahrenheit, during the time that the oxidation would be occurring between 1000 and on down to room temperature as it cools, by that time the casting has started to pull away from the mold and in fact, oxygen does become available.

And even if the environment were reducing initially, that is only over a very short period of time until the mold gets, if you like, dried out. Certainly subsequently during the majority of the cooling there is extensive amounts of oxygen or like air available and in contact with the metal surfaces.

Q Thank you. That's why I said "apparent contradiction." I believe you've answered that for me.

WRBpp

You observe in your testimony that the oxide was present over the entire surface of the cam gallery cracks. Did that include the area forming the boundary between the base metal and the weld material?

JUDGE BRENNER: Just for my benefit, Mr. Goddard, are you talking about either boundary or the boundary where the weld material separated or were you asking generally as to either boundary?

MR. GODDARD: I thought the question was clear such that they could provide an answer to it. I can split it if you like.

JUDGE BRENNER: No, that's fine; it's your question. I just wanted to key myself in and also maybe key the witnesses.

MR. GODDARD: For the record, both.

WITNESS WACHOB: Could you repeat the question again; I'm sorry.

BY MR. GODDARD:

Q In your testimony at page 6, the third paragraph, the third sentence, you state that the oxide was present over the entire surface of the cam gallery cracks. Did this include the boundary area of the base metal in the weld material and was the oxide present on both sides?

A (Witness Rau) Mr. Goddard, I'm sorry to be so long here. There is an oxide on the fracture surface

WRBpp

between the weld bead and the adjacent cast iron. It is not as thick and not of the same character as the oxide on the pre-existing shrinkage crack that has occurred under a different set of circumstances. Basically, it's thinner. And, quite frankly, we did not examine it in great detail with regard to the two sides. The crack runs along the heat affected zone in the cast iron immediately adjacent to the high nickel weld material. And it certainly has an oxide on it but it is certainly not of the same thickness as the oxide which is in the cast iron over the majority of the shrinkage crack.

Q Where does that oxide come from, Dr. Rau?

A I believe that that oxide is formed during the cooldown from the weld repair itself. You make the weld, the shrinkage crack reforms between the interface of the weld and the cast iron while it is cooling down and then it oxidizes as it is cooling down. But of course you recall that the rate of cooling from a half inch or three-eighth inch weld bead is very much faster than the original cooling of the block. So the thickness of the oxide that results during this cooling is much, much thinner than the thickness of the oxide which developed during this cooldown from the solidification temperatures.

Q Do you know whether the original block on EDG 103 saw any operation at all such as a shock test at TDI before

WRBpp

the cam gallery areas of that block were welded?

A Mr. Goddard, I know I do not have any firsthand information which would say definitively that such testing were not done, but I certainly have an opinion based on the access and the conditions under which you could make those weld repairs. And I don't believe it is realistic that those repairs were done after the engine was assembled for any kind of testing. In order to do the weld repairs you would have to completely disassemble that entire area and it's my opinion that was not done.

JUDGE BRENNER: If I could ask a question. In your answer to Mr. Goddard's previous question, Dr. Rau, I inferred that you believed that the weld repairs were made prior to the cooldown process or as part of the process while the block was still cooling down; am I right?

WITNESS RAU: No, sir. The block, I believe, cools down and then before all the final machining is done before it is actually assembled into an operational engine, the weld repair is made. But that is after the block has cooled down.

JUDGE BRENNER: Well, then, I guess you'll have to tell me again because I didn't understand what your basis is for believing the oxide layer would be different on the side of the crack where the weld material was still adhering as opposed to the side from where it was separated. Maybe I

WRBpp

missed something.

You stated that there was oxide between the weld bead and the crack but that it's thinner. And I thought you meant thinner than the oxide in the cast iron where the weld had separated.

WITNESS RAU: There is some confusion here, your Honor.

JUDGE BRENNER: All right.

WITNESS RAU: I was comparing the oxide -- recall we have a crack which extends from the surface of the cam gallery which has a weld repair. And it runs along the boundary between the weld bead and the adjacent cast iron until it gets down to the deepest portion of the weld repair beyond which there is a shrinkage crack which was not completely removed and ground out before the weld repair was made. I was comparing and contrasting the oxide thicknesses on the pre-existing shrinkage crack which runs from the base of the weld further -- deeper into the metal with the thickness and character of the oxide on that crack which is between the side of the weld bead and the adjacent cast iron there. And in making the weld, of course, the metal has to be heated up again. You're melting the metal. And when that weld bead cools down we have a second time where the fresh crack which is formed between the weld bead, the side of the weld bead and the cast iron, also is exposed to high

WRBpp

temperatures after the crack is formed and on its way down to room temperature. But that period of time is very much less than the period of time which the shrinkage crack was exposed. In the case of the weld bead it may have been in the order of a half an hour or minutes, whereas, in the case of the block it was a matter of days.

JUDGE BRENNER: All right. I understand that comparison. Let me ask you about the comparison that Mr. Anderson for the County talks about, and I'm paraphrasing him. He, in effect, says that the oxide based on FaAA's theories, the oxide should have been present on the side of the crack to which the weld material was still adhered. And he said in his view it was not.

Could you tell me whether you agree with him?

WITNESS RAU: I never did understand what Mr. Anderson was talking about there, your Honor. The crack which occurs between the weld bead and the cast iron when the repair weld is made occurs in the heat affected zone of the cast iron immediately adjacent to the weld bead. It does not truly occur at an interface where you have nickel iron on one side and cast iron on the other side.

So for all intents and purposes, when a crack is formed in that heat affected zone immediately adjacent to the weld bead interface, you have the same material on both sides of the crack. One side you're closer to the weld and

WRBpp

the other side you're closer to the cast iron. And those two surfaces are going to oxidize to the extent they do in a comparable fashion independent of which side is it. Now, Mr. Anderson has said that that well -- excuse me, that that oxide is different than that which is in the shrinkage crack and we agree completely with that statement. It is in fact different from the reasons which we just talked about.

JUDGE BRENNER: All right.

Just to make sure the part of Mr. Anderson's testimony you're recalling is the same part that I asked you about. Do you have a copy of his supplemental testimony?

Mr. Goddard, I'm sorry. Let me say for better or for worse, your whole line of questions has been very much along the lines of questions I wanted to ask, which I appreciate. But the down side of that for you is once in a while there is a detail that I wanted to get and I'm interrupting rather than waiting for the witnesses to have to recall the whole subject again.

I'm looking at page 7 of that supplemental testimony at the top.

WITNESS WACHOB: Which question is that?

JUDGE BRENNER: The last part of a long answer. 7. I'm looking at the very last paragraph on 7 which begins "Alternatively, if the oxide layer postulated by FaAA" -- do you have that?

WRBpp

WITNESS RAU: One minute, your Honor. I haven't found it yet.

Yes, I have it.

JUDGE BRENNER: So am I correct that you will disagree with the following statement by Dr. Anderson, "I examined cross sections of the crack under a microscope and observed no sign of the so-called dark oxide in the area of the crack to which weld material was still adhering."

WITNESS RAU: I don't think I disagree with that, your Honor. I think perhaps what Mr. Anderson is trying to indicate I disagree with. But to the extent he means that that portion of the crack to which weld material is adhering is in fact the crack between the weld bead and the cast iron, I agree that there's no indication of the thick dark oxide. I don't know what he means by so-called, but it's a different thickness and character of oxide than that which is on the thick -- excuse me -- on the shrinkage crack which extends much deeper into the cam gallery region of the original 103 block.

JUDGE BRENNER: All right. But if he means that there's no oxide present then you do disagree because it is inconsistent with your prior answer discussing the nature of the oxide that you believe to be present in that area?

WITNESS RAU: Yes, I disagree with the statement that there's no oxide there.

WRBpp

JUDGE BRENNER: That's not what he said but we'll find out what he meant later.

Mr. Goddard?

BY MR. GODDARD:

Q Dr. Rau or Dr. Wachob, what are beach marks?

A (Witness Rau) Beach marks are a scientific slang term, if you like, for marks left on a fracture surface which represent or, of you like, mark a position which a crack front occupied at a given period of time. And if you have a progressing crack you may have obviously different marks representing the position of the crack front at different points in time. They typically result from either differences in the mechanical loading which created various segments of the crack extension or from differences in the time or the chemical environment which causes oxidation to the surfaces. But some differences basically which causes an appearance difference such that when you look at the fracture surface, either with your eye or with a microscope, you see beach marks which characterize and distinguish between the surface of the crack at one point in time and the surface of the crack after it has extended to some further position.

Q Thank you.

In your testimony on page 7, you indicate that an examination of the surface of the cam gallery saddle number

WPBpp

7 crack after it had been broken open did not reveal any beach marks or other surface variations on the fracture surface which might indicate progressive crack extension.

What other surface variations on the fracture surface might be present which, if present, would indicate such progressive crack extension?

A Mr. Goddard, the other things I was talking about didn't want to restrict it only to the more traditional causes of beach marks which are the ones I've indicated to you. You can also introduce marks on the fracture surface of a growing crack due to rubbing -- fretting, if you like -- of the surface, or sometimes you can have a change in the plane on which the crack is growing which are indicative of crack extension, some change or advance of the crack. And these are the other things I was referring to. Basically I would state there is absolutely no indications of any positioning or the crack stopped and then continued on either once, twice, or any number of times. There is just nothing to distinguish any one point on the fracture surface from any other point along the shrinkage crack except for, again, the weld itself.

