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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.

Thursday, November 1, 1984.

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

BEFORE:

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

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

JUDGE GEORGE A. FERGUSON, Member,
Atomic Safety and Licensing Board.
(Not present.)

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APPEARANCES:

On behalf of the Applicant:

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C O N T E N T S

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C O N T E N T S (Continued)

EXHIBITS	FOR ID.	IN EVD.
Suffolk County exhibits		
to Joint Direct Testimony:		25566
7 - FaAA rpt on TDI R4 and RV4 EDG cyl blocks and liners, June '84		
24 - Depo, Maurice Lowrey, 5/10/84; Pp 1, 14-16		
32 - Depo, Clinton Mathews, 5/8/84; Title pg; 106, 107		
54 - Bd notification sgd Reis, 4/17/84		
55 - Region I notification to Program Support Br, Insp and Enforc re Shoreham EDSGs		
56 - TDI Owners Gp review of SNPS cyl blocks; 3 pgs		
57 - Depo, Wm Museler, 5/22/84; Pp 1, 7-8, 14-17, 43-46, 98-99		
58 - Depo, Robt Taylor, Attachment; 5/10/84		
59 - Depo, Robt Taylor, 5/10/84; Pp 1, 40-41, 67, 69-70		
66 - Depo, Simon Chen, 5/15/84 Pp 1, 29		
67 - IOM, Pratt to Lowery: Cyl Block Castings		

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CONTENTS (Continued)

DOCUMENTS INSERTED (Cont'd)

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P R O C E E D I N G S

JUDGE BRENNER: Good morning.

Whereupon,

ROGER LEE MC CARTHY,

HARRY FRANK WACHOB,

CHARLES A. RAU,

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:

JUDGE BRENNER: If there are no preliminary matters, we are prepared for you to complete your follow-up questions, Mr. Dynner.

Did you have something, Mr. Ellis?

MR. ELLIS: Judge Brenner, you may want to delay this, but I am prepared to advise the Board on what the Long Island Lighting Company proposes to do. We had a meeting last night and I would like to be able to advise the Board at your earliest convenience, so I can begin working on it.

JUDGE BRENNER: I think it would be better to finish this panel. Why don't you just give us the bottom line, and then we'll come back to the details at a time

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that is convenient to you.

Did you want to leave today, Mr. Ellis? Is that part of the consideration?

MR. ELLIS: Yes, sir, but I can leave much later today, so I could come back at whatever time would be more convenient for the Board, so it can finish this panel.

JUDGE BRENNER: I guess I would like to try to finish the panel. If it turns out that for other reasons you want to leave, come back and tell us and then we will take it up, but why don't you give us the bottom li e if you can in a sentence or two, and then I'll think about that. And then we'll come back for the details.

MR. ELLIS: In a couple of sentences, the company believes that the record should reflect the actual loads and should have the benefit of the tests, and that the record, if it is supplemented and reopened for that purpose will then still permit the Board to find either at 35 or 33, and therefore, LILCO has proposed a very limited reopening for crankshafts and a very limited supplementation for blocks, and if pistons are not settled, it will for pistons as well.

And I am prepared to tell the Board what the boundaries or limits are of the supplementation and reopening, and I am prepared to tell the Board what kind of a schedule LILCO believes should be considered.

JUDGE BRENNER: Have you discussed all this with

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the other parties?

MR. ELLIS: Yes, sir. But I think in fairness, Mr. Dynner has not really had an adequate opportunity to consider it and react. He was cross-examining yesterday, and then we had the meeting last night. And I just wanted to advise the Board of that, and he may wish to have a longer period of time to react to it.

JUDGE BRENNER: All right.

Why don't you all see if you can make some time to discuss it further during the lunch break and maybe we'll permit a little bit of additional time. And let's see where we are in terms of this proceeding so you will know whether it is reasonable to expect you to take up this other subject during the lunch break.

All right, Mr. Dynner. You had estimated, if I recall correctly, and please correct me if I'm wrong, that you had about 45 minutes left. And at the time you told me that I thought that was a long time, and I certainly hope that that's the outside limit, and that you can complete in that time. I know you are going to try. And why don't you begin now?

MR. DYNNER: Thank you, your Honor.

RECROSS-EXAMINATION (Continued)

BY MR. DYNNER:

Q This question is directed to the FaAA witnesses.

WRBeb

Since October 12th, 1984, have any physical changes been made to the section samples from the original EDG 103 block that Dr. Anderson inspected at FaAA on that date?

A (Witness Wachob) FaAA has made one physical change. That physical change was on Section D-1, which was cut with a saw. And that was the only physical change of any of the pieces that exist.

Q Can you describe the physical change precisely, please, to this Section D-1?

A D-1 is a fracture -- half of a fracture that we have taken from the cam saddle 7 position, and approximately a quarter inch was -- a quarter was cut off of that piece.

Q Why?

A This was for the superprobe/microprobe analysis to get it in the equipment.

No other physical changes have occurred.

Q And other than the microprobe of that quarter inch corner there were no other examinations that were conducted since October 12th that you're relying on. Is that true?

A There has been no additional metallography or fractography performed since that date.

Q My word was "examinations." Are you trying to limit my word?

WRBeb

A The pieces that were even brought into the court were obviously looked at, so that's a visual examination.

Q Okay.

And had the samples with the circumferential cracks in them been subjected to a liquid penetrant examination prior to October 12th?

A Yes, they had. I believe Dr. Johnson may be able to tell you the exact date. I don't remember exactly.

Q I don't need the exact date. Thank you.

What is the pressure of the jacket water in the EDGs during their operation?

A (Witness Johnson) The normal operating range is 10 to 30 pounds. We normally see operation at about 25 pounds.

Q By "pounds" do you mean psi?

A Yes, sir, pounds per square inch.

Q Mr. Youngling, what are the factors that cause the psi of the water to vary from 10 to 30?

A Restriction in the system, performance of the pump, temperature of the water; very slight, though.

Q During shutdown, what is the water pressure in the system kept at?

A Do you mean in standby service?

Q Yes, sir.

A There is an external keep-warm pump that

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maintains the circulation flow, and the pressure is approximately 2 pounds, maybe a little less.

Q Why is the low-level coolant alarm set at 20 gallons?

A That alarm point is selected in order to maintain sufficient head on the pump to ensure adequate performance of the pump.

Q If the alarm goes off, indicating-- If the low-level alarm goes off, is there an automatic system which feeds additional water into the EDG water circulating system?

A The makeup capability is not an automatic feed, it's a manual action. The alarm signifies to the operator low level. He has to go down and open the valve.

However, there is certainly ample time to do that.

Q You say he has to go "down" to open up the valve. Can you tell me normally where is the operator located in relation to the valve that he would have to open?

A When the engines are operated, we keep a man in the room with the engines, but in a LOCA event it is entirely possible that there would not be an operator in the room, so he would have to go down to the engine room and open the valve.

Q When you say he would go "down," do you mean he

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would be in the--

A Well, he could be in the control room, he could be somewhere else in the plant, and he would have to be dispatched to the room.

Q What is the capacity of the makeup reservoir?

A The makeup source is demineralized water. We have a storage tank of demineralized water which has a capacity of 100,000 gallons.

We also have a cross-tie where we could if we had to use condensate which has a storage capacity of 600,000 gallons.

JUDGE MORRIS: Mr. Dynner, are you leaving that subject?

MR. DYNNER: If you have a question, please go ahead, sir.

JUDGE MORRIS: Well, I did have one quickie.

Mr. Youngling, do you know the inventory of water in the cooling system during normal engine operation?

WITNESS YOUNGLING: Yes. I don't know the precise number, Judge, but I believe it is approximately 200 gallons, somewhere in that range.

JUDGE MORRIS: Thank you.

BY MR. DYNNER:

Q Mr. Youngling, how much water is in the jacket water system in the engine itself?

WRBeb

I'm sorry if that was just asked, because I was conferring and didn't hear the answer.

A (Witness Youngling) Yes. I don't remember the exact number but it is approximately 200 gallons.

Q Dr. McCarthy, I believe you made a statement yesterday to the effect that you thought about four gallons of water per hour are blown into the lube oil from the combustion chamber during operation. Is that a correct summary of what you said? And if not, please correct it for me.

A (Witness McCarthy) I indicated that a minimum calculation for engines designed of the era of these engines would be four gallons per hour of water vapor in the gaseous blow-by past the piston rings.

TDI has estimated that number at nine gallons an hour.

Q So that is water vapor blow-by which would then go into the exhaust. Is that correct?

A No. About 99 percent of the exhaust products go out the exhaust. Approximately one to two percent blows by the cylinder rings, goes into the block, and then is, in a very real sense, scrubbed as in a spray scrubber by the engine oil in the crank case.

Q What happens to this water vapor when it is scrubbed?

WRBeb

A Well, some of the water vapor will go out the crankcase vent. Other will be condensed in the crankcase by contact with the cooler walls and the cooler oil, but because of the elevated temperature of the oil, will have a high vapor pressure and will continue to condense -- continually condense and evaporate off through the crankcase vents.

Q You said this was a calculation you made. Was it based upon actual measurements of the EDGs at Shoreham?

A No, the actual number for Shoreham was obtained from TDI.

My calculation of a lower bound of four gallons was based on SAE Nomograph SB494, which was published in 1981, dealing with diesel engine oil consumption and specifically their parameters for large diesel engine piston ring blow-by, and I used that as a lower bound.

TDI claims the number for their engine is nine gallons per hour.

Q Mr. Youngling, does the TDI Operating Manual or other governing manuals for the operation of the EDGs permit water in the lubricating oil in the engine?

A (Witness Youngling) Yes, it does.

Q How much water is permitted in the lubricating oil?

I think you testified, or someone testified that

WRBeb

there were 700 gallons of lube oil -- is that correct? -- in the EDGs?

A Yes, that's the right number.

Q How much water is permitted by the operating manual in the lube oil system?

A I would have to look.

JUDGE BRENNER: Mr. Dynner, if I might?

I take it that that figure-- I don't think it was exactly 700 gallons yesterday, but whatever the figure was, about 700 gallons of lube oil, that is per engine. Is that right, Mr. Youngling?

WITNESS YOUNGLING: Yes, Judge.

JUDGE BRENNER: Is there any interconnection at all between the lubricating systems or water cooling systems among the three engines once the respective fluids are-- Well, let me stop the question right there.

WITNESS YOUNGLING: No, there are no interconnections; which is consistent with the separation criteria.

MR. DYNNER: While Mr. Youngling is looking, if I may just ask a follow-up question for you, Dr. McCarthy:

BY MR. DYNNER:

Q As a result of the process that you have described concerning the four to nine gallons of water, as a result of that process, how much water actually enters the

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lubricating oil in the system?

A (Witness McCarthy) That question can't be answered by a simple number because water is continually entering the lubrication oil that is directly below the crank in the sump and evaporating back into that space and being let out the crankcase.

I don't recall the steady-state operating oil content specification but there is a steady -- which is what the TDI manual addresses, is the steady-state water content that it is very difficult to push the level below.

There is water in all internal combustion operating oil, and that is the primary purpose for the anti-acids because there is also sulfur and other blow-by products in all lubricating oil, and you have to neutralize that.

Q Well, then, Dr. McCarthy, you are not suggesting by your testimony that the four to nine gallons of water per minute that you have talked about would exceed -- per hour would exceed the permitted amounts set by the TDI Operating Manual, are you?

A It couldn't, by definition, since there is no way to operate the engine without blow-by somewhere in that range. I only mentioned the numbers because it puts the possible consequences of a weepage from some sort of crack or leak in perspective because of the volume.

WRBeb

Q Mr. Youngling, if you need additional time to look, I will proceed with some other questions to the panel.

A (Witness Youngling) Yes, Mr. Dynner. I don't have the information here. I do not have the manual here, so I can't give you that information until I get that manual.

Q Do you have the County's exhibits? There was a bunch of them put on the table and--

A Yes, I gave them back to you last week.

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JUDGE BRENNER: The answer for now is that he doesn't know. I don't think it's that important.

BY MR. DYNNER:

Q Mr. Youngling --

JUDGE BRENNER: You can make of it what you want later, okay. The answer is he doesn't know and that's where the record stands.

BY MR. DYNNER:

Q Mr. Youngling, how often is the lubricating oil tested for contamination by LILCO?

A (Witness Youngling) Under the PM requirements we will test it once a month. We test it now at approximately ever two to three hundred hours of operation.

JUDGE BRENNER: I had asked him that question yesterday, Mr. Dynner, and the answer is the same as it was yesterday.

BY MR. DYNNER:

Q And what is the test that is performed at that time?

A (Witness Youngling) We send the oil samples to an outside lab and the lab does a spectrographic analysis as well as a physical properties analysis.

Q How much time elapses between the time that you send the oil sample out and the time that you get the results back, approximately?

WRBpp

A A day or two.

Q Dr. Rau, am I correct that you testified yesterday that the stress on the first thread of the stud is about two and a half times lower than the stress at the block top? Is that a correct statement?

A (Witness Rau) That's not precisely correct, Mr. Dynner.

Q Please correct it for me.

A I don't recall my precise words but basically I indicated that the stresses at the block top compared to the stresses in the block at that thread where the first thread of the stud loaded up the thread in the block was greater than two and a half times or less than two and a half times lower.