Q In your opinion, would it be possible for a crack to propagate progressively in cast iron of the type used in the original 103 block without leaving beach marks?

A Well, it's tough to give you a yes or no answer.

WRBpp

In the extreme case the answer is yes. You can dream up circumstances where, in fact, you could get advance of the crack and not see a clearly defined beach mark. But under conditions of significant oxidation, oxide formation during the casting process, had there been any crack extension there would have been a marked difference in the oxidation characteristics at the tip which would clearly delineate a beach mark, an indication that the crack had in fact extended, and no such indication exists on the cam gallery shrinkage cracks which we examined.

Q However, Dr. Rau, if the crack had, in fact, occurred during operation and it occurred during similar mechanical loadings of that cam gallery area, and if they occurred closely proximate in time, then progressive cracking would not be likely to indicate such beach marks; is that not true also?

A I don't think it's completely true. But again, you have to give, you know, more a definitive hypothetical before I really can answer it. Let me tell you why I don't think it's true. If you started out with no crack in a cast iron and then very quickly caused a crack to grow and grow and grow and if this is all in lubricating oils so there was no substantial amount of oxidation, then I would agree it's possible you might not see the marks indicating the growth of the crack.

WRBpp

However, we have in our situation, as you know, a thick oxide which clearly marks the position of the shrinkage crack. And we have done cross sections which show there is no extension of that crack which would have any lesser amount of oxide.

So I think, again, given all the factual bases which are actually in effect in the original 103 block cam galleries, that is not possible.

Q Then, Dr. Rau, would I be correct in assuming that the absence of beach marks on the crack you examined is a significant factor in your overall conclusion that progressive crack extension did not occur?

A Well, it's one of the factors and it's there for a significant -- I think you asked me if it was significant, right?

Q Yes, I'm asking if that is one of the significant factors you are relying on in your overall conclusion, that the crack extension was not -- that there was not a progressive crack extension here?

A In the general sense that I described the fracture surface markings -- that's not just beach marks. The absence of any marking which might in fact result from excess oxidation or from mechanical means is a significant contributor amongst the others to the opinion I hold.

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Q At page 7 in your answer to question 11 you start a sentence as follows:

"The existence of cam gallery cracks in other new block castings...."

and then you go on to refer to the oxide and the calcium on the crack surface and the morphology of the cracks as demonstrating conclusively that the cracks are fabrication-induced.

What other new block castings were you referring to there that exhibit cam gallery cracking?

A Let me refer if I might to Mr. Schuster who can describe the evaluations which LILCO did after the identification of cam gallery indications in 101 and 102. It is his and his consultant's observations which I was referring to there.

Q You refer to other new block castings and before you refer to Dr. Schuster I was hoping you might refer to Dr. Wells who sponsored the testimony at page 20 of LILCO's original testimony involving inspections at other stations.

However, if either Mr. Schuster or Dr. Wells can provide some substance to that phrase "new block castings" I would be interested in hearing their replies.

A (Witness Schuster) In February-- In March and April of 1983, after the cam gallery cracks were discovered visually in the Shoreham diesels, myself and a Mr. Isleib,

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who is a casting consultant, a gentleman from the Site Engineering Office, and the assistant corporate metallurgist went out west to Delaval and did inspections on five new blocks which were in various stages of fabrication in the foundry.

Several of these blocks-- Excuse me.

One block had just been removed from the mold and was cleaned just prior to our performing the examination, and the other blocks were in various stages of fabrication.

In addition to that we also stopped in Kansas and looked at a commercial engine that was in operation and did an examination of that block and found the same indications in that cam gallery area.

I should add that the examination were performed utilizing magnetic particle and visual, both.

Q Thank you, Mr. Schuster.

Dr. Wells, do you have anything you might add to that answer?

A (Witness Wells) The only block that we have looked at in other nuclear stations, which is similar to the Shoreham engines, is the block -- the two blocks, actually, at River Bend that have shown no cam gallery indications. Others of course have a different design but the engines do not have the same detailed design.

Q Dr. Wells, do you know the nature of the

WREeb

examinations which were performed on the cam galleries at the blocks on the two River Bend engines?

A They were just visual examinations I believe.

Q Mr. Schuster, did all five of the blocks that you examined at TDI demonstrate cam gallery cracks?

A (Witness Schuster) Yes, sir, they did.

Q Were those painted blocks at that point with the exception of the one that had been removed from the casting?

A The blocks-- Let's see.... I don't believe all of them were painted. As I recall, some were painted and some were unpainted, yes, sir. But precisely which ones and how many I don't recall at this point.

Q On the blocks that had in fact been painted, were you able to visually detect the presence of cam gallery cracking?

A No, sir. We were able to visually verify-- We were able to visually see indications of cam gallery cracking on the commercial engine, and that is part of the documentation package for LDR-1224 which recorded what took place on this trip that we're talking about.

The way that you can see this is the oil gets into the paint and becomes evident visually. After we cleaned this we were then able to verify that with magnetic particle examination.

JUDGE BRENNER: Mr. Schuster, I'm a little

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confused. I don't understand why looking at what you have termed a commercial engine, I believe you said in Kansas, is probative of what I take to be the proposition in Answer 11 of the supplemental testimony that because you find cam gallery cracks in other engines that that is supportive of the fact that they are introduced in the casting and cooling process rather than the operational process.

WITNESS SCHUSTER: For the sake of continuity, the intent in looking at the engine in Kansas was twofold:

One, did other, similar engines, similar to the ones at Shoreham, have these cam gallery indications? And the one in Kansas did, and in fact this engine had some 50,000 hours of operation as indicated by the owner.

In addition to that, we then traveled to TDI in California and looked at the blocks in various stages of construction from the point at which it was taken out of the mold and the raw blocks were sitting on the floor.

Now in addition to one of the engines that we did do an inspection on while we were at TDI was another operating engine which was their test engine--

JUDGE BRENNER: You mean the R-5?

WITNESS SCHUSTER: Yes, sir. And it had cam gallery indications in it -- I mean the -- It's the straight-six in-line engine.

JUDGE BRENNER: I was going to ask you that.

WRBeb

The R-5 is a V I believe.

WITNESS SCHUSTER: That's right. I answered too quickly.

That engine also had cam gallery indications, and had some operating history which was all part of our overall evaluation of the indications.

BY MR. GODDARD:

Q Mr. Schuster, in the blocks you looked at at TDI, were any of the cam gallery cracks found by mag particle inspection that were not seen in visual examination?

A (Witness Schuster) Yes, sir.

I would like to add one other thing, too, which came to mind as we were talking.

Prior to our going to TDI, TDI also did some examinations of their own. They did some penetrant examinations and verified with penetrant that there were also indications in the cam gallery areas. That had slipped my mind because I wasn't part of those examinations, but TDI did in fact perform these. And it is documented in some communication we had with them.

JUDGE BRENNER: But that is after a point in time when LILCO discovered the cam gallery cracks?

WITNESS SCHUSTER: We discovered the cam gallery cracks; we notified TDI; we brought this casting specialist onboard and we started the investigation. TDI came to the

WRBeb

site, looked at the cam gallery indications, and -- you know, on all the engines.

They also, after we notified them, did some fluorescent penetrant as indicated by communications with them on those cam gallery areas in their own factory.

Subsequent to that, we traveled to Kansas and then to California and verified, utilizing magnetic particle inspection on the blocks there.

BY MR. GODDARD:

Q Dr. Wells, you testified that at River Bend the examination of cam galleries was visual only and not by mag particle. Is that correct?

A (Witness Wells) That's correct, Mr. Goodard.

Q Had the paint been removed from the cam galleries on the blocks at River Bend?

A I don't believe they removed the paint.

Q Do you know what magnification was used in those visual examinations of the River Bend cam galleries?

A I do not, Mr. Goddard.

Q Do you know whether all of the cam gallery areas were inspected or whether there was a limited inspection?

A No, sir, I don't know that.

Q Mr. Schuster, we just heard reference to Mr. Isleib's report. I believe that is Exhibit S-8 of the County's supplemental testimony. Do you have that in front

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of you, or are you familiar with that enough that I can discuss it without your referring to it?

I have reference to a portion of what is marked at the bottom as page 7 of that report.

A (Witness Schuster) This is a May '84 report, sir, and it is not of the same time frame that we were discussing earlier.

Q This is not the report you were referring to then?

A No, sir.

Q Thank you.

A The report I'm referring to would be a part of LILCO Deficiency Report 1224.

Q Thank you.

Then I will address this question to Drs. Rau and Wachob, again referring to page 7, numbered paragraph 3, the conclusions of Mr. Isleib in County Exhibit S-8.

In view of his inspection report on the replacement 103 block which revealed no hot cracks or tears on the casting, including the cam gallery areas, how do you explain the presence of such cracks after the block has been placed in operation at Shoreham?

A (Witness Rau) I think Drs. Wells and Wachob may want to add, but my understanding is that the visual inspection done by Mr. Isleib and the others on the

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replacement 103 block at the factory showed no indications visually, no reportable indications.

A visual inspection done even today on the replacement block 103 shows no reportable indications. It is only the more sensitive non-destructive inspection techniques which in fact reveal those very shallow surface indications in the replacement 103 block even today.

Perhaps the inspectors or Dr. Wachob may want to add something.

A (Witness Wachob) Again I would just add that there was a procedure by which the block was certified and approved, and I believe Mr. Seaman is aware of that documentation and actual procedure used. He may want to address it.