Q And can you tell me what the stress is at the point of the first thread in the stud in Ksi, approximately?

A Only approximately -- I don't have the results in front of me. My notes indicate that it would be three to five Ksi, that's the range of stress. Again, that's a conservative number from the conservative fine element analyses.

Q It's true, isn't it, that the first thread of the stud is located something less than two inches below the top of the block; isn't that right?

A The first thread in the block is about an inch

WRBpp

and a half. The first thread adjacent to the load applied by the stud is about 1.8 inches below the top of the block.

Q It's true, isn't it, that the TDI strain gage test reference to which was deleted from page 28 of the original testimony, demonstrated the the preload stress alone is still near 10 Ksi two inches below the block top; isn't that right? That's on page 28.

A Mr. Dynner, I believe the -- my recollection is that the strain reported by TDI at that gage location was, in fact, of the order you have indicated when converted to stress. But again I would note that that's not in the stud hole, that's not in the thread, that's over in the counterbore and again we were not able to independently verify those strain gage results and that's why we've not relied upon them.

Q Did I understand your testimony correctly that none of the ligament cracks extended into the liner landing ledge itself?

A I'm not sure I understand exactly what you mean by into the liner landing edge itself?

Q Ligament cracks extend down the counterbore. At the end of the counterbore you have testified that you never saw a ligament crack that did not arrest at the landing ledge; isn't that right, the cylinder landing ledge?

A Dr. Johnson might want to comment about the

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details. Yes, it doesn't extend beyond that ledge. That's a horizontal ledge. It doesn't extend beyond that on the -- well, on what is no longer the counterbore on the cylinder hole in the block.

Q My question was is, has there been any ligament cracks that actually extended into the liner landing ledge itself?

A (Witness Johnson) There have not been any ligament cracks which extended at the counterbore below the ledge.

Q That's not my question. I said have there been any cracks that extended onto the landing ledge itself?

MR. DYNNER: I'm going to have distributed and ask to be marked for identification as Suffolk County Diesel Exhibit 79.

JUDGE BRENNER: That's the right number. Why don't you tell us what it is?

MR. DYNNER: Yes, sir.

This is a document consistenting of five pages. The first page is entitled at the top, "Eddy Current Examination Report." It is stamped over, "Preliminary Report." And on the next page, again, "Eddy Current Examination Rep .t, Item Inspected DG 103 cylinder block." It is dated 9-12-84 and in one of the blocks it says, "see attachments." And attached to that document the third page

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is a schematic drawing. At the bottom it says, "Cylinder Number 4, stud number 7." The following page also is a schematic drawing and it says, "Cylinder number 5, stud number 2." And the last page says, "Crack lengths to scale of 1 equals 1 inch," it looks like.

BY MR. DYNNER:

Q Can any of you identify this report?

Dr. Johnson?

A (Witness Johnson) Yes. This is an eddy current inspection conducted on the segment of the old DG 103 block which was returned to -- which was delivered to the FaAA laboratory and this inspection was conducted in the laboratory.

Q Thank you. If you would turn to the last page, can you explain to me what the schematic drawing means where you see the line and the label that says, "Crack extends on land?"

A I believe that means that the eddy current -- we had an eddy current indication that extended onto the land but did no extend over the land.

Q Did you do any further examination of this sample which either confirmed or failed to confirm this eddy current indication of the crack on the landing ledge?

A I believe that would be also a penetrant inspection of the same area.

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Q All right. My question is did it confirm the existence of the crack extending onto the landing or did you find that this eddy current and the other examinations were -- did not confirm that fact?

A I will have to look at the reports and see if it was confirmed to go onto the land or not.

Q Anyone on the panel, so far as you know, is there anything which shows that this document is incorrect?

Dr. Rau --

MR. DYNNER: I hear no response, your Honor.

BY MR. DYNNER:

Q Dr. Rau, have you personally examined the cam saddle areas number 2 and number 8 on the replacement 103 block?

JUDGE BRENNER: Let's back up for a second, Mr. Dynner, I wasn't positive where you were going to go with this and I didn't want to mark a lot of documents unnecessarily. But now that you have adduced what you have, we will have it marked for identification as Suffolk County Exhibit 79 and I guess we can call it FaAA eddy current report of original -- September 12, 1984 FaAA Eddy Current Report of Original 103 block.

(Whereupon, September 12, 1984 FaAA Eddy Current Report, etc. was marked as Suffolk County Exhibit No. 79 for identification.)

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MR. DYNNER: Thank you, sir.

BY MR. DYNNER:

Q Dr. Rau, do you recall the question? I can repeat it if you like.

A (Witness Rau) Please.

Q Have you personally examined cam saddle areas numbers 2 and 8 on the replacement 103 block?

A No.

Q Dr. Rau, in your analytical predictions that you refer to in the supplementary testimony of the LILCO panel on page 13, I think you testified that among those predictions were finite element analyses that you performed isn't that right?

A I'm sorry, Mr. Dynner; what are you asking me?

Q I'll repeat the question.

Is it true that the analytical predictions that are referred to in the last paragraph, the second line on page 13 of your supplemental testimony, that those consisted of, among other things, finite element analyses of preload and firing stresses, is what I have in my notes; is that correct?

A They do involve the results of finite element anslyses, yes.

Q Did those analyses consider thermal stresses?

A Yes, sir.

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Q It's true, isn't it, that these finite element analyses which regarded the circumferential cracks did not use any strain gage data at all; isn't that right?

A Yes. The finite element analyses are just that; that's correct.

Q Thank you.

Did you later attempt to confirm your finite element analyses of circumferential cracks by carrying out strain gage testing?

A No, Mr. Dynner, that has not been done. We did not believe that was necessary.

Q You did so, in fact, in the case, for example, of the finite element analyses on the pistons, didn't you?

A I have no detailed information on what was done on the pistons. Perhaps somebody else does.

Q Anyone on the panel can answer that.

A (Witness McCarthy) Yes. The infinitely more complex geometry of the piston was -- that model was verified by finite element.

It might be pointed out that I was talking about the overall geometry of the piston. The circumferential land area is a simple part of the block geometry whereas the piston model was of the entire piston. The block is still a more complex entirety to model than a piston.

Q Dr. Rau, your finite element analyses did not

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take into consideration any residual stresses that might be in that area, did they?

A The finite element analyses themselves, Mr. Dynner, obviously did not include the residual stresses. I've indicated previously that the results of those finite element analyses suggest very large stresses concentrated right at the sharp corner between the counterbore and the liner land. The magnitude of those stresses would produce localized plasticity during preload and operation such that if there were any residual stresses at that location they would dissipate or shake down as it is sometimes called, so there would not be any substantial residual stresses at that location where circumferential cracks initiate even if, in fact, there were any there to begin with.

Q Did you make any Goodman diagrams for the issue of the initiation of the circumferential cracks?

A No, sir.

Q Thank you.

What maximum firing loads did your finite element analyses assume in the EDGs in this analysis?

A Are you referring to considerations of circumferential crack locations?

Q Yes.

A The analyses were performed with a firing

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pressure of 1670 psi. As I've indicated before, the finite element analyses are linear, and the corresponding stresses associated with any higher or lower firing pressure could be computed, if you like, scaled from the calculations that were performed. I would also like to indicate that with regard to fatigue initiation it is, in fact, the average firing pressures which are relevant and not the maximum ones. If sometimes the firing pressures might be slightly higher than 1600, sometimes they may be slightly lower. In general, the average firing pressures are considerably below the 1670. And they're the ones, on average, which would control the fatigue cracking if, in fact, it were to occur.

Q You said fatigue initiation. Is what you just tesitified also true for propagation of an existing circumferential crack?

A Yes, sir, it would be the average pressures. Again, the cracks, if they were there and if they were growing would grow slightly faster when the stresses were higher and the stresses would be slightly higher if the pressures were slightly higher. But there would be corresponding times when the pressures were slightly lower, the cracks would grow slightly slower and on average it's the average pressure that would control the rates of crack propagation if, in fact, they were to progress.

Q Well, when you said you used 1670 psi, did you

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derive that from some other analyses other than the analysis that you performed on the circumferential cracks?

A That's not a derived number, Mr. Dynner. Perhaps someone else on the Panel would like to comment. That's a very conservative comment of the average firing pressures and, in fact, more respresentative of the maximum firing pressures. But it was a number which was not derived but basically was derived from analysis of the engine not from analysis of the finite element work.

Q Well, how did you calculate that the stress resulted from those loads, from those firing loads?

A That's precisely, Mr. Dynner, what the finite element analysis does. Each on the -- the finite element analysis breaks the area of concern up into a little erector set-type elements and within each element there are nodes and integration points and the finite element takes -- excuse me, the finite element analysis takes the applied loads to the engine which is modeled and computes the stresses at each location, each integration point within in each element throughout the structure which is being analyzed. And it's a direct output from the computer calculation. The finite element model.

Q I'm interested in comparing the finite element analyses basis that you used for circumferential cracks with the finite element analysis that you used in connection with

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the block top cracks. And I note, and I would like you to comment, for example, on the fact that on page 44 of your prefiled testimony you indicate the finite element analysis were used to get stress values, which are used to determine possible mechanisms for crack initiation. And then later on on pages 45 and again on page 47, you point out that those finite element analysis in the block top were then used to get Goodman diagrams and you emphasized that they are useful for the purpose of determining whether crack initiation is possible. But they do not predict rates of crack propagation.

Why wouldn't the same standards hold true for the finite element analysis that you performed on the circumferential cracks?

A Okay, Mr. Dynner. I think you are misrepresenting the testmony. The passages you have paraphrased led to the impression that the finite element analysis results would not be useful for crack propagation where, in fact, what was said that the Goodman diagram representation which is based, in part, upon the finite element results could not be used directly to predict crack propagation.

Now, with that statement, there's really no significant difference, let's say, no basic difference between the analysis used to consider the circumferential

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crack location used to consider the block top locations. In fact, as I mentioned, there are combinations of two and three-dimensional finite element analyses used for both regions and, in fact, the three-dimensional analyses are, in fact, identical. They are the same analyses in all respects. There is a difference in the two-dimensional analysis used to analyze the circumferential crack locations and that is simple because the analyses, the two-dimensional analyses used to analyze the block top were focusing on the block top and the refinement of the mesh size in the vicinity of the liner land was not sufficient to analyze the liner land. So a different two-dimensional analysis was used which, in fact, had much increased refinement in that area when, in fact, that area was being analyzed.

WRBagb

But with regard to loads applied, operating conditions considered, both analyses were identical.

Q If a circumferential crack propagated at approximately a 45-degree angle but it did not propagate into the stud boss area it would reach the jacket water in about 1.5 inches, isn't that right?

A Mr. Dynner, I do not have a scale drawing in front of me. If a crack though did initiate at the sharp corner at the intersection of the counterbore and the liner land and if in fact it grew indefinitely on a 45-degree plane in between the stud bosses, it could in fact reach the water in some of the order of 1.5 to 2 inches, I don't remember the exact number.

JUDGE BRENNER: Mr. Dynner, how much more do you have? It is a little past 9:45 now.

MR. DYNNER: I have five questions.

JUDGE BRENNER: All right.

MR. DYNNER: Five points -- I may have a follow-up question on any one of them but they are relatively short.

JUDGE BRENNER: If you are not finished by 10:00 on your own I may tell you that you are finished at 10:00, so bear that in mind.

MR. DYNNER: Yes, sir.

BY MR. DYNNER:

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Q Aside from the cam gallery cracks, have weld repairs been discovered in any other portions of the EDG blocks

MR. FARLEY: Objection, asked and answered yesterday.

JUDGE BRENNER: I am going to have to have the question again, I'm sorry.

BY MR. DYNNER:

Q Aside from the cam gallery cracks, have weld repairs been discovered in any other portions of the EDG blocks?

JUDGE BRENNER: Sustained.

BY MR. DYNNER:

Q This is directed to LILCO:

If LILCO had known that there were cracks in the cam gallery areas of the EDGs with so-called cosmetic welds, would LILCO have accepted the blocks from Delaval.

That is for LILCO.

A (Witness Youngling) Mr. Dynner, that is a hypothetical question that is impossible to answer.

Q I'm talking about the cracks -- let's ask a specific question:

If you had known about the specific cracks in the cam gallery area of EDG 103's original block with the weld material there, would you have accepted those blocks from

WRBagb

TDI?

Dr. Rau, I wish you wouldn't do what you are doing.

JUDGE BRENNER: Now that's not fair, Mr. Dynner. If you are going to make --

MR. DYNNER: I didn't say what he was doing.

JUDGE BRENNER: If you are going to make that comment you really had better ask him what he is doing so he will have an opportunity to tell you.

BY MR. DYNNER:

Q What are you doing, Dr. Rau?

A (Witness Rau) I am writing a note to myself, Mr. Dynner.

Q Thank you. Would you please be sure that that note is not put where Mr. Youngling can read it?

JUDGE BRENNER: No, he doesn't have to do that if he is writing a note to himself. If you want to inquire what he is writing and so on, you can check on it later and then see if you need to bring anything to our attention.

MR. DYNNER: All right.

JUDGE BRENNER: I want to add that my own observation, since I happened to be looking at the time you made your comment -- and I am not always looking at the witnesses when you make comments like that -- is that it didn't appear to me that he was writing a note that he was

WRBagb

trying to direct to Mr. Youngling's attention. That doesn't mean he wasn't, but it did not so appear to me.

All right. Go ahead.

BY MR. DYNNER:

Q Can you answer the question, Mr. Youngling?

A (Witness Youngling) If we had known that there was a weld repair in that area, I think our -- I believe our actions would have been very similar to the actions taken when we discovered the indications and the cracks in the area, that being we would go back, look at the operating experience, review the situation with the manufacturer, perform appropriate analyses and come to a conclusion. That conclusion would probably have been the same conclusion that we are at today, that the engines are acceptable for operation.

Q What is the approximate normal percentage of carbon in -- quote -- normal class 40 gray cast iron?

A (Witness Rau) There is a range of carbons, all of which are appropriate for class 40 cast irons. My recollection is that it ranges between 2 and 4 percent carbon. I believe the 101, 102 and original 103 were approximately 3 or 3.25 percent, something on that order. I would have to check the chemistry to be precise.

Q Can Martensite form if the carbon content exceeds 2.11 percent?

WRBwrb

A Yes.

Q Dr. McCarthy, yesterday you told us about a tugboat that you said, I think, had run for a period of two weeks with a mixture of oil and salt water -- lubricating oil and salt water.

Is it your testimony that the experience of that particular tugboat is applicable to the EDGs at Shoreham such that they would be able to operate during a loop LOCA with a mixture of lubricating oil and water in the range, I think you said, of 50 percent?

A (Witness McCarthy) Yes, I do believe it is generally applicable because certainly it is an expensive experiment to run to determine can a large multi-thousand horsepower diesel engine run with substantial lubrication oil contamination by water.

This particular engine-- You know, if someone asked you that question in the abstract you could think of a lot of hand-waving arguments both ways. In point of fact, somebody ran the experiment the hard way.

I think it is instructive that, you know, contrary to what someone might allege, you are not going to expect, even with substantial water contamination, engine failure in the next hour, the next ten hours, or, realistically, in the next hundred hours after it happens.

Q What type of engine was this, by make?

WRBwrb

A The manufacturer of this particular engine -- It was a Pielstick engine. That's Alsthom-Atlantique, is the manufacturer, or the ultimate owner of the firm.

Q How many cylinders did it have?

A Eight.

Q What was its overall rated horsepower?

A My recollection is 4300. But I would have to check that.

Q What was the name of the tugboat?

A I'm sorry; I do not remember.

Q What was the name of the owner of the tugboat?

A I don't remember that. It was a tug used in barge pushing down in the Gulf.

There are still discovery hassles, so we have not yet got all the material in the case.

Q What was the name of the operator of the tugboat?

A I do not recollect.

Q You say the tugboat operated in the Gulf?

A Yes. My recollection, once again, is that at the intersection of the Mississippi and the Gulf, and was used in-shore, and then barge-pushing up the Mississippi.

JUDGE BRENNER: It seems to me I should have set your time limit at five minutes less, since you can spend your last five minutes asking these questions. I infer from that that you have no other important questions left.

WRBwrb

MR. DYNNER: I think these are very important questions.

JUDGE BRENNER: No, they're not important at all.

MR. DYNNER: Am I to infer from that that Dr. McCarthy's testimony is not important on this particular matter, and is not going to be given much great weight by the Board?

JUDGE BRENNER: No; my statement stands for itself. My statement came after questions such as the name of the tugboat, and not the size of the engines.

MR. DYNNER: Well, I can explain, Judge Brenner--

JUDGE BRENNER: Don't explain. You've got my comment. And you've got about two minutes left.

MR. DYNNER: All right.

BY MR. DYNNER:

Q Is the salt water a better lubricant than the fresh water, Dr. McCarthy?

A (Witness McCarthy) In point of fact, slightly, but not significantly.

Q Where did you get your information about this tugboat?

A I was retained by Alsthom-Atlantique to look at why this particular diesel engine failed.

Q So you got the-- The owner or the operator, who

WRBwrb

are they?

A The manufacturer of the engine.

Q How was the amount of seawater in the lubricating oil measured at the beginning of this two-week period?

A Well, it wasn't measured, it was sort of derived.

And, once again, I used the two-week number as a conservative, because the only records access we have had so far are the last and most recent ship log, and that indicated the initial recognition of the error whereby, through valve opening mistakes, the crankcase was filled with a mixture of water and oil, which would just about double the oil volume. And then they didn't have any on board, and they drained it off, and ran for some-- And then they reportedly had other such mistakes.

So we are just inferring that there certainly has been at least two weeks -- the engine operating experience may have been longer -- with various mixtures. But in this last round they filled the crankcase completely and drained it down so they could run.

That's my understanding.

Q Do you know exactly how long they ran with more than 25 percent water in the lubricating oil system?

A Beyond that entry date of the log, we do not. It could have been, obviously-- There are representations that there have been other such mistakes made on this vessel, but

WRBwrb

that's all the reasonably reliable record that I have.

Q What loads was the engine run at with all this water in the lubricating oil system?

A Well, I can't testify to its service profile during that period.

Q You would agree with me, wouldn't you, Dr. McCarthy, that this experience you're talking about is something like hearing the story of somebody who jumped out of an airplane, the parachute didn't open, and he survived. You wouldn't expect that to recommend that other people jump out of airplanes on that basis, would you?

A Well, I hope my remarks haven't been attributed that I recommend to people that they run their diesel engines with substantial water in the oil.

What is clear from this -- and I guess I would disagree as a characterization -- is that this is a highly fluke event, because it's clear that this engine oil was operating for a substantial period with a substantial amount of water because of the failure mode which first had to fail the bearings and then the crank. So it took it some very long operating period, even with the obvious water contamination, to bring about the failure.

JUDGE BRENNER: All right, Mr. Dynner, I can't resist saying it sounds like you pulled that analogy out of thin air.

WRBwrb

If you have one more question I'll let you ask it.

MR. DYNNER: That's terrible, Judge.

(Laughter)

JUDGE BRENNER: I'm just trying to encourage you to finish your questions. I'll try anything.

MR. DYNNER: I have one more. This is a short one.

JUDGE BRENNER: This is your last one.,

MR. DYNNER: You're right.

BY MR. DYNNER:

Q Mr. Youngling, it's true, isn't it, that inspections and audits to discover cracks such as appeared in the cam gallery area in the weld material there, are required by LILCO's quality assurance program? Isn't that right?

A (Witness Youngling) No, Mr. Dynner, that is not true. The inspection requirements are stipulated by the specifications which are controlled as part of the design process, which is one attribute of the quality assurance regulations, Appendix B to 10 CFR 50.

JUDGE BRENNER: All right.

Mr. Goddard, to you have any questions?

MR. GODDARD: Yes, Judge Brenner, we do.

JUDGE BRENNER: Could you give me a time estimate, please?

WRBwrb

MR. GODDARD: Forty-five minutes.

JUDGE BRENNER: All right.

RECROSS-EXAMINATION

BY MR. GODDARD:

Q Dr. Rau, you testified yesterday morning that weld repairs of the cracks in the cam gallery areas of the blocks would introduce compressive stresses in the cast iron in the vicinity of the weld bead; is that correct?

A (Witness Rau) I think what I said, Mr. Goddard, was that it would introduce compressive stresses in the cast iron beneath, or, if you like, deeper than the weld bead.

I think I also testified that along the side of the weld bead, as a result of the shrinkage of the weld, you would introduce tensile stresses that are, in fact, responsible for the cracks which occured between the weld bead and the cast iron when the repair weld was made in the original 103 block.

Q Are there any other sources of residual stress in the region of the cam gallery; that is, such as stresses introduce during the process of casting and cooling the block itself?

A Yes, sir. The shrinkage stresses introduced by the casting itself were, in fact, the stresses responsible for formation of the original shrinkage crack. But, again, the fact that the shrinkage cracks stopped and did not

WRBwrb

continue to extend is indicative that the residual stresses had dropped to a low level, or even gone compressive at the point where the shrinkage crack stopped extending.

WRBeb

Q What, in your opinion, would be the potential significance of those residual stresses which remain vis-a-vis the significance of the residual stresses which were introduced during the weld repairs of the cam gallery areas?

A The residual stresses that remain, including those introduced by the repair welds, would make the computations, the analyses which we performed even more conservative with regard to whether or not those shrinkage cracks will extend or could extend during operation.

In other words, the applied stresses from the through-bolt are such as to maintain that region in high compression, and the various operating conditions do not produce stresses sufficient to overcome that initial compressive condition. In addition,-- Therefore, the cracks cannot extend.

The residual stresses you have asked me about would tend to further reduce the steady stress or the amount of compression at the tip of the shrinkage crack and increase the margin between -- or the certainty, if you like, with which the compressive stresses remain and therefore reduce the already negligibly small possibility that they would extend.

Q You testified in response to one of Mr. Dynner's questions that you had not measured the residual stresses

WRBeb

in the cam gallery area. Is it possible for you to estimate the magnitudes and directions of those stresses?

A Yes, I think you can estimate the directions. I think you can also estimate the magnitudes, but the estimates of magnitudes would be less precise. You would have to make certain assumptions about the specific weld conditions which are not known.

I think the important thing is that the stresses beneath the weld repair in the thinnest portion of the cam gallery in the direction toward the water jacket if you like will certainly be compressive, and the magnitude of that compression will depend upon the magnitude of the tension out in the weld bead.

But in any case it is always going to be compressive and therefore, I don't believe it is of any consequence how much more conservative it is than the enormous amounts of conservatism already demonstrated.

Q These questions are probably best put to the LILCO panel, but anyone on the panel is free to try to answer them.

Has it been observed whether or not the latex paint or epoxy paint which was applied to the blocks covers the cracks in the cam shaft gallery? In other words does it obscure those cracks, or did it obscure those cracks at the time of painting?

WRBeb

A (Witness Schuster) There were some differences in what we saw in the area. As I indicated earlier, you have the push rods, the cam shaft, and other parts and components of the engine which prevents you from cleaning the paint out underneath those areas.

A (Witness Rau) Mr. Goddard, perhaps I could add to what Mr. Schuster said.

Having examined these regions with the paint on and also with the paint off, I will tell you there is a substantial difference, and the paint does substantially obscure your ability to ascertain or examine what is there.

Q Could anyone on the panel explain how the cam gallery cracks in the original 103 block and in the 101 and 102 blocks became visible through exposure to the lubricating oil?

A (Witness Schuster) During a-- As I testified earlier, during a routine inspection by our test engineers in the cam gallery area, the oil gets into the crack in the paint and you have a white epoxy paint and it gives you a somewhat white-black background. It is almost like a penetrant, only using engine oil.

Have I explained it for you?

Q I think so. I was wondering whether Mr. Youngling had a comment or not.

A (Witness Youngling) No.

WRBeb

Q Mr. Schuster, can you tell me approximately how deep the cracks in the paint were?

A (Witness Schuster) No, sir. I don't know the thickness of the paint. It would be a standard, maybe three or four mills, something like that, maybe a little more. It's an epoxy paint. I don't know. I didn't measure the thickness.

Q Can you explain why the paint on the cam gallery areas in fact cracked if the stress field in that area is always in compression?

A My only explanation for the paint being open in those areas is that it tends to do this anyway because of the surface tension. You know, when you paint it, paint doesn't necessarily cover a crack. It will, due to surface tension, pull away from it. Initially it looks like it covers it but if you walk away and you come back, you can see it again.

Q I believe we just heard testimony from FaAA that in fact that paint does a considerable job of obscuring or filling those cracks, and I was wondering if that stress field is in constant compression, how this cracking occurred to the point where, as you estimated, there would be a three to four mill depth of those cracks which--

A Can I add one thing?

Q Yes, please.

WRBeb

A There is one consideration, that maybe thermally that this could happen because when you paint the block, if you paint it cold and then it would be heated up, so it is possible I guess that the paint-- There is a thin section over that crack and it could separate at that point. That is the only comment that I would have.

A (Witness Rau) If I might add, Mr. Goddard, it is a very complicated geometry, if you like. If you have a crack and then you paint it, as Mr. Schuster I think indicated, the paint will, at least in part, tend to get partially sucked into the crack and, depending on the details of the condition, you could end up with a layer of paint which, as you cross over the crack, isn't perfectly flat and straight. It has kind of got like a buckle in it. Okay? It may not even be uniform in thickness.

And then when it is bolted up and squashed in compression, if you've got a buckle and you squash it in compression, you can bend the paint locally, or squash it and, you know, it can break in compression, too, by just being squeezed into the crack or squeezed out of the crack.

The point I'm trying to make is that if you paint over a crack which has any opening at all, and then squash it, you can break the paint.

Q Dr. Rau, do you agree with Mr. Schuster's speculation that the thermal conditions in that area could

WRBeb

have been responsible for this cracking, if you will, of the paint?

A Well, anything is possible. And I am not saying it doesn't contribute, but I would be surprised of the increase in temperature from room temperature to the operating conditions, about 160, alone would be responsible for that. But again, if it is hanging on by a thread and you get a little bit, it could kick it over the top.

Q Thank you.