A (Witness Schuster) If I can interject just to help a bit, the block visual inspection was in accordance with MSSSP-55 which is a manufacturing standard that is utilized for castings, and it has some very good visual criteria that it utilized by the inspection person.

Q Mr. Seaman, are you looking eagerly to add something to that answer?

MR. FARLEY: I don't think he remembers the question.

WITNESS SEAMAN: I think the question has been adequately answered by Dr. Rau. The fact is that the

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original examinations which were performed visually did not reveal any relevant indications. These were the ones that were done out in the shop by our consultant and some of our PQA inspectors, and by TDI.

These were re-performed recently, which also -- visually again, which also revealed no reportable indications. I think that's the important point.

BY MR. GODDARD:

Q Does FaAA have any knowledge as to whether the casting technique for the original EDG 103 cylinder block differed from those techniques used for casting the DG 101 and 102 blocks?

A (Witness Wachob) They were all cast within a short period of one another, and we are unaware of any other changes in molds or casting procedures that would have occurred during that time.

A (Witness Rau) Let me just add we are not aware that there were in fact any changes at all made during that time frame.

Q Are you aware of any changes in metallurgical practices at TDI that occurred during the period when these three blocks were cast?

A Mr. Goddard, can you be a little more specific with regard to what you mean by metallurgical changes? I don't know what you're asking exactly.

WRBeb

Q Okay.

What I am looking for, Dr. Rau, is a basis for understanding why the properties of the original EDG 103 block are so radically inferior to those of the 101 and 102 blocks.

A Okay. I think we can answer that. Let me ask Dr. Wachob to do it.

A (Witness Wachob) The casting of large cast iron parts such as the cylinder block that we're talking about today are, as we have mentioned before, affected strongly by the cooling rate.

In addition to the cooling rate, however, levels of tramp elements can lead, and in rare occasions do lead to Widmanstaetten formation.

An additional factor that has to occur beyond this tramp-level problem is the fact that wet molds or hydrogen or water somehow have to be involved in that casting process.

And it is a synergism that occurs between those three items. When those three items are present you get significant, extensive, degenerate Widmanstaetten formation. We don't know which combination of those have occurred, but obviously the 103 block does show the fact that Widmanstaetten has occurred and that these variables obviously played an important role in producing it.

WRBeb

Q Last Tuesday Dr. McCarthy testified that tramp elements were present in the old EDG 103 block. Would you have any opinion as to why the discovery of those tramp elements in the B bar that was cast at the same time as the old 103 block did not reveal the presence of those tramp elements before the block was placed in service?

A (Witness Rau) Yes, Mr. Goddard. The answer to that is that the chemical analyses done by the fabricator, TDI, and reported did not include chemical analyses for all the tramp elements including lead.

And again we stated previously the specification for acceptance of the Class 40 gray cast iron did not require such analyses either.

Q But those analyses were in fact performed subsequently, weren't they?

A They were not performed by TDI, to my knowledge. They may have been.

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Q And they were performed by FaAA subsequently? I'm sorry I confused you with the question.

JUDGE BRENNER: Well, you don't know that TDI did not perform such analyses, either, do you?

WITNESS WACHOB: The chemical specifications and call-out of the particular heat do not list lead as one of the elements that was analyzed for. It lists a variety of other ones, but not lead.

WITNESS RAU: But you're right, we have no reason to know one way or the other whether they have subsequently-- They certainly had access to pieces of the original 103 block, and what they've done with them I don't know.

JUDGE BRENNER: I'm not asking about subsequently, I'm asking about at the time they originally tested the B bar.

WITNESS RAU: We only know what they reported, your Honor.

JUDGE BRENNER: Does LILCO know one way or the other whether TDI performed any analyses of the B bar which would have disclosed the tramp elements; I take it lead being the primary one?

Am I right, Dr. Rau, that if they had performed one for lead, that would have been a good tip-off for the Widmanstaetten problem?

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WITNESS RAU: No, I don't think that's completely correct, your Honor. Certainly if you were to measure very large amounts of lead, that would be a tip-off. The levels of lead which had been measured in the original 103 block casting are certainly sufficient, given the slow cool rates and the presence of moisture or hydrogen to introduce degenerate Widmanstaetten graphite. But those levels alone would not necessarily have been a tip-off.

JUDGE BRENNER: Maybe I'm wrong: don't you always have moisture and hydrogen present in a large casting process such as is going on here, or did go on here?

I guess I don't know what you mean by the significance of the moisture and hydrogen.

WITNESS RAU: No; I think it's a matter of degree, your Honor. There are certain specifications, and they differ with different fabricators with regard to the pre-heat temperatures and things which are designed to dry out, if you like, and to eliminate the moisture from the mold materials. To the extent that is done less well, or not done at all, or not done adequately, you can get excessive amounts of moisture which then turn to steam during the process, and produce extensive amounts of hydrogen which may not normally be there if the procedures are followed.

JUDGE BRENNER: Let me return to the question I

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asked a few questions ago of LILCO, whether LILCO knows one way or another whether TDI performed other analyses of either the original 103 block or the B bar beyond that which was reported to LILCO at the time and accepted, the old 103 block.

WITNESS YOUNGLING: Judge, we are not aware of any additional analyses.

JUDGE BRENNER: Are there any other TDI blocks -- and I'm addressing this to LILCO and FaAA collectively -- which have lucked out the way the old 103 block did, and had a large presence of this degenerate Widmanstaetten graphite structure, or is this one of a kind?

WITNESS RAU: It's definitely not one of a kind, your Honor. We have first-hand information of the presence of degenerate graphite, Widmanstaetten graphite, in one other block which we have had the opportunity to examine.

Perhaps Dr. Wachob would like to provide additional detail on that.

WITNESS WACHOB: One other additional block out of -- I believe it was a V block. We had the opportunity to go and replicate and to remove a section of that block, and it does show extensive Widmanstaetten graphite.

So that we have at least two instances where we know that Widmanstaetten graphite has occurred in the cylinder block castings.

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JUDGE BRENNER: Is that a block being used at a nuclear plant? Is that a block of TDI diesel being proposed for a nuclear plant, or in use in a nuclear plant?

WITNESS WELLS: The block we're referring to is the so-called St. Cloud engine used in commercial power generation in Florida.

JUDGE BRENNER: Okay. I'm sorry; I knew that from your testimony.

Those are the only two that--

WITNESS WACHOB: The other important factor is that this St. Cloud block also had substantial cracking stud-to-stud as well as ligament cracks.

WITNESS RAU: I think those are the only two we're aware of, your Honor. But you're also aware that there hasn't been extensive examination of the other blocks.

JUDGE BRENNER: Do you know if the-- Remind me of one fact: Am I correct that if you examine the B bar for the original 103 block, you will not find the Widmanstaetten graphite problem? Is that correct?

WITNESS RAU: It's my opinion you will not. We obviously did not have the bar to cut up. But the test results indicate to me that, in fact, it did not have extensive Widmanstaetten graphite. I mean, we wouldn't expect it in that diameter casting.

JUDGE BRENNER: I guess I don't know why,

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obviously you wouldn't have the bar to cut up. Could you explain that?

WITNESS RAU: Yes. TDI doesn't have it any longer. Or at least that's what they represented to us.

JUDGE BRENNER: Well, I'm glad we clarified that. I was under the misimpression that your testimony about the condition of the B bar for the old 103 block was based on an examination of the block -- of the B bar. And it's not?

WITNESS RAU: No, sir, it's based upon the reported measurements of the tensile strength reported by TDI.

JUDGE BRENNER: Is that a typical practice, not to keep the B bars around for blocks that are sold and accepted?

WITNESS RAU: That is not uncommon practice, your Honor. They may be kept for short periods of time, but certainly over a period of seven or eight years we're talking about here it would not be -- it could be more common than not, I think, to discard such test bars after some period of time.

But different manufacturers do have different practices: there are some who keep them for extended periods of time.

JUDGE BRENNER: All right.

The question I was leading to before I got too

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diverted with this interesting bit of information was if you know whether the B bar or any other test bar -- as you have discussed, the A, B, C designation is for different size test bars -- whether any test bars for the St. Cloud block have been examined by yourself or others as to the presence or absence of the Widmanstaetten degenerate structure, and what that test bar shows, if, in fact, such test bars have been examined, to your knowledge?

WITNESS RAU: Your Honor, we're not aware of any tensile bars that have been cut out of any location in the St. Cloud block.

JUDGE BRENNER: All right. I was not restricting it just to cut-outs.

Maybe I'm not understanding your term. But I thought that a B bar, as contrasted to a cut-out, is a bar that is cast in the same pour as the block is cast. And I would not have called that a cut-out: maybe you would.

WITNESS RAU: That's correct, your Honor. We're not aware, and we have not had access to either the B bar or any other bar, or any samples cut from the St. Cloud bar.

We have, in fact, as Dr. Wachob indicated, examined the block and are aware of the cracks present in it, and the microstructure.

JUDGE BRENNER: Did you attempt to learn whether there were any similarities in the casting of the old

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Shoreham 103 block and the St. Cloud block which were common to those blocks and different from the other blocks that did not have the problem1? Or was that beyond the scope of your investigation?

WITNESS RAU: The answer is yes, your Honor. But we were not successful in getting any detailed information from TDI with regard to the specifics of the casting on the original 103 or, for that matter, the St. Cloud.

JUDGE BRENNER: Do you know --and, if so, what's the answer -- whether TDI had the B bar, or any other test bar for the 101 and 102 blocks still in existence?