Dr. Wachob or Dr. Rau, referring to the metallography of the circumferential crack which you sectioned from the original 103 block and the metallography of the crack which was section from the cam gallery at No. 7, does a comparison of those two provide any meaningful evidence as to whether the circumferential crack was operationally-induced and the cam gallery crack was fabrication-induced as you have testified?

A We did not do, Mr. Goddard, detailed metallographic examinations of the circumferential crack region. Therefore, I can't make a comparison between.

As I have indicated at some length. there is strong evidence in the cam gallery region that that is in fact fabrication-induced. I think it would be fair to say that I have no evidence from what we have done in the circumferential crack area that it is in fact

WRBeb

fabrication-induced.

Q Have you completed your answer, Dr. Rau? Or Dr. Wachob, did you care to add anything to that answer?

A (Witness Wachob) Nothing else.

Q Thank you.

Have you done enough of an examination of the circumferential crack which you sectioned out of the 103 block to determine whether there was a presence or an absence of oxide layers of any nature on that crack?

A (Witness Rau) No, Mr. Goddard, we did not do detailed metallography in that region. As we have indicated, based on the observations, we have no reason to believe that that's a fabrication-induced crack and we saw no reason to make such detailed examinations in the circumferential crack location.

Q You did visual examinations at that crack location, did you not?

A Yes.

Q Under what magnification?

A We used the Stere binocular microscope magnifications up to approximately 70 times, and much lower than that, too.

JUDGE BRENNER: 70? 7-0?

WITNESS RAU: Yes, your Honor.

BY MR. GODDARD:

WRBeb

Q Based on that magnification and your expertise or familiarity with examining objects of this nature, can you make any comments as to the appearance of that crack insofar as it might include the presence or absence of oxide or other unusual characteristics at the crack surface?

A (Witness Rau) Mr. Goddard, there was nothing extraordinary about the crack, or any oxide on the crack. Certainly we can say from the examinations we did that there was not a very, very thick oxide in that location, but I'm quite certain there was a thin oxide on that crack.

I don't know if I am giving you the information you are seeking, but that's all I have to say about it.

Q I realize we are into a qualitative area at this point inasmuch as you did not do a detailed examination, but can you describe the coloration of that surface oxide?

A Mr. Goddard, again we did not do extensive examinations.

We did break open a small corner of what was a circumferential crack and my recollection is that the fracture surface was lighter -- I'd say less dark than the fracture surface in the cam gallery or the ligament area. My recollection is there was a little bit of red in it. But I really-- I don't have any detailed recollection.

Q Thank you, Dr. Rau.

How about yourself, Dr. Wachob? Can you add

WRBeb

anything to that answer?

A (Witness Wachob) No, sir.

Q I would like the FaAA witnesses to refer to page 5-2 of the FaAA Block Report of June 1984. For convenience that is Suffolk County's Exhibit Number 7, at what is numbered page 29 in the revised cylinder block exhibits, if you can take a moment and find that.

A (Witness Rau) What page, Mr. Goddard?

Q 5-2.

A Thank you.

Q In Section 5.0 of that report at page 5-2, Failure Analysis Associates recommends in its recommendation No. 6 that:

"For blocks with known or assumed ligament cracks, the absence of detectible cracks between stud holes of adjacent cylinders should be established by eddy current inspection before returning the engine to emergency standby service after any period of operation other than no load."

Is that currently FaAA's recommendation?

A No, sir.

Q What is the current recommendation of FaAA as to that inspection after various load level operation?

A The recommendation is virtually identical except we require the inspection -- or recommend that the

WRBeb

inspection be done whenever the engine was run at load levels in excess of 50 percent of 3500.

Q That 50 percent load level was included in your testimony which was filed by LILCO on August 14th. Is that correct?

A Yes, I believe so.

Q Your report on the cylinder blocks was finalized and published in June, 1984. Is that correct?

MR. FARLEY: Objection, not correct.

JUDGE BRENNER: I didn't hear the rest of your objection.

MR. FARLEY: It has been testified, your Honor, repeatedly that it was not the final report.

JUDGE BRENNER: All right. I guess I didn't hear the word "final" in the question, but we know the testimony on it, and the question is when was it issued, which I think we also know.

Why don't you move on to your next point?

MR. GODDARD: All right.

BY MR. GODDARD:

Q Can you explain what caused the change in recommendation from inspection after any operation to inspection after operation at 50 percent or higher load between the June 1984 date of issuance of the FaAA report and the publication of this testimony on August 14th?

WRBeb

A (Witness Rau) Yes, Mr. Goddard. Quite a few things happened between the preparation of the draft report in June and the submittal of our testimony in mid-August.

The most important thing which happened was our confirmation through direct measurements of the tremendous difference or degradation in the mechanical properties of the original 103 block. It was in fact the quantification, the measurement of those differences that enabled us to perform the cumulative damage analyses again, or update it to take into account those measured differences.

And in doing so, the demonstrated margins, reliability margins demonstrated by the test period between March 11th and April 14th, 1984, by the testing of the original 103 block with those degenerate Widmanstaetten graphite degraded properties led to a much larger margin between what was demonstrated there and that which would be required should there be a loop LOCA in 101 or 102 or the replacement 103 block.

That tremendous increase in the margin enabled us to relax the requirements that had been recommended in our preliminary draft report in June.

Q Thank you, Dr. Rau.

MR. GODDARD: The Staff has no further recross for this panel.

JUDGE BRENNER: Thank you, Mr. Goddard.

WRBeb

FURTHER EXAMINATION BY THE BOARD

BY JUDGE MORRIS:

Q Dr. Rau, I would like to understand a little bit better the picture of the compressive stress in the cam gallery area, and I suggest we look at our diagram, which is Suffolk County Exhibit 77.

If we look in the region where the crack is and where the weld is, if we start on the right-hand edge -- holding it this way -- on the surface of the weld, can you then describe the situation going left from there over to the wall in terms of what kind of stress relative magnitude and direction, if that is possible?

A (Witness Rau) Judge Morris, you are asking specifically about the residual stresses from welding or....

Q Yes.

A Yes. The shaded region right-most in the location of the crack in the cam gallery is representative schematically of the weld. When that weld is made, the block is not substantially preheated. Therefore, the weld metal is very hot and then it starts to solidify, bonds if you like to the adjacent cast iron, and then starts to shrink.

As it shrinks it wants to get smaller, but of course the surrounding cast iron is precluding that and therefore, the tensile stresses start to build up in the

WRBeb

weld metal. And those tensile stresses are primarily largest in the vertical direction because you can't have any substantial stresses in the horizontal direction. There's a free surface there and it can't support any, but in the vertical direction you can.

And so what happens is you generate substantial tensile stresses across the shaded weld portion.

Now as you move to the left into the cast iron where the shrinkage cracks exist, that is in fact the portion of the cast iron which is resisting or, if you like, holding open the weld metal and causing it to be loaded into tension. So the physics of the situation are such that that material immediately adjacent to the weld material as you move left, again in a vertical direction, must be compressive because it's getting--

If you think of yourself as standing where the cast iron is and the weld metal tries to pull you closed or pull you down, you get squashed. If you stand where the weld metal is, then the cast iron adjacent is tending to pull you up or hold you up as you attempt to shrink.

So the net result is that you end up with a high tensile stress in the weld, relatively uniform in magnitude, and in fact limited by the strength of the weld metal. You end up with the highest compressive residual stress immediately adjacent to the weld, vertically in direction.

WRBeb

And then as you proceed further to the left, the magnitude of the compressive residual stresses will gradually decrease and taper off towards zero. They will continue to be compressive, however, through the entirety of the cam gallery section as you move toward the left wall.

Q Are you able to give approximate values for the stress as you go horizontally to the left from the weld?

A Well, as I said, it would depend on the details of the welding conditions. But a reasonable approximation might be to use the yield strengths, the flow strengths of the respective metals. And you will, in all likelihood, end up with a tensile yield strength level in the weld, and then you will end up with a compressive yield strength level in the adjacent cast iron.

And again in this degenerate structure that is somewhat lower than it would be in a good or typical gray iron, but something, you know, less than 10 Ksi, or of that order in the cast iron immediately adjacent to the weld. And that would stay reasonably constant at that level for a while because that is limited by the strength of the cast iron, and then it would start to drop off and approach zero as you go out toward the left-hand side.

Q Thank you.

JUDGE BRENNER: Mr. Farley, do you have any what I guess would be re-redirect?

WRBeb

MR. FARLEY: May I have a few minutes to confer with my panel?

JUDGE BRENNER: Yes. The reason I'm hesitating taking a break now is I want to use the break to switch witness panels. But how much time would you like to confer?

MR. FARLEY: Just five minutes.

JUDGE BRENNER: I guess we might as well take the break if you feel you need to do that.

Come back at 10:45.

(Recess.)

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JUDGE BRENNER: On the record. Mr. Farley, do you have re-redirect?

MR. FARLEY: May I proceed with one question?

JUDGE BRENNER: Surely. I might have even given you two. Go ahead.

FURTHER REDIRECT EXAMINATION

BY MR. FARLEY:

Q Dr. Johnson, during the examination this morning you testified that ligament cracks did not extend onto the liner land. Referring to Suffolk County 79 for identification, would you please explain the -- or elaborate on your explanation with respect to the note on the last page?

A (Witness Johnson) We have done two independent liquid penetrant tests in the same area. One was done in the field by LILCO and one was done by FaAA in the laboratory. Both of them show that that crack does not go onto the liner land area. The eddy current test has an indication on the liner land but the accuracy of the eddy current test as I have mentioned before, is the order of a tenth of an inch. So all of those -- the eddy current combined with the penetrant tests are consistent with the fact that we have no crack running down on the liner landing area.

MR. FARLEY: That's all I have, Judge Brenner.

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JUDGE BRENNER: Is there any followup, strictly limited to the questions asked since your examination, Mr. Dynner?

MR. DYNNER: I have no followup but I wanted to move Suffolk County Exhibit 79 into evidence, which I neglected to do in the last round.

JUDGE BRENNER: Any objection?

MR. GODDARD: None.

JUDGE BRENNER: Hearing none, we will admit Suffolk County Diesel Exhibit 79 into evidence.

(Whereupon, Suffolk County Diesel Exhibit 79 was received as evidence.)

JUDGE BRENNER: I think that the time has finally come down where we can excuse you as a Panel. I have observed that the dynamics of a witness panel, the procedural dynamics, are complex. I have said that before in this proceeding and I have seen a microcosm of the complexities while this Panel was here, including many examples of inconsistent advice from different questioners and the Board such as be as brief as you can but be complete, don't use your imagination, use your imagination, make that complex matter simple, don't oversimplify it it's more complex than that, and so on. And we appreciate, and I know all Counsel, even from parties that disagree with your

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position because they have their own witnesses that they prepare, recognize that these matters are difficult and in the course of all that we expect to get the substance out also. So we appreciate what you've been through and we appreciate your efforts at assisting us and we ask you to pass that on to Dr. Wells on our behalf also. And you're all excused at this time.

(The witness panel excused.)

JUDGE BRENNER: Can we get the County's witnesses empaneled? Mr. Goddard, did you want to introduce your colleague, as long as there is a moment?

MR. GODDARD: Yes, sir, I would. With me at Counsel table at this time is Robert G. Perlis of the Office of the Executive Legal Director who will be assisting me in this proceeding.

JUDGE BRENNER: Yes, as I recall Mr. Perlis had a written notice of appearance in this case near the beginning at least a year and a half ago or so.

MR. PERLIS: That's correct.

JUDGE BRENNER: And now he has shown up in the flesh.

While they are getting ready I want to thank the County for the minor housekeeping matter of including the attributions of witnesses in the revised testimony. That was helpful since I had done that in my earlier testimony

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and now I can use just the new document.

We're ready whenever you are.

Whereupon,

ROBERT N. ANDERSON,

STANLEY CHRISTENSEN,

G. DENNIS ELEY,

RICHARD B. HUBBARD

and

DALE G. BRIDENBAUGH

were recalled as witnesses and, having been previously duly sworn, testified further as follows.

AGBpp

MR. BRIGATI: Thank you, Judge Brenner, and good morning. Good morning, Judge Morris.

Before I start with our witresses we do have copies of the more legible exhibit introduced yesterday. I believe the number is 78. It is the trip report dated April 14, 1983 and I won't try to describe it further at this point.

JUDGE BRENNER: You've got the correct number and we appreciate that. If you could make sure they get -- the copies that the reporter uses in the official file, that they are the more legible ones, I would appreciate that.

And this came in yesterday and we are substituting legible copies.

(Documents distributed.)

MR. BRITAGI: Since the County's witnesses on the block panel are the same as the witnesses for the crankshaft testimony, I assume there is no need to introduce them. They do have name tags.

JUDGE BRENNER: All right. And they have been previously sworn also.