I ask LILCO also. Anyone can answer.

WITNESS RAU: Your Honor, I don't personally recall asking specifically that. But we had numerous discussions with TDI where we attempted to ascertain all the related, and what we thought relevant, background. And that's one of the things we would have been asking for. And I'm relatively confident we were told that those bars for 101, 102 and the original 103 just were no longer in existence.

JUDGE BRENNER: I have restricted it, in some of my questions, to the B bar because we have been talking about that. I don't mean to do that. I should broaden the question to any what you would consider comparable test bars; in other words, something that might be representative

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of the block which was cast out of the same pour.

I'm not hearing any affirmative answer from anyone on the panel.

WITNESS RAU: We have asked, your Honor, for any samples, relevant samples, from 101 and 102, and been told there are none.

JUDGE BRENNER: Mr. Youngling, do you know if anybody asked explicitly for any test bars for the 101 and 102 blocks from TDI?

WITNESS SCHUSTER: I believe Mr. Isleib, when we went to TDI in 1983, did -- you know -- have some discussions with TDI in regard to the chemistry. I don't remember the specifics of -- you know -- of the examinations. And that's the reason why I haven't discussed it earlier.

WITNESS RAU: Your Honor, if I could add one more thing.

TDI also informed us during our discussions that the current procedure in which they cast a series of different size bars in the same pour with their casting was not utilized back at the time of the fabrication of the original 103, 101 and 102. And, in fact, there only was a B bar at that time. Whereas, today, for example in the replacement 103, there was a B bar, and there were C bars and D bars. And they did have additional material now, but

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they did not have such material at the time of the casting of 101 and 102 and the original 103.

JUDGE BRENNER: I was going to wait and ask you about a related point, but as long as you mentioned it: In your Exhibit B-40 you refer to, I think, to a "cast-in" test block for the new test bar for the new 103 block.

Is that something different than the way the B bar for the old 103 block or the 101 or 102 block would have been prepared? Can you explain what the significance of the term "cast-in" is?

WITNESS RAU: Your Honor, again, TDI has indicated to us that by their current procedures, at least by the procedure that was used in the replacement 103 block, they did in fact modify their mold so as to cast some of these larger diameter bars in one of the cavities which ordinarily would be the center of a cylinder, if you like; what would ordinarily be sand with nothing in it. Clearly they have added additional material in there, as a minimum. And it's also our understanding that the position of the B bar at the time of casting 101, 102 and 103 is not necessarily the same place that these samples are located. But we were not able to ascertain the detailed position of the B bar in the mold at the time of 101, 102 or the original 103 casting.

JUDGE BRENNER: Is my inference, however, correct, that it is not surprising or significant in your

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professional opinion that the B bar for the old 103 block would not exhibit the degenerate Widmanstaetten structure, whereas the block itself did?

WITNESS RAU: That's not at all surprising, your Honor.

Yes, in our opinion, and based on quite extensive technical literature, it requires a slow cooling rate in addition to these other factors in order to produce the degenerate Widmanstaetten structure. And the technical references are basically unanimous, really consistent, that in thin cast bars even when people have attempted to produce it they have been unsuccessful in producing it.

JUDGE BRENNER: In talking about the test bars, I think it's fair to say it's mostly your testimony rather than the questions that have begun to focus on B bars for the old 103 and the 101 and the 102 block. And you've discussed that the method whereby TDI is casting test bars has changed since that time. But were there other test bars prepared for the 101 and 102 block and the original 103 block besides the so-called B bar?

WITNESS RAU: It is my understanding, your Honor, that there were not. That's what TDI responded to a very direct question posed by me.

JUDGE BRENNER: Is that your understanding, too, Mr. Younling? Or anyone from LILCO who would be in a

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position to know?

WITNESS SCHUSTER: I don't completely understand the question, your Honor.

JUDGE BRENNER: The question is: with respect to the 101, 102 and original 103 block, at the time they were cast by TDI were there any other test bars prepared in any fashion besides the so-called B bars for each block that we have been discussing?

WITNESS SCHUSTER: Not to my knowledge, sir.

JUDGE BRENNER: Is your knowledge based on any records, or having asked?

WITNESS SCHUSTER: It's based on my recollection of the work that Mr. Isleib did when he was in Oakland, sir.

JUDGE BRENNER: I'd like to ask this for any witness for LILCO:

Were there any requirements involved in a procurement or quality assurance process for TDI to prepare certain types of test bars and maintain the existence of those test bars?

WITNESS SCHUSTER: The thing I would like to add, your Honor, is that the test bar is destructively tested, so you really don't have the bar. You do a tensile test -- you know -- chemical, whatever it happens to be, whatever the requirements are, and you, in essence, destroy the bar. You might have some pieces left over. But, you know, the bar

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itself to my knowledge and my understanding, you know, would not be something that you would have around at that point.

JUDGE BRENNER: I thought I heard some testimony, and maybe I misunderstood, that some fabricators do, in fact, keep certain test bars, or maybe it's only portions of test bars, around. Is that wrong?

WITNESS RAU: I said that, your HOnor. And that's true. What we're talking about is keeping the actual broken samples.

They have a procedure, sometimes they keep it for 'x' number of years in case some issue comes up.

JUDGE BRENNER: You never know.

I guess my question remains the same to LILCO.

WITNESS SEAMAN: What I can add to that is, we didn't have any specific requirements and/or specifications to have them retain the pieces of the B bar, for example. The specification did require that they issue a certified material test report which included reported results of the B bar test. And we have that in our documentation package as part of the original purchase requirement for the block.

But that's the extent of it in terms of B bar or any other type bar testing.

JUDGE BRENNER: Does anyone know from any records or other information from TDI when TDI disposed of the B bar for the original 103 block and the 101 and the 102 block?

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Was it right after the tensile stress, or do they keep it for some period of time? Months or years? Did they throw it out in August of '83? Does anybody know?

WITNESS YOUNGLING: Judge Brenner, we never asked them that question. So I do not know when they disposed of it.

WITNESS RAU: The only thing I can add to that is, it certainly was prior to the time we made the request of TDI, which would have been relatively late July or August, certainly some time prior to that, this year. That's all we can say.

JUDGE BRENNER: Actually, that's an inference on your part, too, isn't it?

WITNESS RAU: Well, it's what they told me in response to a direct question asking for those materials.

JUDGE BRENNER: Mr. Schuster, you wanted to add something?

WITNESS SCHUSTER: The testing of that material is documented on certain material test reports. Those reports are certified to be accurate and true. And, you know, the necessity for that material to be around for an extended period of time, you know, becomes less with the amount of certification that goes with the material. And I think that that ought to be pointed out.

JUDGE BRENNER: Those test certification reports

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which were received by LILCO, did they show any difference in ultimate tensile strength for the 103 B bar as compared to the 101 and 102 B bar?

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WITNESS SEAMAN: Yes, Judge Brenner, it did indicate that the tensile strengths were a little bit less -- on the order of 10 percent less -- but still above the minimum requirements by the ASTM standard. I could check the specific numbers if that is of interest but again they were on the order of 10 percent less than what we saw in 102 and 103, but still above the minimum required for the standard.

JUDGE BRENNER: I know I'm talking about quite a few years ago, but did LILCO make an increase as to what might have accounted for the difference in ultimate tensile strength test reports even though, in LILCO's view, all the ultimate tensile strength reports were still acceptable?

WITNESS SCHUSTER: Your Honor, could I direct -- could I help in one area? Mr. Seaman referred to 101 and 103 and the lower tensile strength was in the 103.

JUDGE BRENNER: That's the way I heard him and if he said it differently it shows that when I think I know what I'm going to hear it plays tricks on me But thank you, Mr. Schuster.

WITNESS RAU: Sir, did you ask for the specific tensile strengths?

JUDGE BRENNER: No.

WITNESS RAU: I'm sorry.

JUDGE BRENNER: And I should disagree with

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Mr. Seaman's testimony that it was approximately 10 percent less. I did not pursue it further and that's consistent with what FaAA said last week or two weeks ago. I guess last week.

Do you disagree with his testimony that they were all acceptable?

WITNESS RAU: No, sir. I do agree. I do not disagree.

JUDGE BRENNER: All right.

My followup question, if you will, was whether LILCO made any inquiries or sought any information to ascertain why the strength of the 103 block as represented by the tests was approximately 10 percent less than the 101 and 102 block.

WITNESS YOUNGLING: Judge Brenner, the materials certifications would have been reviewed by Stone and Webster as part of their review of the specification of the as-delivered product. They did not tell us of any problems. And in retrospect if they were looking at gray 40 and saw the ultimate tensile strengths within the range, they probably would have been accepted. I'm not aware of any questions that were asked as to the differences.

JUDGE BRENNER: To your knowledge, did you or anyone else for LILCO go back and try to ascertain whether, in fact, any questions were asked at the time given the

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the later discovered problems with the old 103 block?

WITNESS YOUNGLING: Judge Brenner, there was a very detailed review of the review done by Stone and Webster on that specification and the as-delivered product. And during that review we did not see any documentation which would have shown any questions being asked.

JUDGE BRENNER: Dr. Rau, since you have the numbers and I'm still not going to ask you for them, maybe I will later or maybe somebody else will, but was there anything significant about the difference in the numbers that should have caused a professional reviewing those tests to inquire further, even though they all met the required classification?