MR. BRITAGI: So they should understand that they are under oath based upon that taking of the oath last time. The County's testimony concerning adequacy of the cylinder blocks of the Shoreham EDGs was originally filed on July 31, 1984 and distributed to the other parties at that

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time. It was introduced with the County's testimony concerning crankshafts on October 1, 1984 and that volume also included testimony concerning the pistons. Pages 143 through 184 of the filing, with the changes that were described back when we introduced the crankshaft testimony, have been assembled in a separate exhibit which has been previously distributed to the Board and the parties. It bears the date October 29, 1984 in the upper righthand corner and is entitled, "Revised Joint Direct Testimony of Dr. Robert N. Anderson, Professor Stanley G. Christensen, G. Dennis Eley, Dale G. Bridenbaugh, and Richard B. Hubbard, regarding Suffolk County's emergency diesel generator contentions concerning cylinder blocks." Since the filing of the testimony on October 1 as part of the overall County's testimony, we have seen fit to introduce some additional changes to pages 143 through 184 in the belief that those changes will simplify the record and I would like to explain them now.

I should note that the original testimony was prepared on the basis of the facts as they were known to the County up to July 31, 1984. Since that time LILCO has presented new information in the form of testimony dated August 14, 1984 and its supplemental testimony dated September 20, 1984. As a result of certain new information presented in those two filings, Suffolk County decided it

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would be appropriate to revise its block testimony as originally filed solely to account for the new information presented in those two new filings.

(Pause.)

Mr. Dynner warns me that there may be some changes to account for testimony adduced during cross examination. It is my impression that there aren't any, but for the sake of safety --

JUDGE BRENNER: No, I think there are some.

MR. BRIGATI: Well, then Mr. Dynner is right. The changes or the major changes can be summarized as follows. We have added references to the revised crack maps that were prepared and introduced by LILCO. The testimony concerning physical property of the blocks has been revised to reflect information concerning the presence of Widmanstaetten graphite in the old block 103 which we were not aware of July 31 and we have deleted portions of testimony pertaining to FaAA's finite element analysis concerning crack initiation in the block top. Those deletions have been marked with diagonal markings to distinguish them from deletions directed by the Board pursuant to LILCO's motion to strike, which deletions are denominated by horizontal lines through the testimony.

As you noted, before I began my remarks, Judge Brenner, we have also revised the testimony to reflect the

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identity of the witnesses who are sponsoring the testimony in the belief that their identification in the body of the testimony may simplify the job of the Board and the parties in interpreting the record later.

We are sorry we didn't do that from the beginning. In connection with those identification of the sponsors for particular questions, I should note that we have changed sponsorship of certain questions from the sheet that was originally filed with the Board in August in certain particulars.

Those changes consist in all but one case of deleting sponsors from the group that may have been sponsoring a particular question in the belief that the multiple sponsorship with respect to those particular answers was probably redundant. However, in one case we concluded that it was appropriate to add a sponsor for a question or an answer and that exception is reflected on page 182 of the testimony where Mr. Bridenbaugh has been answered as a sponsor of the testimony appearing as the first answer on that page.

Judge, at this point is it appropriate to have the revised b ock testimony introduced or marked as an exhibit?

JUDGE BRENNER: Yes. Well, we'll end up binding it into the transcript as if read rather than give it an

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exhibit number. One minor thing, I believe footnotes 191 and 192 on page 158 should have been struck through.

MR. BRIGATI: Let me note, and I'm sorry I failed to note this, this is -- I haven't gotten far enough into my prepared remarks.

JUDGE BRENNER: I'm sorry.

MR. BRIGATI: It's all right.

In handing out the revised testimony to the Board and the other parties two days ago, we gave out copies that failed to include some deletions or changes that were appropriate and I'd like to describe them now. We -- in reviewing that material, we discovered that on page 158 footnotes 191 and 192 should have been deleted in keeping with the Board's order to strike. And the copies that will be provided for the court reporter as part of the official record include such deletions.

I'd also like to note that on page 159, footnote 195 should be revised to reflect a citation including the words, "Block report" in place of "id" since the "id" refers to material that has been stricken and to clarify the reference.

Similarly, on page 163, footnote 204 --

MR. FARLEY: Excuse me, Judge. I don't understand how that's going to read.

JUDGE BRENNER: It will read "Block report at

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5-1."

MR. BRIGATI: It should read "FaAA Block report at 5-1," Mr. Farley.

MR. FARLEY: Thank you.

MR. BRIGATI: And I will be happy to give you a copy of the testimony that includes these, what I consider to be, editorial changes if this explanation causes you any confusion. Also, on page 163, footnote 24 had an "id" -- footnote 204 had an "id" that had to be changed to reflect FaAA Block Report because the "id" was referring to a footnote, previous footnote, that had been stricken.

I should also note that the County believes that pages 1 through 25 of the Joint Direct Testimony introduced on October 1, 1984 includes background information that is pertinent to the revised block testimony and we assume that those pages will be considered in connection with the testimony being filed today.

JUDGE BRENNER: All right. That's acceptable. I don't remember mechanically exactly what we said at the time we bound the County's testimony in, but I wouldn't be surprised if there was not some reference to the fact -- going back up -- it was bound in for the first time in conjunction with the fact that we're going to hear oral questions of the County's Panel regarding crankshafts.

And at that time I believe we bound the entire

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testimony in with the caveat that we were only actually admitting into evidence -- well, no, I think we admitted the whole thing into evidence --

MR. BRIGATI: I believe you did, Judge. I could find --

JUDGE BRENNER: All right. I should have thought before I opened my mouth. I think it is going to be mechanically okay. In any event, your comment just now is acceptable and those pages are in evidence.

MR. BRIGATI: Thank you.

MR. FARLEY: Note our objection for the lateness of this, please?

JUDGE BRENNER: Lateness of what?

MR. FARLEY: Of this evidence. As I understood it, what was going to be used as evidence was the modified document that was given to me on -- it was dated October 29.

JUDGE BRENNER: All right. Your objection is noted.

MR. BRIGATI: In addition to the revised block testimony that I have just been describing, we have assembled a package of exhibits which pertain only to that testimony from the package of exhibits originally filed with the County's collective diesel testimony, filed on July 31. In that connection, I should note that certain of the

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original block exhibits have been eliminated entirely and others have been reduced in scope in keeping with the Board's direction to try to eliminate unnecessary information from the documents.

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The current package of block exhibits are bound into a volume entitled "Suffolk County's Exhibits to Joint Direct Testimony - Cylinder Block Exhibits."

Judge, I don't know whether you have a copy of that in front of you. You are about to receive one.

(Document handed to the Court.)

MR. BRIGATI: Copies were disseminated to the Staff and to LILCO's Counsel yesterday I believe.

I should note that these exhibits consist of Exhibits 7, 24, 32, 54 through 59, and 66 through 67.

Finally, we have filed supplemental block testimony dated October 18th, 1984, responding to LILCO's supplemental testimony on the blocks dated September 20th, 1984. That testimony is bound into a volume entitled "Supplemental Testimony of Dr. Robert N. Anderson, Professor Stanley Christensen, G. Dennis Eley, and Richard B. Hubbard Regarding Suffolk County's Emergency Diesel Generator Contention Concerning Cylinder Blocks."

You will note that Mr. Bridenbaugh is not a sponsor of any of that testimony.

That testimony also includes in the same volume ten exhibits numbered S-1 through S-10.

JUDGE MORRIS: Could I ask a minor question?

MR. BRIGATI: Certainly, Judge Morris.

JUDGE MORRIS: Have you noted that Question and

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Answer 13 are not listed?

MR. BRIGATI: Thank you, Judge. We can't seem to file anything perfect in this proceeding.

JUDGE BRENNER: Well, just so you understand what I'm sure Judge Morris meant, it is for you to make sure that your word processors didn't drop something out rather than just a simple omission of a number.

MR. BRIGATI: I believe that it is an omission of a number, but we will check that to be absolutely certain.

Thank you, and I apologize.

With that introduction of our testimony, I will address certain questions to Dr. Anderson who will serve as the chairman of this particular panel of the County's witnesses.

DIRECT EXAMINATION

BY MR. BRIGATI:

Q Dr. Anderson, do you have before you the revised joint--

JUDGE BRENNER: Let's go off the record for a minute.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

BY MR. BRIGATI:

Q Dr. Anderson, do you have before you the revised joint direct testimony dated October 29, 1984, the exhibits

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to that testimony, and the supplemental testimony dated October 10, 1984, as just described by me?

A (Witness Anderson) Yes, I do.

Q Have I accurately described that testimony and the changes that have been made in the original testimony as it was filed on July 31, 1984, on your behalf concerning the cylinder blocks?

A You have accurately described it, yes.

Q Do you have any further explanations concerning changes to that testimony that you desire to make at this time?

A Yes, I do.

Q Will you please make your statements?

A Yes.

I want to note that based upon the testimony of Failure Analysis witnesses during their cross-examination which supplemented their original testimony, as well as information disclosed during their depositions, and on my own examination of materials, I now believe that destructive examination of the original block for EDG 103 indicates evidence of significant quantities of Widmanstaetten graphite in certain areas of the block top.

Assuming those quantities of Widmanstaetten graphite are represented by the photomicrographs shown in LILCO's Diesel Exhibits B-33 and B-34, the effect would be

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to reduce the mechanical properties of the cast iron in those areas.

Although that reduction cannot be accurately quantified, the result could be that the initiation and propagation of such cracks in those areas would occur with fewer hours of EDG operation at higher loads, or fewer quick starts to high loads than would be the case if those areas did not have such quantities of Widmanstaetten graphite.

There is, however, insufficient evidence to conclude that areas of block tops EDG 101 and 102, which have ligament cracks, are free of Widmanstaetten graphite or that the material of those blocks has the properties of typical ASTM Class 40 cast gray iron.

I should also note that we have studied the changes in the dimensions of the cracks discovered in EDGs 101, 102 and 103 as recently filed by LILCO, Revised Exhibits B-16, B-17, B-18 and B-25, and those changes do not cause us to revise our original opinions concerning the significance of those cracks.

Q Thank you, Dr. Anderson.

MR. BRIGATI: I will address the following questions to the entire panel to be answered by each member in turn when I call your name.

BY MR. BRIGATI:

Q Is the testimony just described by me, together

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with the accompanying exhibits and the additional explanation just provided by Dr. Anderson, true and accurate to the best of your knowledge and belief?

Mr. Bridenbaugh?

A (Witness Bridenbaugh) Yes, it is.

Q Professor Christensen?

A (Witnss Christensen) Yes, it is.

Q Dr. Anderson?

A (Witness Anderson) Yes, it is.

Q Mr. Eley?

A (Witness Eley) Yes, it is.

Q Mr. Hubbard?

A (Witness Hubbard) Yes.

Q Do you adopt that testimony as your testimony in this proceeding?

Mr. Bridenbaugh?

A (Witness Bridenbaugh) I do.

A (Witness Christensen) I do.

A (Witness Anderson) I do.

A (Witness Eley) I do.

A (Witness Hubbard) I do.

MR. BRIGATI: Judge Brenner, we offer into evidence the County's testimony as just described, together with the exhibits accompanying that testimony.

MR. FARLEY: May I be heard?

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JUDGE BRENNER: Yes.

MR. FARLEY: I object to the introduction of the direct testimony, beginning on page 143 and extending through the answer on the top of 146, because the entire testimony states on its face that it is based on the preliminary and draft FaAA report.

And I object to the introduction of the testimony beginning at the top of page 150, the first question and answer referring to the--

JUDGE BRENNER: I'm sorry, what page, Mr. Farley?

MR. FARLEY: 150, your Honor, referring to the TDI Owners' Group, as being beyond the contentions admitted for litigation pursuant to the Board rulings on July 5th.

And finally I object to what remains of the testimony, beginning with the question and answer on page 168 and extending through the answer on 170, on the ground that it is nothing more than a statement of questions unanswered by the testimony.

JUDGE BRENNER: Have you completed?

MR. FARLEY: That completes the testimony. I would like to make a motion on the exhibits.

JUDGE BRENNER: Let me deal with the testimony first, unless you think we should take them up together.

MR. FARLEY: No, sir.

(The Board conferring.)

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JUDGE BRENNER: Your objections are denied on the basis that they could have and should have been made on the schedule we set for motions to strike, unless you think I'm missing something. As I understood your objections, that is my ruling.

MR. FARLEY: I thought they were encompassed in the motions to strike which were denied in part.

JUDGE BRENNER: There is that ruling then.

MR. FARLEY: But now I want to object to just these two items.

JUDGE BRENNER: You don't have to repeat your objections made in your motion to strike just for the sake of any record because you've got your record on that. So if that is your purpose, there is no need to take up the time.

MR. FARLEY: I understand that. I didn't do it for that reason.

JUDGE BRENNER: All right.

MR. FARLEY: May I be heard on the exhibits?

JUDGE BRENNER: Yes, but you are likely to have the same reaction, so consider that in what I ruled in our ruling here when you tell me what the basis is for your motions on the exhibits.

MR. FARLEY: All right, sir.

JUDGE BRENNER: I don't want to take up time on things that you should have and could have included in your

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motion to strike, or go over any motions which you may have made then which were denied, or at least not granted.

MR. FARLEY: On the motion to strike, the Board ruled that voluminous exhibits would not be admitted, but only partial exhibits. I do not think-- I object to Exhibit 7--

JUDGE BRENNER: That's not exactly the ruling, but go ahead.

MR. FARLEY: I object to Exhibit 7 proposed by the County on the ground that it is an impartial -- I mean it is an inaccurate and only a partial appropriate part of the FaAA preliminary report of June 1984.

In the alternative, if you disagree with that objection, I would respectfully urge that the complete report be admitted into evidence.

JUDGE BRENNER: Maybe I don't understand. I thought what you said is exactly the same thing in both your points. I assume that the remedy you would seek as to the first one would be to have the whole report introduced into evidence.

MR. FARLEY: No, sir, I just want to object to this partial--

JUDGE BRENNER: You want to keep the whole thing out?

MR. FARLEY: Yes, sir.

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JUDGE BRENNER: Well, we're not going to do that. We've been through enough of this litigation to know that we're not going to do that with that report.

MR. FARLEY: All right, sir.

JUDGE BRENNER: So in the alternative, you want the whole report admitted in evidence.

MR. FARLEY: Yes, sir.

JUDGE BRENNER: I don't know what portions the County has deleted because I have only just now received the scaled-down version of the County's Exhibit 7.

I take it it is correct that there are deletions from the FaAA Block Report since the time of your initial filing in August.

MR. BRIGATI: Yes, Judge, and there are significant deletions, and the significant deletions were made--

JUDGE BRENNER: You've answered my question. I just wanted to ascertain the facts, which you answered.

We are going to let the County put in what it wants to put in in the first instance, when the objection is that the exhibit is incomplete.

And Mr. Farley, on cross-examination you can bring out other parts of the report that you think should be brought out and then make an appropriate motion that some course -- or upon the completion of your cross-examination

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that we should admit other portions of the report into evidence, and we will gladly consider such motions in the context at that time.

MR. FARLEY: I object to Exhibit 55 on the grounds that it is hearsay. The people, the authors of the documents are not here to be cross-examined, and there is no way to establish or verify the authenticity of the events reported.

JUDGE BRENNER: Well, I don't even know what it is, and I'm not going to worry about it because you could have and should have made that motion in your motion to strike. And you can pursue it on cross-examination, and then we will give it the appropriate weight.

That is why this Board sets times and schedules for motions to strike in advance of testimony, to avoid all this when we are waiting to get to the testimony. So I don't understand what was on LILCO's mind, but go ahead. Get to your next one.

MR. FARLEY: I object to Exhibit 56, which is the partial extract from the Phase II report of the TDI Owners' Group on the cylinder block component.

JUDGE BRENNER: Why?

MR. FARLEY: And finally-- Again, that I understood the ruling on July 5 to be that to the extent that a particular Phase II report tied in with one of the

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four components that was going to be litigated, it would be admissible, but not the TDI Owners' Group, the DR/QR generally.

JUDGE BRENNER: Let me put it to you this way:

If you can point specifically to any of the portions of your motion to strike that we granted that should have included one of the exhibits and for some reason or another, either because your motion neglected to reference the exhibit or because we had in the scope of that ruling-- There has been plenty of time since the time of our order for LILCO to bring that to our attention, and we shouldn't be hearing it for the first time now, when we are about ready to get to the witnesses.

Notwithstanding that, if you can point to something in our order granting parts of your motion to strike that we did grant which should have encompassed one of these exhibits, I will be willing to look at it. But otherwise, you are too late on motions to strike.

MR. FARLEY: May I respond?

JUDGE BRENNER: Yes.

MR. FARLEY: I understood from the order of July 17th, 1984, ruling on the motion to strike, that the Board indicated it did not know what exhibits, if any, the County would move into evidence and on the basis of that, the Board would not grant the motion to strike with respect to all of

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So your premise was not quite correct.

JUDGE BRENNER: No, that's--

MR. FARLEY: So now that they are moving them into evidence I thought I should object.

JUDGE BRENNER: That is not quite right, Mr. Farley, although maybe you could infer that from the written order. I will be glad to tell you as one of the authors that that is not quite right.

We expressed the fact that we did not know what exhibits the parties were going to move into evidence in the context of encouraging the parties to cut down on those exhibits, but we would have, as part of our ruling on portions of the testimony that we did strike, have included necessarily any exhibits which were there only for the purpose of being related to that testimony which we struck.

And I think, although I am not sure, that at least in one or two cases we did do that, either where your motion motion expressly referenced the exhibit or where it was obvious.

But there was a lot in that motion to strike, some of which was acceptable and a lot of which wasn't. And you run that risk when you file those kinds of motions that anything that was legitimate with the proper priority would get lost with a whole lot of things that were not well-supported in our view. So your premise was not quite correct.

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Your premise was correct as to the kind of motion you just made as to Exhibit 7, and I have indicated you might well be accorded some relief on that. That's in the category of being too voluminous. But if you point to something in our ruling I will consider it. But what I'm saying is, you should have done this over a month ago. I don't even remember the date of our order now, but I guess it was in August.

MR. FARLEY: July 17th --

JUDGE BRENNER: Our order ruling on your motion to strike?

MR. FARLEY: No, you're right; the July 17th order was following up the July 5th hearing.

JUDGE BRENNER: I've got the order now. It was September 7th, 1984.

Hearing time is precious and it should be used for hearing time and that's why I schedule motions for other times.

MR. FARLEY: I understand, your Honor, I just have one more objection and I'm finished.

JUDGE BRENNER: All right.

MR. FARLEY: I object to Exhibit 67 coming into evidence again on the grounds of lack of foundation and authenticity.

JUDGE BRENNER: All right.

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I'm going to deny it as being late unless you can point to something on our ruling on the motion to strike that should have encompassed it but through inadvertence either on the part of LILCO and the way it expressed the motion or on the part of the Board and the way we expressed the ruling I am not going to consider it.

I don't know right at this point in time what this exhibit is tied to in all of this testimony and I'm not going to stop and educate myself right now on the subject, I am being very candid with you. That's why when you file the motions in advance I can go through that analyses. And we gave you the benefit of a prehearing order and you could have come back after that order and I would have gone through the analyses again if I thought it was warranted but I'm not going to stop everything and do that now.

But you have ample safety valves, which is another reason I'm not concerned, that is, by pursuing the exhibit -- your problems with the exhibits through the cross-examination of these witnesses.

MR. FARLEY: Excuse me a minute, Judge Brenner.

(Pause.)

I'm sorry, I can't find it. That's all I have.

JUDGE BRENNER: All right.

Having denied LILCO's objections which were just made and indicating the possible relief in at least one

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area, we will grant the motion to admit the prefiled direct written testimony and exhibits of Suffolk County as related to the cylinder blocks, specifically we will admit into evidence and bind into the transcript as if read Suffolk County's revised joint direct testimony which are of all of its five witnesses concerning the cylinder blocks which document was dated October 29, 1984 and Mr. Brigati has explained the changes and let's bind that in at this point.

(The revised joint direct testimony follows.)

SUFFOLK COUNTY, 10/29/84

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

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

REVISED JOINT DIRECT TESTIMONY OF DR. ROBERT N. ANDERSON, PROFESSOR STANLEY G. CHRISTENSEN, G. DENNIS ELEY, DALE G. BRIDENBAUGH AND RICHARD B. HUBBARD REGARDING SUFFOLK COUNTY'S EMERGENCY DIESEL GENERATOR CONTENTIONS CONCERNING CYLINDER BLOCKS

KEY TO IDENTIFICATION OF WITNESSES

This testimony has been amended to reflect which of the County's witnesses are sponsoring individual answers by noting initials of the sponsors before each answer or by noting "All" before answers being sponsored by all witnesses.

The initials used for the various witnesses conform to the first initial of their last names as follows:

A = Dr. Anderson

B = Mr. Bridenbaugh

C = Professor Christensen

E = Mr. Eley

H = Mr. Hubbard

JOINT DIRECT TESTIMONY OF
DR. ROBERT N. ANDERSON, et al.

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CYLINDER BLOCKS

Q. What is the purpose of this testimony?

A. (ALL) The purpose of this testimony is to set forth the results of our evaluation of that portion of the County's contention which addresses the cylinder block problems of the EDGs. That portion states:

> "Cracks have occurred in the cylinder blocks of all EDGs, and a large crack propagated through the front of EDG 103. Cracks have also been observed in the camshaft gallery area of the blocks. The replacement cylinder block for EDG 103 is a new design which is unproven in DSR-48 diesels and has been inadequately tested."

Q. What are your conclusions regarding the adequacy of the design and manufacture of the cylinder blocks?

A. (ALL) We believe the block cracks are evidence that the EDGs are over-rated and undersized. The EDG cylinder blocks are not properly designed and manufactured to withstand the stresses to which they are subjected. We are concerned that LILCO proposes to use the cracked blocks of EDGs 101 and 102 for EDGs in nuclear service during the operation of the Shoreham plant. Those blocks are unreliable and are likely to experience crack propagation which can lead to catastrophic

failure of the EDGs. The newly designed block for EDG 103 is unproven and inadequately tested.

Contrary to the conclusions reached by FaAA in the cylinder block report[162/] and by the Owners' Group DRQR Report on cylinder blocks, we conclude that:

1. The cracks in the ligament between stud holes and liner counterbores of the blocks of the EDGs are not benign and may lead to catastrophic failure of the engine. Further, the cracks may not be fully contained between the liner and the region of the block top outside the stud hole circle.

2. Field experience in non-nuclear service has not been systematically documented or reviewed in order to demonstrate the extent of ligament cracking or the immediate consequences of such cracking.

3. The deepest crack (5-1/2* inch depth) between stud holes was measured after the immediate shutdown of EDG 103 following crack propagation during overload

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162/ "Design Review of TDI R-4 and RV-4 Series Emergency Diesel Generator Cylinder Blocks and Liners," FaAA-84-5-4, Failure Analysis Associates, June, 1984 (the "FaAA Block Report"). (Exhibit 7).

*/ FaAA has since changed this measurement to 3 inches.

Accordingly, whenever the 5½-inch depth for this crack is refered to, it should be read 3 inches.

testing of EDG 103, and contributed to the decision to replace the block. The replacement block has not been adequately tested.

4. Blocks with ligament cracks (those of EDGs 101 and 102) have not been demonstrated to be capable of withstanding a LOOP/LOCA event. While we agree with FaAA's conclusion that cracks between stud holes are likely to occur and propagate in blocks with ligament cracks, we disagree that FaAA can predict with any accuracy when such cracks will initiate or the rate at which they will propagate.

5. The preliminary material evaluation by FaAA of the microstructure of a small region of each block top of the EDGs is not representative of the properties of the entire block and does not demonstrate that the block EDG 103 is significantly weaker than the other two blocks. To reach conclusions regarding the sufficiency of the material strength of the blocks of EDGs 101 and 102 in comparison to that of EDG 103, the material of all three blocks must be adequately evaluated.

6. The cracks in the cam gallery support region of the EDG blocks may be detrimental to the operation of the engine. Further, the assessment of these cracks has failed to demonstrate that the cracks will grow very slowly or not at all, at 75 percent load, or that the cracks can be attributed solely to the casting process.

Based on the foregoing, we conclude that it has not been demonstrated that the cylinder blocks of the EDGs will reliably perform their required functions, and thus, there can be no assurance that the EDGs will perform satisfactorily in service.

Q. Please describe the cracks which have occurred in the cylinder blocks of the EDGs.

A. (ALL) There is no disagreement that numerous cracks exist on the block tops of EDGs 101 and 102, running in the radial/vertical plane between stud holes and the cylinder bores. These cracks are shown in drawings, and some of them are described, in the FaAA Block Report.163/ Similar cracks were found in the top of the block of EDG 103, which also had cracks between stud holes for adjacent cylinders 4 and 5.164/ On

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163/ FaAA Block Report at 1-2 to 1-3 and Figures 1-2 and 1-3. See also revisions in LiLco Exhibits B-16 and B-17.

164/ Id. at 1-2 and Figure 1-4. See also revisions in LiLco Exhibit B-18.

April 14, 1984, during qualification testing at 3900 kW, a crack was noticed starting under the no. 1 cylinder head and extending across the front of the EDG 103 block and about 4 1/2 inches down the front of the engine.165/ Subsequent inspection of the EDG 103 block showed that many existing cracks had propagated, and that additional between-stud hole cracks had developed at four other locations.166/ In addition, there are cracks in the camshaft gallery areas of all three EDG blocks.167/ These cracks have been observed to grow in the EDG 103 block.168/

Q. Does the FaAA Block Report provide a satisfactory design review of the cylinder blocks?

A. (P, H) No. Rather than a design review of the blocks, it is a summary of FaAA's "investigation of the structural adequacy" of the blocks.169/ FaAA fails to address most of the

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165/ Letter dated April 17, 1984, to Administrative Judges from E.J. Reis (NRC Staff). (Exhibit 54).

166/ FaAA Block Report at 1-2 to 1-3 and Figures 1-5 to 1-8. See also revisions in LiLCO exhibit B-25.

167/ Id. at 4-6.

168/ Morning Report, NRC Region I, March 20, 1984. (Exhibit 55).