WITNESS RAU: It's difficult for me to answer that since I'm not a manufacturer and a caster of these particular blocks. All I can really say is --

JUDGE BRENNER: Make believe you have forked over big bucks to buy them and you're reviewing them.

WITNESS RAU: If you're a manufacturer and you have a standard procedure for making a block like this and you measure B bar properties and you routinely get 45 to 47 Ksi and you get that each and every time, one after another, month after month, year after year, and all of a sudden you get one at 42.4 for example, that might be an indication that something is different about that particular block.

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But I don't quite know whether or not all of their blocks were coming on 45 to 47 or whether some of them occasionally came out to 42. It would depend really on the control which the fabricator has on the process and how reproducible it is as to whether or not it should have been a flag for something different.

JUDGE BRENNER: Well, you're a good salesman. You have convinced me that I should ask you for the number now, because I don't know if the ones you were using, for example, are the numbers or not.

Can you give them to us?

WITNESS RAU: The B bar result, your Honor, on the original 103 was 42.4 Ksi.

JUDGE BRENNER: Mr. Goddard, I hope you'll forgive me for all of this but as I said, you're heading down a similar path and I'm afraid I would have forgotton all my questions otherwise.

MR. GODDARD: As long as I can get a reasonable extension of my one to two-hour estimate on my cross examination.

JUDGE BRENNER: Absolutely.

WITNESS RAU: Your Honor, the other two B bars were 45.2 and 46.7 Ksi, respectively. And I've got the engine number. One is 74010 for the first and 74011 for the second.

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Perhaps Mr. Youngling or one of the LILCO people can identify which of those two is which.

JUDGE BRENNER: I don't think it is significant but if you have it handy, Mr. Youngling.

If you don't know, I don't need it.

WITNESS YOUNGLING: The lowest serial number is the 101. So --

JUDGE BRENNER: Okay.

Previously, somebody tried to explain and I think it might have been you, Dr. Rau, but in any event somebody from FaAA that you can have variations in the ultimate tensile strengths for a large casting such as this block and still be within the class. And I think the example you gave us was something along the lines of the fact that you could have a class 40 gray iron that actually tested at 55 Ksi ultimate tensile strength. And you could have a class 50 that tested at around 52 Ksi. And if that's the case what are the criteria for assigning a classification to the block? Is it just the ultimate tensile strength or is it something else and what do you use to measure that ultimate tensile strength to fit within the class, since the UTS can vary in places?

WITNESS RAU: It is a fact, your Honor, only the ultimate tensile strength by the ASTM A48-64 specification.

JUDGE BRENNER: Is that based on a particular

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size test bar?

WITNESS RAU: Yes, your Honor. Typically, the ASTM specification calls out a letter after the specification. For example, there might be a glass 40B which would indicate it's the B bar which is used to evaluate whether or not it meets the minimum requirements of class 40. Sometimes you call the class 35C, for example. That might be exactly the same material, just that the evaluation is done on a thicker bar and you have a lower minimum ultimate tensile strength.

JUDGE BRENNER: All right. How were the procurement orders for the Shoreham blocks set up. Was it just class 40 without any limitation to a typical test bar. And if that's the case, what is it that guides the buyer and seller towards a mutual meeting of the minds as to what test bar would be the standard?

WITNESS YOUNGLING: Judge Brenner, I would have to review the documents, the specifications, and get back to you on that.

JUDGE BRENNER: All right. If you could do that, I think I'd be interested in knowing that.

All right. I think it's about time for a break. When we come back we'll go back to your questions, Mr. Goddard. Let's take a 15 minute break until 3:50.

(Recess.)

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JUDGE BRENNER: Back on the record.

Mr. Dynner, I recognize that you just received LILCO's motion this morning. At least I assume you received it when the Board did. And although we would like to discuss it today, if you want to put it over until tomorrow morning, we will accept that also.

MR. DYNNER: I am prepared now, Judge, to discuss it, as I said I would be after the break. There may be a document I was trying to find. I can refer to that document, and I haven't been able to find it just off this quick 15-minute search. But I am prepared, if you want to, to discuss it now, or we can wait. It is at your discretion, sir.

JUDGE BRENNER: All right, let's do it now then.

Mr. Farley, did you want to add anything to the written motion which we have read, and the testimony, which we have read but perhaps not thoroughly digested?

MR. FARLEY: I found from our colloquy on the motion to strike in connection with the testimony at the beginning with Dr. Wachob that I think the best procedure is for you to, if you have any questions, ask me.

The only thing that I can assure the Board personally is that since I have -- this occurred since I have been personally responsible for the block testimony and no matter what anybody says, the only criticism that could

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be leveled at this is the possibility of timeliness. As far as turning over all the documents, the County has got them and the Staff has got them as soon as they were in existence.

As far as the relevance and the materiality of it, I don't think there is any question that it jumps out. I have done it as fast as it was humanly possible to do it. There were a lot of people working very, very hard, very, very long hours to get it done earlier and it just could not be done.

Now it has been characterized---

JUDGE BRENNER: We don't know if anybody objects yet, although it sounds good. Maybe I should let you go aryway.

MR. FARLEY: I was saying, Judge, it is being characterized as a moving target, which I think is not exactly accurate. I can't help, LILCO cannot help, FaAA cannot help, nobody can help a complex compcnent like the blocks and the effort to agree with Staff on the testing that they requested and the testing going on.

And then I've got this obligation to produce everything and tell everybody about everything, and then I get hit with the supplemental testimony by the County, and then I can't do anything about it. And that doesn't make any sense to me.

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JUDGE BRENNER: That's not accurate, Mr. Farley. LILCO could have the right to request rebuttal testimony and I indicated that could be orally or in writing, and you'll recall we had some prehearing discussions pertinent to that, too. I will leave it at that.

MR. FARLEY: You are exactly right, Judge. I do agree.

JUDGE BRENNER: I do have a minor question which you may deem to bear on timeliness although I wasn't going to put it that way, that precisely.

Around about the day before we recessed for the two-week break which -- I guess the last hearing date was October 4th, if I've got my dates right, that Thursday, in any event, on or about October 3rd -- and I don't have the transcript but I think we had a little dialogue, you and I, in which I pointed out that you had orally told us that cam shaft gallery cracks had been discovered on the new 103 block, or crack indications, and I said that on behalf of the Board, we appreciated that timely oral notice.

You also told us that it was LILCO's then present intention not to file any supplementary testimony on it, and I didn't comment one way or the other whether I thought that wise or unwise, nor would it have been appropriate for me to do so.

What I did say was if you were not going to file

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testimony, you were going to have to find some other way of giving us something in the nature of a Board notification that would fill out the very concise and necessarily preliminary oral notification by you. And what I had in mind was if you did something in writing, you could obviously have your experts look at it and make sure you were putting it correctly, and so on.

And you said -- and this last part may be off the record, but I believe you said it -- that you were going to -- you were working on it that afternoon, I think, some words to that effect, and we were going to get it. And I expected that to be a time frame of a day or two from October 3rd or 4th.

And with uncharacteristic passivity I waited through the whole break, through a period of two weeks without issuing an order asking where is it, although I thought about it from time to time. But I figured you knew what you were doing and the time would come when we would pull all this together. And I guess the time has arrived here.

And that basically comes around I guess to timeliness. I thought we were going to hear something about this in writing from LILCO long before today. Even though there may have been some work done in the last few days which could not have been included in that, at least we

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would have, I expected, have gotten a report on exactly what was discovered, exactly what LILCO was doing about it, and kind of a status report, if you will, of what work was going on and when we might expect that work to come to some conclusion.

And that, with 20-20 hindsight perhaps, -- but I don't think it's hindsight, I think we knew what was happening even back then in terms of the procedures -- would have given you the foundation to say that was the notification and everybody heard about it two weeks ago, including the Board, and now you have decided to file testimony because you've got something to report, and that is as a result of the work that you told us formerly was in progress. But we didn't quite get that foundation.

So if you want to answer, I am curious as to why not.

MR. FARLEY: I did not propose to file any supplemental testimony. I did propose to comply with your order about formal notification which is exactly in accord with my recollection.

The first time that I knew anything about strain gage data was when I am in California for the deposition of Messrs. Rau, Wachob and Taylor.

JUDGE BRENNER: That was October 11th.

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

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Then we produced the preliminary sketch that was made an exhibit to the Rau Exhibit 3 of the deposition--

JUDGE BRENNER: Let me interrupt because I really think I got a little long-winded in my comment before. But more precisely, my question is why did we not receive the written Board notification very shortly after October 3rd or 4th, which you said you would file when your decision was not to file any further testimony on the subject of new discoveries of cam shaft gallery crack indications in the new 103 block?

MR. FARLEY: Judge, my recollection was that we had a discussion in which we were scheduling the filing of the supplemental testimony by the County and by the Staff, in which you set the date of the 18th. And it was at-- Whatever day that was, that was the day that you told me to do something by October the 12th, which is -- and my recollection of the transcript is that I said that was all right.

I get to October 12th and I don't know what to do because the strain gage data has not been reduced. So we come back here to get ready for the hearing.

Last Tuesday I asked for the data. It is still not available. And my consultants keep working on it, and it is not a simple thing to do. And I get it Saturday night.

JUDGE BRENNER: I guess I understand what you are

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saying. I think somewhere in my rambling comment before there was a solution to your problem, and I can tell you I have been there, where experts whom I was going to put on as witnesses are still developing things. And there are a number of ways of accommodating that, one of which I suggested.