169/ FaAA Block Report at i and ii.

functional attributes of the cylinder blocks set forth in the Task Description for the Component Design Review.170/ We believe it is significant that FaAA does not conclude that the cylinder blocks are adequate for nuclear service and capable of unlimited operation. However, based solely upon the FaAA Block Report and its supporting packages, the TDI Owners' Group concluded that the cracked blocks of EDGs 101 and 102 and the replacement block for EDG 103 (pending final material study results for the original and replacement EDG 103 blocks)

> are acceptable for intended function with implementation of routine inspections in accordance with E&DCR F-46505.171/

Q. What does the TDI Owners Group mean by the phrase "acceptable for intended function"?

(A,B,H)

A. The DRQR Report does not expressly define this phrase, but indications are that it refers to the ability of the cylinder block "to withstand with sufficient margin a LOOP/LOCA event."172/ There is no suggestion of what a "sufficient margin" might be. Mr. William Museler, a vice president

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170/ Id., Appendix.

171/ DRQR Report, Vol. 4, Cylinder Block, at 3. (Exhibit 56).

172/ Id. at 2; see also Id. at C1 and C2.

of LILCO and former technical manager of the TDI Owners' Group program, testified that the ad hoc acceptance criterion applied by the Owners' Group program for adequacy of the EDGs was not the performance rating of the EDG established by the FSAR and the contract specification.173/ Rather, the TDI Owners Group criterion was reliable operation during the testing required to be performed plus one LOOP/LOCA event for seven days.174/

Q. Is the TDI Owners' Group acceptance criterion intended to be applied to qualify the EDGs only for operation during the approximately 18 month period until the first refueling outage at Shoreham, when the newly purchased Colt EDGs are scheduled to be installed?

A. (B,H) Not according to Mr. Museler. He testified that although LILCO intends to replace the EDGs with Colt diesels by the first refueling outage, the Owners' Group criterion was intended to qualify the EDGs for a period "far beyond the interim period."175/

173/ Deposition of William J. Museler (May 22, 1984) ("Museler Deposition") at 7-8. (Exhibit 57).

174/ Id. at 14-17.

175/ Id. at 43-46.

Q. Is the criterion used by the TDI Owners' Group appropriate to ensure that the EDGs, and specifically their cylinder blocks, are adequate and reliable enough to meet the requirements of GDC 17?

(B,H)

A. No. The Owners' Group criterion is extremely limited, subjective and does not meet the technical requirements of GDC 17. As discussed above, the proper technical standard for GDC 17 is the performance rating for the EDGs set forth in the FSAR. That rating -- 3500 KW continuously for one year and 3900 kW for 2 hours per 24 hour period -- was established by LILCO and approved by the NRC Staff on the basis of the required service for the EDGs. There is no rational or regulatory basis to eliminate that performance standard.

Q. Did the FaAA Block Report use the same improper acceptance criterion as the TDI Owners' Group for determining the adequacy of cylinder blocks?

(A,B,H)

A. FaAA issued an interim report on the cylinder block and liner, which concluded preliminarily that the DSR-48 cylinder blocks may be adequate "for interim use" depending on further analysis.176/ Mr. Robert Taylor of FaAA, who prepared the

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176/ Exhibit 1 to Taylor Deposition. (Exhibit 58).

interim report, testified that in determining "interim use," he used an "intended load profile" for two years of about 260 hours of EDG operation, including 80 hours at full load and less than one hour at 3900 kW.177/ In the final FaAA Block Report no statement is made as to whether or not the cylinder blocks are adequate for interim or any other use, so no acceptance criterion is expressly applied. However, FaAA appears to have further reduced the inadequate and improper criterion of the two year "intended load profile," because the FaAA Block Report only specifically addresses whether an engine block with cracks between the stud holes and cylinder bore (so-called "ligament cracks"), but with no stud hole to stud hole cracks, can be predicted to survive a LOOP/LOCA event.178/ This criterion is totally inadequate to satisfy the standards required by GDC 17.

Q. The FaAA Block Report sets forth a number of conclusions and recommendations which are applicable to the EDGs. Do you agree with the FaAA conclusion that the cracks in the ligament between the stud holes and liner counterbore are "benign."179/

177/ Taylor Deposition at 69-70. (Exhibit 59).

178/ FaAA Block Report at 4-3 to 4-5.

179/ Id. at 5-1.

(B,C,E)

A. We strongly disagree with FaAA's conclusion that these ligament cracks are "benign." First, FaAA states, and we agree, that one consequence of the ligament cracks might be leakage of coolant (although not into the cylinder).180/ Such leakage is far from "benign," and could lead to catastrophic failure of the EDG.

Q. How could the leaking of coolant lead to a catastrophic failure?

(B,C,E)

A. The leaking of the coolant could result in temperature increases of the upper part of the cylinder liner and head. The consequent thermal stresses on the cylinder block, cylinder heads, pistons, and other engine components increase the likelihood of cracking. For example, the overheating of the cylinder liner could crack the liner and/or cause a partial piston seizure. A partial piston seizure makes combustion gas blow-by highly probable, which may lead to a crankcase explosion and complete piston seizure. Lack of sufficient coolant could also lead to distortion of the cylinder head, which could cause the exhaust valves to fail to seat completely. Distortion of the cylinder head and the leakage of gases from the

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180/ Id. at ii to iii.

exhaust valves could lead to overspeeding of the turbocharger and damage to the blades and rotor, which would stop the turbocharger. This would result in an insufficient quantity of air supply to the engine, further increased temperatures of the operating parts, and ultimately to a complete piston seizure. Complete piston seizure would cause bent or broken connecting rods, serious overloading and possible cracking of tne main bearing shells, cracking in the engine base and stretching of the main bearing hold down studs. A complete piston seizure will almost always stop the EDG.

Q. Can you predict how quickly the coolant would leak from the ligament cracks?

(C,E)

A. Coolant water could leak rapidly from ligament cracks. The coolant water is under pressure of 40 psi. The rate of leakage would depend on the number of cracks and their widths. The leakage becomes critical when the expansion tank (coolant reservoir) either cannot replace the loss of coolant water fast enough or is depleted. A dangerous overheating condition occurs when the temperature is high and the water low so that the circulating coolant mixture consists of liquid and vapor.

Q. Do you agree with FaAA's conclusion that the ligament cracks are benign

> because the cracked section is fully contained between the liner and the region of the block top outside the stud hole circle.181/

(B,C,E)

A. It is not clear what FaAA means by this description. FaAA describes the ligament cracks accurately as running between the stud holes and the liner counterbore, so the cracks do run to the stud hole itself. We believe that FaAA is referring to the "apparent arrest" of the ligament cracks at the liner landing ledge.182/ This conclusion as to the "apparent arrest" of ligament cracks is based upon observation of ligament crack depth on the EDG blocks, and unconfirmed183/ and incomplete information regarding selected blocks of TDI engines in non-nuclear service.

Q. Were ligament cracks "fully contained" during the testing of the EDGs?

181/ Id. at 5-1.

182/ Id. at 1-2 and 1-3.

183/ Id. at 1-1.

(A, B, C, E)

A. No. The history of the ligament cracks on the EDG blocks does not support the conclusion that they are "fully contained" and therefore "benign." On the contrary, the large 4½" crack which occurred on the EDG 103 block during overload testing ran from a stud hole at cylinder No. 1 which already had a ligament crack. Compare Figures 1-4 and 1-8, FaAA Block Report. That comparison also discloses that after the overload test was aborted, nine new stud hole to stud hole cracks had initiated. Thus, even if the ligament cracks on the EDGs had not propagated downward past the liner landing, they cannot be described as benign. If the ligament crack is in fact arrested at the liner landing ledge, it would appear that continuing sufficient operating stress causes cracks to initiate and propagate radially and vertically from the stud hole with the ligament to adjacent stud holes or to the outer wall of the block.184/ Finally, Figure 1-8 contradicts FaAA's assertion that ligament cracks will not grow beyond the 1-1/2" depth of the liner landing ledge, because it shows six ligament cracks with a depth of 2 to 2-1/2." LiLco's recently revised version of Figure 1-8 is LiLco Exhibit B-25, and it shows only one ligament crack having a depth of 2½ inches, but that still contradicts FaAA's assertion.

184/ Note that Figure 1-8 of the FaAA Block Report shows that most of the ligament cracks had reached a depth of at least 1.5", the reported depth to the liner landing.

Q. Doesn't FaAA's data on cracked blocks in non-nuclear service demonstrate that the ligament cracks are "benign" and cannot have adverse "immediate consequences"?185/

(A,C,E)
A. No. The unconfirmed information given in the FaAA Block Report186/ does not support FaAA's conclusion at all. FaAA concludes that the mechanism of crack initiation in the cylinder block tops are low cycle fatigue during startup to high load levels, high frequency fatigue from firing pressure stresses, and overload rupture occurring at loads above rated power levels.187/ These factors, which also affect crack propagation, are all related to the loads at which an engine is run, that is, the higher the load, the greater the stress and the more likely is crack initiation and rapid propagation. FaAA states the hours which the non-nuclear engines have run, but does not disclose the loads at which they ran during those hours. We believe it inappropriate that FaAA has relied at all on the marine non-nuclear cases they cite. When asked why FaAA had decided not to examine cracks in blocks other than at Shoreham, Mr. Taylor of FaAA responded:

185/ FaAA Block Report at 5-1.

186/ Id. at 1-3 to 1-4.

187/ Id. at ii.

> Well, the engines in the Marine service see a different service than shore-based engines. Their load profiles are different. They're operated differently, and just looking at the block for the COLUMBIA without knowing the size of the liners, how much the liners protruded, exact load history, even if I were to go look at that block, I would -- there's a wealth of other data that would be pertinent that I don't have yet and probably would not be able to reconstruct.188/

Mr. Taylor also testified that data such as load factors would make examination of other cracked blocks useful. FaAA concedes that non-nuclear engines generally operate at lower loads and with fewer starts than nuclear diesels.189/

~~Q. Do you have additional comments on the specific cases of non-nuclear engine block cracks relied upon by FaAA?~~

~~A. Yes. The information on the M.V. Cott does not disclose load levels for this DMRV 16-4 engine, the methods by which crack depth was measured, or the fact that as the result of the cracks the engine blocks were repaired and modified.190/ During the telephone conversation on which FaAA relies for its~~

188/ Taylor Deposition at 40- 41. (Exhibit 59).

189/ FaAA Block Report at 4-3.

~~190/ Letter dated November 30, 1983 from Lowrey (TDI) to Blanding (American Bureau of Shipping). (Exhibit 60).~~

information on the M.V. Gott, the owners also told FaAA that (i) the blocks on the Gott were being machined to reduce stresses, (ii) the engines on the Gott had been so extensively modified they could no longer be considered "stock" TDI diesels, (iii) a maintenance/inspection program for the engines much more comprehensive than the recommended TDI program was being used, and (iv) the design of the TDI blocks, with a cylinder liner placed in a counterbore, "is an old design which nobody uses anymore because of the resulting thermal problems."191/ The FaAA Block Report fails to disclose this information.

The statement on the M.V. Columbia fails to disclose load levels or that the State of Alaska replaced the cracked block and derated the TDI DMRV 16-4 engines by approximately 43%.192/ Further, these engines were originally rated at over 35 HP less per cylinder than the EDGs. Information on the St. Cloud, Copper Valley, Homestead and Bhiel engine blocks do not disclose

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191/ FaAA Block Report Ref. 1-3, Memo of June 7, 1984 telephone conversation between Spiegel (FaAA) and Liberty (U.S. Steel). (Exhibit 61).

192/ Evaluation of the Operational and Maintenance History of, and Recent Modifications to, the Main Engines in the M.V. Columbia, SES Report No. 123-01, by Seaworthy Engine Systems, Inc., April 1983, at 2-1. (Exhibit 62).

~~load levels or other pertinent operating information, such as peak firing pressures. The engine at Homestead is rated at 8800 kW, but is operated at only about 6000 kW. Three of the TDI engines owned by Copper Valley have been derated by 20%. Maintenance history documents obtained by LILCO or FaAA from Copper Valley disclose many problems, including replacement of a block on engine S/N 75011, but do not specifically refer to ligament cracks in the blocks.193/ Finally, FaAA has supplied no information on the block material properties or chemical composition of the cylinder blocks in non-nuclear service. Yet FaAA believes these factors are very important to crack initiation and propagation.194/ In summary, FaAA's information on non-nuclear service does not demonstrate its conclusion that the ligament cracks on the EDGs are "benign."~~

Q. Do you agree with FaAA's conclusions that ligament cracks and stud hole to stud hole cracks are predicted to occur after operation at high loads and/or engine starts to high load?195/

~~193/ Maintenance History on TDI S/N 75011 and 75012, Copper Valley Electric Ass'n. (Exhibit 63).~~

~~194/ FaAA Block Report at 4-5 to 4-6, iv.~~

FaAA Block Report at 5-1.

195/ ~~Id. at 5-1.~~

[Continued at p. 163]

(A)

A. Yes. But FaAA understates the stresses to which the blocks of the EDG are subjected, and thus underestimates the likelihood and rapidity of the initiation of ligament cracks and stud hole to stud hole cracks, and the speed of propagation of those cracks. Thus, FaAA has failed to demonstrate that blocks with ligament cracks are capable of reliably withstanding a LOOP/LOCA event.

Q. Please explain why you believe these stresses are underestimated by FaAA.

A. First, FaAA understates pressure loads on the block by assuming a peak firing pressure of only 1600 psi[196] rather than the actual value of 1700 psi or greater at 100% load.