Let's hear what the parties have to say to your now-pending motion to admit this testimony.

Mr. Dynner.

MR. DYNNER: Judge Brenner, the County would strenuously oppose the motion that LILCO has made to insert this new testimony. The reasons are basically as follows:

First of all, the strain gage testing and additional measurements that form the basis of LILCO's testimony, or at least the strain gage testing, is a part of the confirmatory testing, so-called by LILCO, in LILCO's status report dated October 17th, 1984, and filed with this Board and the parties.

As the Board knows, that testing involves, among other things, operating the EDG 103 engine with its replacement block for an aggregate of 740 hours at 3300 Kw and, at the same time during that testing, taking strain gage measurements of the cam gallery area.

LILCO filed its status report, and I note for the record that of course the County has not responded to it, in

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which it argued basically that these proceedings should not be delayed by virtue of this additional testing, that the proceedings should go ahead as if nothing were happening but that, in accordance with LILCO's interpretation of the Byron case, this Board should keep the record open and at the end of all the testing, and I think they estimated -- in fact I know that they estimated that the test and post-test inspections were not expected to be completed until December 2nd, at that time, when presumably all parties would have available to them the test data, and it could be reviewed by the experts, at that time the parties could come back to the Board and show that something significant had happened as a result of that testing.

We haven't responded to that report but we have not so far vigorously objected to that position and in fact, we have gone forward, I think quite vigorously, in an effort to expedite these hearings and get them over with.

Now we have LILCO bringing in or attempting to bring into this proceeding a portion of the testing being carried out and reported in its status report that LILCO feels may be favorable to LILCO's point of view.

The County of course feels blind-sided by this. We have not had an opportunity to prepare to have discovery as to all of the testing that is going on, and we now--

JUDGE BRENNER: If I could interrupt for just a

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moment, and then I will certainly let you continue.

Mr. Farley represented that all the parties, including the County, were being given everything that was generated as a result of these tests. I took that to include these latest strain gage test reports.

MR. DYNNER: No, sir, the only documentation that I've received on the strain gage test is the single chart or graph that Mr. Farley alluded to that was given to me as I was about to commence the deposition on Thursday, October 11th. I have not seen any documentation other than that.

JUDGE BRENNER: I'm sorry for the interruption. Why don't you continue?

MR. DYNNER: Yes, sir.

Now I spoke earlier about shooting at a moving target, and clearly this is even more egregious a situation, much more egregious a situation of shooting at a moving target than the reference this morning which regarded additional testing on the composition of the so-called oxide layer.

It is our position that LILCO was given full and fair notice, indeed was given an order by this Board. I do have the transcript of October the 3rd and its relevant pages in extract form. It shows at transcript page 24,075 that I raised on the record on October 3rd and said:

"LILCO's Counsel informed me yesterday

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that at the present time they do not expect that the crack indications on the new replacement, the 103 block, will lead to additional supplementary testimony on LILCO's behalf although it may in the future."

Mr. Farley responded to my statement on transcript page 24,082, in which he said:

"Mr. Dynner indicated to you that we may file supplementary testimony on the new 103. I think that is very, very unlikely. I don't want to say absolutely, positively it won't be done, but I don't want to give the impression that it is something that is contemplated."

And Judge Brenner, as you have noted, you then noted that somebody is going to have to tell the Board what was going on with these new indications that had been found, and you said in fact on transcript 24,083:

"Some sort of notification or summary of what the situation is, if we are not otherwise going to hear about it in the testimony...."

would be required.

And Mr. Farley said "All right."

You then, Judge Brenner, set a time for the filing by LILCO of anything that it may have to say on the subject, whether it was the notification which you ordered

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LILCO to present, or supplementary testimony.

There was a discussion on 24,086 of the transcript, and on 24,087 you said that you think that:

"If it got in...."

You were speaking of LILCO's supplementary testimony.

"If it got in the parties' hands at least by October 12th, then you would be on safe ground, and anything beyond that will depend on viewing the factors."

Mr. Farley said the 12th it is, or "The 12th is it," the transcript says. I think it means "The 12th it is."

And Mr. Farley has quite rightly agreed that the 12th was the filing date.

Now I quite --

JUDGE BRENNER: Well, Mr. Farley and I had a pretty good recollection of it as it turned out, in our little dialogue just before.

MR. DYNNER: Yes.

Now I quite understand that certain data might not have been generated in time. I think that in time as we all live with the deadlines that the Board sets forth -- and I don't like some that the Board sets either -- this is simply a case in which, as the status report indicates,

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additional testing was being carried out. I'm not sure when it started but clearly that additional testing began prior to October 11th, the day of the deposition, because I was given and had an opportunity to ask some question on a chart showing some preliminary information from that strain gage test.

Nothing else was forthcoming and nothing was forthcoming before we filed our supplementary testimony on behalf of the County on October 18th. Therefore, we were deprived of the opportunity of responding to LILCO's supplementary testimony or modification and report upon the situation with the new 103 block.

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Now we come to the motion's timing which occurs on October 29, the day when the County concluded it's cross examination of this Panel. I wish to bring to the Board's and parties attention the fact that it was on October 22, the day that the County's cross examination began, that this Panel attempted to bring before the Board new testimony concerning this strain gage testing that was October 27. And Dr. Wells, on transcript page 24,381, related to and gave some information about the new strain gage readings and I, of course, objected and moved to strike. Judge Brenner ruled on transcript page 24,385 that there was no testimony on a strain gage analyses performed by FaAA on the cam gallery and at least with respect to the reference to that strain gage analysis he ruled that that reference should be stricken and that's on transcript 24,386 to 387.

Now --

JUDGE BRENNER: Actually, I don't have to go through it. We granted the motion that there is a typo in there but what I say on line 15 is we are going to grant the motion. It wasn't actually striking anything in particular but we don't have to rehash that. We know it was done.

MR. DYNNER: Yes, sir. Now, LILCO's motion says that it wasn't until October 27 that the vertical stress results from the strain gage testing was available. That's on page 2 in numbered paragraph 3 of its motion. I don't

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and am not suggesting that LILCO's motion is incorrect. But I do point out that as early as the 22nd, the first day we were starting to cross examine these witnesses, apparently at least Dr. Wells was prepared to testify about the strain gage tests on that date.

In conclusion, and I'm sorry this has been so long, but we feel quite strongly about the impropriety of this motion, it is clearly not only untimely but would seriously prejudice the County. In terms of cross examination of the witnesses, we have not had an opportunity for full discovery on these matters. It is a classic case without placing any blame at anyone's feet, of being blind sided and of shooting at a moving target if ever there was one. And for those reasons we object to this motion and request that it not be granted.

JUDGE BRENNER: Mr. Goddard?

MR. GODDARD: The Staff would not oppose LILCO's motion outright. However, many of the points made by Mr. Dynner in his opposition to LILCO's motion to admit this testimony, the Staff would support as being valid. Without reaching the question of discovery, the Staff would at least request that in the event this testimony were to be admitted and that LILCO's motion to get the same were granted, that the Staff and County not be placed in a position whereby they would not have this Panel available for cross

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examination on this testimony at some time subsequent to the Staff's instant cross examination and, of course, allow the County a chance to reopen it's cross examination within the scope of this testimony. For planning purposes, the Staff would not be ready to proceed before Thursday of this week. The Staff has no position with regard to what sounded like an impending request to reopen discovery by the County. The Staff at this point has no -- the Staff has no plans even if the court would entertain such a motion to reopen its own discovery on this issue.

In short, the Staff's position is we would not opposed the motion if the needs of the other parties could be accomodated if this testimony were to be admitted.

JUDGE BRENNER: All right. Thank you. Mr. Farley, I am looking at the status report, LILCO's status report, dated October 17?

MR. FARLEY: Yes, I have it.

JUDGE BRENNER: And page 5 of that report, the first full paragraph on that page states, "LILCO does not, however, seek to supplement or reopen the record at this time to include this information." And among other things, that sentence follows, as I read the document, the strain gage measurements. Isn't that inconsistent with what you are asking us to do just a short time later?

MR. FARLEY: I beg your pardon?

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JUDGE BRENNER: Is that sentence not inconsistent with that which you are now asking us to do?

MR. FARLEY: I think it is inconsistent but it is explainable. First of all, your Honor, we did not have the liquid penetrant or the magnetic particle inspection reports as we said in our motion until the weekend of the 21st. They weren't even done until after the October the 12th date. As soon as we got them, those are the documents that I said that we gave to the County and to the Staff. The strain gage data consists of tapes and so they have to be reduced and the data is reduced in the form of the Exhibits attached the the motion. Monday of last week I told Mr. Dynner that I had only one set of two sets of photographs, one showing the locations of the cam gallery areas before the strain gages were put on, and one showing the area after the strain gages were put on. I was sorry I only had one set but he could look at them any time he wanted. I haven't heard anything further.

JUDGE BRENNER: That was the 15th?

MR. FARLEY: That was last -- the 22nd.

JUDGE BRENNER: All right. That's Monday of this week, isn't it?

MR. FARLEY: Today's the 29th.

MR. DYNNER: Judge Brenner, I feel absolutely compelled, if I may, just to clarify that point, because I

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want the record absolutely clear. Mr. Farley, in fact, did offer to have us look at these things. At that point I said to Mr. Farley, but Milton, this is part of this overall testing. And I understand your status report is we are not going to put all this testing in. Now, you can't have it both ways, I said. Either you leave everything out for now and we go ahead and proceed with this hearing, or we go in and say this stuff is all relevant and let's wait until December 2nd or whenever we get a chance to review all the testing and then we will proceed. But you can't have it both ways. And for that reason I don't see any reason why you should give me everything piecemeal.

I would like to have it. I want that discovery. I have asked, in fact, and wrote a letter to the Staff that I want to get all of the information and inspection reports from these so-called confirmatory tests.

And I told Mr. Farley I would appreciate getting that directly from him so I didn't have to get it from the Staff but that I thought it was not relevant to these proceedings. During that conversation Mr. Farley never told me, never hinted, at the fact that he was going to file supplementary testimony on the strain gage data and on the strain gage testing.

So there was an opportunity, because I talked to Mr. Farley to advise us, and it wasn't until Friday, in

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fact, this past Friday, when I called Mr. Farley and I said, Milton, one thing I want to tell you, you know, is I've been looking back in the transcripts and I see the Board has ordered you to put in some kind of notification about these cracks in the cam gallery area. I'm going to raise it with the Board, but I don't want to blind side you. And so I'm telling you now in case you've forgotten about it.

Mr. Farley, at that time, said, well, that's going to go in along with our supplementary testimony. And that was the first time that he said anything to me about it.

JUDGE BRENNER: When was that?

MR. DYNNER: This past Friday. And I told him if it came in -- I didn't know what is motion would look like, but I said I'll oppose it.

JUDGE BRENNER: I thought you were going to tell me you said well you would be glad to look at when you came in and take a position on it.

MR. DYNNER: I told him flat out that I would oppose it and I gave him some of the reasons why and they're obvious. Sorry for the interruption but if we were going to tell what happened, we want it to be complete. And I will add that Mr. Farley, I think, probably misspoke when he referred to mag. particle and liquid penetrant tests. Those, in fact, were given to us around October 3rd and they

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appear as Exhibit S7 in the County's Supplementary testimony.

MR. FARLEY: You have documents that were served on Sunday, the 21st.

JUDGE BRENNER: Every once in a while I think I should take a 10-minute rest and let you two thrash it out and I'll be glad to do that if you want.

MR. FARLEY: No, sir, I'd rather have you run it.

JUDGE BRENNER: Well, in that case, let me do it.

MR. FARLEY: Yes, sir.

JUDGE BRENNER: Mr. Farley, can you tell me what the significant bottom line is in this testimony that you want to put in, in view of the fact that it is apparently part of the ongoing testing program discussed in your status report on which there may be other facts uncovered next week and the week after all the way until your proposed completion date which, as I recall, is early December?

MR. FARLEY: There are two bottom lines, Judge, and that is the measurement of the depth of the cam gallery cracks at 2 and 8, I think it was, on the replacement 103 and the second is the strain gage results which are confirmatory of the opinion that FaAA has already expressed and that is, namely, that the vertical stresses in that area are compressive, thus, preventing any crack propagation.

JUDGE BRENNER: How do we know you might not have

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different crack measurements next week, either in these same areas or other areas and that are deeper, for example.

MR. FARLEY: I can only respond that I don't expect that, your Honor, but that is a fair observation.

JUDGE BRENNER: The testing and measurement program is still going on including the gage measurement; isn't it?

MR. FARLEY: I don't think the gage measurement is going on now. They probably will go on after the engine test is completed.

JUDGE BRENNER: I understand that.

MR. FARLEY: Yes, sir.

JUDGE BRENNER: But the preoperational strain gage measurements are complete on the new 103 cam gallery areas?

MR. FARLEY: I'm sorry, sir?

JUDGE BRENNER: Are you telling me that the strain gage measurements of the cam gallery areas on the new 103 block prior to test operation are now complete?

MR. FARLEY: That's my understanding, yes, sir.

JUDGE BRENNER: Everything you have to say about it is in this testimony?

MR. FARLEY: Yes, sir, that's my understanding.

JUDGE BRENNER: And the supporting documentation exists for it?

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MR. FARLEY: Yes, sir.

JUDGE BRENNER: Mr. Dynner, partially in consideration of your claim of prejudice, part of this proposed additional testimony by LILCO deals with their view as to the fact that the forces are compressive in the cam gallery area. Is there not Staff testimony on the same lines which you have to be prepared to discuss through your cross examination and/or any further followup?

MR. DYNNER: Yes, sir. And as you know from the cross plan that I filed with you on Friday, it is an area that we do intend to followup on. I would point out two things based upon the last colloquoy --

JUDGE BRENNER: My immediate question is even though now you've got the testimony being offered by witnesses by LILCO for the first time, but is not the subject already one of fair notice to everyone in terms of anything you need to prepare for it?

MR. DYNNER: In terms of the subject matter, the subject matter has been discussed and the subject matter of the Staff's testimony is not based on any strain gage reading. It is based upon an analysis of the geometry of the area. And, in fact, the Staff itself is the ones who have insisted that this strain gage testing be carried out because presumably the Staff is not confident with the results of their analysis of the geometry of the region.

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They want to see something more than that.

Now, this strain gage testing is incomplete for two reasons. Number one, as I understand it the engine was run at only 3300 Kw, so the strain gage testing is not going to tell us anything in terms of what might happen at 3900 Kw. Now, I realize I'm not tesifying that that is argument --

JUDGE BRENNER: I thought these were preoperational strain gage tests.

MR. DYNNER: These are strain gage testing being carried out during this 740 hour aggregate run at 3300 Kw.

JUDGE BRENNER: Of course, they'd have to be in this timeframe.

MR. DYNNER: Yes, sir. Now, that's one point. Now, another point is that the strain gage measurements are not going to be conclusive of anything because, as a matter of fact, if this testing -- at the end of this testing, there are inspections made of the cam gallery area. They show that even at 3300 kilowatts there has been some growth in that area that presumably is going to demonstrate that notwithstanding the strain gage analysis that there has been some tensile strains in that area and they are not all compressive, and that would be proof in the pudding.

Now, that raises the whole issue that I am trying to bring before the Board of the objection to LILCO

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bringing in piecemeal parts of the overall testing program.

It seems to us if we had access to everything we would agree that for our purposes the current testing is relevant. And the reason it is relevant is not that it is capable of proving that the engines are okay, because it is only being carried out at 3300 Kw rather than 3500-3900 but, rather, that if things failed and problems develop at 3300 Kw, that certainly is a clear indication that the same problems would arise a higher load.

So it seems to us that we ought to adopt a clear and consistent approach, that the record has been closed as you pointed out, Judge Brenner, on page 5 of LILCO's status report. LILCO, at the top of the page, specifically referred to the strain gage measurements that are being taken or will be taken as a part of the test, that is, in line 4 at the top of page 5 and later on, say that they don't want to supplement or reopen the record at this time to include this information.

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Now we find that some 12 days later that they have in fact moved to supplement the record in this regard. It is inconsistent, it has left us without any notice. At some point we have to come to some conclusion about what we are litigating. As long as LILCO is free to put in its latest information that is favorable to LILCO -- because frankly we don't know what is not favorable: we did get a report from the press that a lubricating oil line broke during the testing of that engine, I don't know very much about it, I haven't seen documentation of those tests yet.

So what we're getting at least right now is one side of a picture that is incomplete and we don't think it is appropriate to have to litigate under those circumstances.

JUDGE BRENNER: In terms of the sentence of the status report that you and I have beaten Mr. Farley with, I suppose that's why lawyers like to put "at this time" every other sentence that they write, but nevertheless the chronology is quite close between that sentence and what came out later.

MR. DYNNER: I am pointing that out simply because it illustrates, as did my conversations with Mr. Farley, the surprise and the fact that this is a totally new issue before us.

JUDGE BRENNER: That's right. And it is only in

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that context because there may be a lot of other things in this status report that I may disagree with, so I don't want to turn the status report into the gospel on anything.

MR. DYNNER: Exactly, I agree with you.

JUDGE BRENNER: All right, give us a few moments here.

(The Board conferring.)

JUDGE BRENNER: Well we've, as you can see, deliberated in your presence for the last five minutes and come to the conclusion that we want more time to deliberate, which was what I wanted to ascertain initially and we will discuss it overnight and come back with our ruling as soon as we have it, which will probably be tomorrow. At this time, we expect that it will be tomorrow.

MR. FARLEY: On your earlier inquiry, Judge Brenner, about the cylinder head footnote, I telephoned Mr. Ellis and he is supposed to be here by noon tomorrow, unless you want him before that.

JUDGE BRENNER: No, I didn't realize you have to have somebody travel just for that.

MR. FARLEY: He's coming up anyway.

JUDGE BRENNER: All right. Whenever he is here for other purposes we will take it up at a convenient time but I would like to get it done certainly this week --

AGBagb

MR. FARLEY: I understand.

JUDGE BRENNER: And Judge Ferguson, as you may recall, won't be here after Wednesday.

MR. FARLEY: Yes, sir.

JUDGE BRENNER: So --

MR. FARLEY: That's why I called him at lunch.

JUDGE BRENNER: Okay. I appreciate that.

Some of the dialogue we have had on this other motion touches on why I asked about that footnote, but I don't want to discuss it through the side door. We'll get our answer on the footnote and then we may have other questions.

Mr. Goddard.

MR. GODDARD: Already?

JUDGE BRENNER: Sarcasm will get you nowhere.

BY MR. GODDARD:

Q Dr. Rau, I believe it was in response to a question asked by Judge Brenner prior to the break that you were making reference to the amount of the trace element lead in the old 103 block.

Do you recall making a reference to that trace element?

A (Witness Rau) Yes.

Q What was the source of your information as to the amount of the element of lead present in the old 103 block

AGBagb

casting?

A These are chemical analyses which were done on the pieces removed from 103.

Q Who performed those chemical analyses?

A Dr. Wachob has the specific references. I don't know precisely.

A (Witness Wachob) They were performed by Twin Cities Testing in St. Paul, Minnesota.

Q That was done by direction of FaAA?

A Yes, sir.

Q Has similar analysis been done on the small portions cut from the blocks of EDG's 101, 102 and any portion of the new EDG 103 block?

A Chemical analyses were performed on the corners removed from the block, yes.

Q Is that on all three of the blocks that I indicated?

A That was on 101, 102 and the original 103.

Q Has any chemical analysis been done on the composition, specifically referring to the lead trace, if any, present in the replacement 103 block?

A Yes, there have been and TDI even performed a test on that.

Q Can you identify for me the percentage or the amount of lead present in each of the four blocks at this

AGBagb

time?

(Pause.)

A I don't have the exact figures here, but I can give you the rough estimates of them.

In the 101 block, there is approximately 20 ppm, the 102 block there is approximately 30 ppm, in the new 103 block it was approximately 20 ppm and in the original 103 block the values ranged somewhere between 40 and 60 ppm, I believe.

Q Did you complete your answer, Dr. Wachob?

A That is my rememberance of the chemistries, yes.

Q Dr. Rau, is there anything you wish to add to that? I noticed you were conferring with Dr. Wachob.

A (Witness Rau) Not directly in answer to the question. I was simply going to comment on the significance of these analyses and the fact that the real import and significance with regard to our testimony and that upon which we rely are the direct physical observations of the presence or non-presence of the degenerate Widmanstaetten graphite rather than the chemical analyses which might be related to why it might be there.

Q If I recall correctly you testified that in order to produce the degenerate graphite you must have the presence of hydrogen, of tramp elements and a cooling grade deviation, is that correct?

AGBagb

A I think you may have misspoke a little bit. It is not a matter of a deviation of the cooling rate but a slow cooling rate in conjunction with tramp elements and sometimes in conjunction with hydrogen.

Q You have no information as to the cooling rates which were undergone by any of these blocks, do you?

A The information which we have is based upon the representations made by TDI that the blocks require some four to five days to cool from the time they are poured and when they come out of the mold; after that time, they are still too hot to touch -- and also our general engineering considerations of how long it might take a metal of that size to cool. But we have no specific first-hand information of whether it is four and a half days or four and three-quarter days --

Q Right.

And presumably all four of these blocks would have cooled at approximately the same rate, isn't that correct?

A It is my opinion that certainly the first three, that is, 101, 102 and the original 103, which were all cast at the same time or within a month of each other and with similar mold designs would have very similar cooling rates. There may have been some modifications in the casting technology which TDI or any other foundry uses over an

AGBagb

eight year period, so there could be some differences at the time of casting of the replacement block. I don't think I can say much more than that, I still believe it would be relatively slow in all four cases.

Q And presumably you have no information as to the amounts of hydrogen which might be present during any of these castings, is that correct?

A Again we have no first-hand or, for that matter, even second-hand knowledge of the quantitative amounts of hydrogen. We are just referring to the literature which suggests that it can contribute and in fact does contribute at certain levels to tramp elements to produce the degenerate Widmanstaetten structure.

Q Now the Widmanstaetten graphite structure predominates in the thick or heavy section areas of a large casting, does it not?

A Well it predominates wherever the cooling rates are sufficiently slow to, in conjunction with these other two factors, lead to the formation of the degenerate Widmanstaetten graphite.

We have previously testified that in these particularly large castings it is our belief and our observation in the original 103 that the degenerate Widmanstaetten graphite exists throughout that casting. It is somewhat less severe in the thinner sections, but

AGBagb

nevertheless there are extensive amounts of it even in the thinner sections, for example, the web as compared to the block top or the cam gallery regions.

Q Why do you believe that the samples which were removed from blocks 101 and 102 would be representative samples of those blocks for determination of the presence of degenerate Widmanstaetten graphite?

A I don't believe that, Mr. Goddard, as I have indicated. I believe quite to the contrary that a B-bar, a 1.2 inch diameter bar, would not be able to detect and in fact would not contain the presence of Widmanstaetten graphite, even if the tramp element level under conditions of slow cooling and perhaps hydrogen were sufficient to produce degenerate Widmanstatten graphite in the thick sections of the casting.

Q I don't believe, Dr. Rau, that I had mentioned the B-bar. In fact, I was referring to the samples which were removed from those blocks for analysis, so would that change your answer?

A Yes, I'm sorry, I misunderstood. You are asking me whether the samples cut from the block of 103 were representative?

Q No, the samples removed from blocks 101 and 102, there were samples removed from those two blocks for analysis, were there not?

AGBagb

A Yes, there were.

Q Where were those taken from?

A As we have indicated, those samples were taken from the top of the block at the intersection of the block top with the side of the block on the exhaust side cylinders 4 and cylinder 5 just above the exhaust manifold support bracket.

Q Then based upon what you have just testified, my question was why do you believe those samples removed from blocks 101 and 102 would be representative samples for the determination of the presence of Widmanstaetten graphite?

In fact, aren't areas at the edge or sides of the block where they are easily removed going to be areas which are cooling faster than internal surfaces of the block?

A Well first of all, there's two answers to that question:

The first is that we have direct first-hand information from our detailed destructive examination of the original 103 block. We have in fact looked at those identical positions taken on the corner of cylinders 4 and 5 and the analogous position where samples were taken on 101 and 102.

We have compared the microstructure at that location with the microstructure at the stud-to-stud regions, the ligament regions and other areas throughout the

AGBagb

block top from which we cut samples and basically found the microstructure to be identical.

And for that reason, we believe that the sample positions are completely representative. And if in fact you get it there or not get it there, you will have comparable conditions at the stud holes or the ligament regions.

With regard to the second half of your question dealing with the expected cooling rates and why in fact that observation might be expected, again we have a massive large casting here and certainly right at the very surface when you first pour into the mold, if in fact the mold is not preheated, you may in fact initially start to cool the casting more rapidly.

But given the enormous size, the cooling rates will very quickly approach comparable values at the surface an inch in, five inches in, because the conduction of heat through the metal is so much faster than the conduction away through the sand and the ceramic that although there may be differences, those differences are virtually negligible compared to all of the other factors.

And for that reason I really wouldn't expect there to be substantial differences in the cooling rate between where the samples were taken and the areas where the cracks occur.

Let me just add one other thing too: the

AGBagb

temperature range over which the degenerate graphite forms or does not form is not immediately after you pour the metal into the mold, it occurs during the cooling process between the temperatures where certain metallurgical reactions occur. And certainly by the time you get to the temperature range where those reactions are occuring, things have gotten very stable -- and by that I mean the temperatures at the surface where the samples are taken compared to the other positions in the block top by that time are going to be -- any differences that might have existed in the early stages have basically been evened out.

A (Witness McCarthy) An additional empirical -- as an expansion on what Dr. Rau said, the ratio of the thermal conductivity of iron to sand is about 100 to 1, and that makes the -- because the sand is so much an inferior thermal conductor to the iron by such a massive ratio it does in essence, if you've got reasonable thermal communication and something at the edge of a three-inch block top has very reasonable thermal communication with the center of the block top, you will have essentially a constant temperature billet with this kind of a thermal mismatch.

Q Dr. Rau, at this time I am thinking back to your testimony which was given on last Tuesday regarding comparison of the UTS or uniform tensile strength of the

AGBagb

B bars to those of the blocks themselves.

Would it be correct to characterize your testimony at that time as being that the analysis of the test bars drawn from the ladles for the old blocks 101, 102 and 103 would not be representative of the actual UTS of the material in those blocks?

A That depends on what you mean by "representative." I did in fact testify that you certainly would expect, even in normal gray cast iron, to have a change or a decrease in the tensile strength as the thickness of the casting or the cooling rate changes.

So if you mean "representative" is it identically equal to the tensile strength in a thicker section, the answer is no. If what you mean is can you infer or approximate or know within reasonable bounds what the tensile strength might be in different sections from a knowledge of the difference in the section size and a knowledge of what the B bar tensile strength is, then the answer might be yes.

The presence of any degenerate Widmanstaetten graphite, of course, complicates and in fact invalidates the comparison or the extrapolation from B bar to thicker section.

Q Thank you, Dr. Rau.

MR. GODDARD: Judge Brenner, at this time the

AGBagb

Staff would move to its cross-examination on the question of circumferential cracking. However, I notice we are pretty close to 5:00 and I anticipate we will have approximately a half an hour of questioning on this subject. Would you prefer to break now or would you prefer that we proceed?

I would prefer not to start it and then have it terminated after just a few questions.

JUDGE BRENNER: We will give you the option, but we would have no objection to your starting if you wanted to. But I will give you the option if you want to stop now.

MR. GODDARD: I would prefer to do that, I think. We will pick up and I will try to move it along as quickly as possible in the morning.

JUDGE BRENNER: Okay.

I don't believe we have anything further today.

And seeing none of the counsel leaping for the microphone, we can adjourn for the day and then pick up at 9:00 tomorrow morning.

(Whereupon, at 4:55 p.m., the hearing in the above-entitled matter was recessed, to reconvene at 9:00 a.m., the following day.)