Second, FaAA has not properly determined the preloading stress or how much of the preload is borne by the liner collar onto the liner landing ledge and how much is borne by the block.[197] FaAA states that "much" of the preload is transmitted to the liner collar, depending upon several variables. But it does not address these variables in terms of their importance or give any calculations. The liner collar

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196/ Id. at 2-3.

197/ Id. at 2-1.

protrusion, or "proudness," above the block top on the EDGs is greater than current TDI specifications, and would result in greater preload on the liner landing ledge.198/ FaAA measured the liner proudness for the cylinders of EDG 103; the measurements varied from 1 to 9 mils.199/

Third, FaAA has not calculated the amount of thermal load on the block due to thermal expansion of the liner.200/ FaAA correctly points out that thermal expansion stress of the liner will not all be transferred to the block, depending upon the clearance between the liner and block.201/ But there are no calculations of the optimum clearance or the amounts of stress not transferred under those optimum conditions. Further, there are no calculations of the actual clearances in the blocks of the EDGs, so there is no basis for FaAA's statement that "interference stresses in the block are as small as possible."202/

198/ Id. at 1-5.

199/ Calculation "Liner Proudness of DG 103, Project No. 03315A", by John H. Lau, dated 6/10/84. (Exhibit 64).

200/ FaAA Block Report at 2-2.

201/ Id. at 2-3.

202/ Id.

Q. Does FaAA's finite element analysis accurately show the effects of stresses on the top of the block?

A. No. The FaAA analysis does not accurately reflect actual probable stress effects. First, it incorrectly assumes a peak firing pressure of only 1600 psi, thereby significantly understating the stresses due to pressures. Second, it assumes the optimum clearance between the liner and block necessary to close the clearance by thermal expansion.203/ If the actual clearance for each cylinder is less than the assumed optimum, the stress effect will be greater. Third, FaAA assumes thermal stresses are symmetric between cylinders. This would only occur if the firing pressure and load in all cylinders were the same. Actually, firing pressures differ significantly from cylinder to cylinder of the same EDG, and TDI's operating manual permits a variance of ± 100 psi. Fourth, FaAA assumes all thermal stresses act radially in the plane of the top of the block. Actually, there are also longitudinal stresses in the upper surfaces of the block, so the thermal stress pattern is an oval shape.

203/ Id. at 3-3.

Q. Please explain how FaAA's incorrect and/or non-conservative assumptions affect its conclusions that ligament cracks and stud hole to stud hole cracks are predicted to initiate and propagate in the cylinder blocks?

A. FaAA predicts that these cracks could occur in fewer than 100 starts from 0 to 90% power or above and/or steady operation for over 100 hours at 90% or higher power, with a block having minimum material properties.204/ The incorrect and/or non-conservative assumptions of FaAA and its understated peak total stress figure of 33 ksi (as compared to the minimum ultimate tensile strength of 32 ksi for a 2-1/2 inch section) mean that the cracks might well initiate under FaAA's predicted conditions in blocks having higher than minimum material properties for ASTM A48-64 Class 40 gray cast iron, or at below 90% of power or at steady operation for fewer than 100 hours, or any combination of these factors. It is not possible to state by what percentage the FaAA conclusion is in error because the many variables, such as actual firing pressures, cylinder block and liner clearance, and "proudness" of the liner are impossible to predict without further experimental data for a specific engine.

204/ FaAA Block Report at 3-6.

Q. FaAA predicts crack initiation to occur at steady running for more than 100 hours at 90% power or above.205/ Wouldn't one expect that at loads above 90% cracks can initiate at fewer than 100 hours of operation? Even taking all of FaAA's [illegible]

(A,B,H)
A. Yes. The higher the operating load, the fewer hours would be required before cracks initiate. FaAA does not address this issue.206/ This is a significant omission. (B,H) A 90% load on the EDGs is only 3150 kW, well below the required actual maximum load of 3881 kW an EDG is required to carry during a LOOP/LOCA event. After 10 minutes into a LOOP/LOCA event, two EDGs must each produce a maximum coincident demand of about 3400 kW, or 97% of rated load.207/ When this factor is combined with accumulated damage from past start-ups and operation, it is apparent that cracks can initiate in a block during a LOOP/LOCA in much less than 100 hours.

205/ Id.

206/ The FaAA Block Report does state that 110% load "is clearly more damaging relative to 100% load than 100% load is relative to 90% load" (at 4-1).

207/ FSAR Table 8-3.1-1 at 4.

Q. FaAA suggests that stud hole to stud hole cracks might not be dangerous, because "the deepest measured crack in this region (5 1/2-inch depth) did not degrade engine operation or result in stud loosening."208/ Do you agree?

(B,C,E)

A. No. FaAA fails to state, indeed if it knows, when this crack grew to a 5 1/2 inch depth or how long EDG 103 operated with this crack. Even if we assume that this crack grew during the "abnormal load excursion" affecting EDG 103 on April 14, the engine could only have run less than 2 hours before it was shut down and the crack was discovered.209/ The very deep stud hole to stud hole crack contributed to the decision to replace the block. Such cracks could cause the loosening and breaking of the cylinder head studs, with consequent loss of power and overloading of the remaining cylinders. This condition would probably lead to engine failure.

Q. FaAA concludes that the cracked blocks on EDGs 101 and 102 can survive a LOOP/LOCA event if they have no cracks between stud holes and if the block material of the original

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208/ FaAA Block Report at 5-1.

209/ Id. at 1-2. EDG ran for 10 minutes after the "abnormal load excursion," then was run for 100 minutes before being shut down when the 5" crack running from cylinder no. 1 was noticed.

EDG 103 block "is shown to be sufficiently less resistant to fatigue than typical gray cast iron, class 40."210/ Do you agree?

A. (A) No. The FaAA's conclusion is based upon a purported ability to accurately predict crack initiation and growth in EDGs 101 and 102 by "cumulative damage analysis of the known experience during operation of DG 103 between 3/11/84 and 4/[illegible]/84."211/ FaAA's analysis is based upon faulty premises and insufficient data. FaAA cannot accurately predict whether and when the cracks in the blocks of EDGs 101 and 102 may cause a failure during a LOOP/LOCA event.

Q. What are FaAA's faulty premises?

A. (A) FaAA bases its analysis on a "linear cumulative damage approach (presented in Section 4.1) to obtain the total fatigue damage" of a block.212/ The use of the linear fatigue damage index is not limited by FaAA, that is, it is assumed applicable for all ranges of stress, load and duration. Extremely high loads for a short duration are known to result in failures or excessive cracking;213/ this fact is not reflected

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210/ Id. at 5-1.

211/ Id. at 4-3.

212/ Id.

213/ Indeed, FaAA emphasizes that the large crack running from the end cylinder down the front of the EDG 103 block

(Footnote cont'd next page)

by FaAA's linear damage index. Further, FaAA assumes that the damage index recorded for EDG 103 between 3/11/84 and 4/14/84 is an appropriate benchmark to predict the behavior of other blocks. On this basis, FaAA concluded that:

> A block with no existing stud-to-stud cracks and material properties sufficiently better than those of DG 103 should be able to complete the LOOP/LOCA requirements without any cracks as deep as the 5-1/2 inch crack in DG 103, while continuing to run normally.214/

However, the assumption for this conclusion is erroneous.

Q. What are the errors in the assumption?

A. (A, B) First, it completely ignores the large crack which appeared in the EDG block during overload testing and ran from cylinder no. 1 about 4½ inches down the block front, resulting in aborting the test, shutting down the engine, and ultimately contributing to the decision to replace the block. The damage caused by that crack and its impact on the ability of an EDG "continuing to run normally" is not assessed by FaAA. Second,

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(Footnote cont'd from previous page)

occurred after a 23 second unusually high load. FaAA Block Report at 1-2.

214/ FaAA Block Report at 4-5.

applying FaAA's damage index to EDGs 101 and 102 in comparison to the EDG 103 index for the stated period does not take into account the effects of differing load spectra on the three engines. Crack dynamics are affected by sequence of loads as well as their duration. FaAA provides insufficient evidence that the EDG 103 block damage in the stated period is a worst possible case.

Q. Do you have other concerns with the validity of FaAA's analysis?

A. (A) Yes. Although we have not had an opportunity to review some of FaAA's underlying calculations which were only obtained a few days ago, we are concerned with FaAA's conclusion that an amount of additional damage required to initiate cracks between studs after ligament cracks initiate must at least equal the cumulative damage required to initiate the ligament cracks.215/ This conclusion does not appear to take into account the results of FaAA's finite element analysis, which shows that after ligament cracks have formed, the transverse stress between stud holes doubles.216/ This increase in stress

215/ Id. at 4-1.

216/ Id. at 3-4.

would appear to cause the damage level to accumulate more rapidly than FaAA considers, and the additional damage required for cracks between studs to initiate would be less than assumed by FaAA.

Second, the quality of the cast iron determines the ease of initiation for a given damage index. This is presented as "n" (Paris law exponent) which is normally an unvarying constant for a given material condition. However, FaAA has considerable trouble in finding the best value of "n" and gives a value of 8.37 to 9.62. The proper value would be determined by testing the metal of the blocks. The conservatively assumed estimates of "n" in the FaAA report have no relation to the actual values for EDG 101, 102, and 103 blocks. The values are expected to be different for each block, because of the significant variance in the TDI casting procedures and its poor quality control. As discussed below, all three blocks should be properly evaluated to determine their material properties, rather than relying upon assumptions which may or may not be correct.

(iii) While the FaAA analysis purports to be empirically based on EDG block behavior, it lacks information of significant importance. When did the ligament cracks first initiate

in each of the three EDG blocks, and what was the cumulative damage index of each at that point? When did the original crack between the stud holes in the EDG 103 block first initiate, and what was the additional damage index accumulated between the initiation of the ligament cracks in the same block and that point? When and under what conditions did the original crack between the stud holes in the EDG 103 block grow to 5-1/2 inches in depth, and what was its rate of growth? When did the large crack running from cylinder no. 1 down the front of EDG 103 first inititate and at what rate did it propagate? The answers to these questions would provide some meaningful empirical data.

Q. Did FaAA use fracture mechanics techniques to predict the rate of crack growth of the cracked block tops of EDGs 101 and 102?

A. (A) No. The FaAA Block Report does not use a fracture mechanics analysis to predict the growth of ligament cracks or the initiation or growth of stud hole to stud hole cracks. But FaAA does use fracture mechanics to predict the propagation of cracks in the camshaft gallery areas of the blocks and of cracks which may initiate in the AE piston skirts. We believe this is a significant inconsistency in the approach FaAA has used to predict crack growth.

Are the properties of the blocks of EDG 101 and 102

Q. ~~Can the excessive cracking in the original block of~~ those of normal ASTM class 40 gray cast iron? ~~EDG 103 be attributed to significantly weaker material than those of EDGs 101 and 102?~~

A. (A) ~~Well~~ There is insufficient evidence of any actual block material properties of EDGs 101 and 102. FaAA examined only a small area of each block top.~~110/~~ But within the same block the cast iron properties may vary widely due to the presence of trace elements in certain areas. A meaningful analysis of the material properties of a cylinder block would require metallurgical examination of numerous sample areas of the block.

The performance of the EDG cylinder block is dependent on the properties of its materials of construction. FaAA's examination of a "small region of the block tops" of the EDGs was inadequate to characterize the materials of each of the blocks. FaAA has assumed that the block is homogenous, but in actuality the casting is not uniform because of the segregation which naturally occurs during the casting process. Therefore, more than a single small area must be evaluated to determine whether or not there are differences in the entire blocks of EDGs 101, 102 and 103. FaAA states, "Specific materials testing is

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~~110/ Id. at 14.~~

required to quantify any degradation in fatigue or fracture properties of the thick section block casting."218/ We agree. However, FaAA proposes that only the material of the original block for EDG 103 be completely evaluated. If that block material is "shown to be sufficiently less resistant to fatigue than typical gray cast iron, Class 40,"219/ the blocks of EDGs 101 and 102 would be predicted by FaAA as capable of surviving a LOOP/LOCA event. This assumes that the materials of those blocks are at least as strong as "typical" material. There is no adequate basis for this assumption. To reach conclusions about the material strength of the blocks of EDGs 101 and 102 compared to that of EDG 103, the material of all three blocks must be properly evaluated.

Q. Can the excessive cracking of the EDG 103 block be attributed to the "abnormal load excursion" at Shoreham on April 14?

(A,B,C,E)

A. FaAA did not do so. FaAA notes that the power outage affected EDG 103 with an excess load for 23 seconds, and that the large crack from the no. 1 cylinder down the front of EDG

218/ Id. at 4-5.

219/ Id. at 5-1.

103 occurred after the excess load event. But FaAA refrains from making any causal connection between the two matters. Neither FaAA nor LILCO documents describing the effects of the power outage220/ disclose the amount of the load during the 23 seconds. We do know that EDG 103 ran at test overload for 100 minutes thereafter before the large crack down the block front was noticed. With the available facts we are unable to determine what, if any, effect the 23 seconds had on the block. Two observations are in order. First, the "abnormal load excursion" demonstrates again that accidents happen, even if they are thought to be unlikely. The EDGs and their blocks should be strong enough to survive such an accident, which might have occurred during the inception of a LOOP/LOCA. Second, EDG 103 ran for ten minutes after the 23 second episode in an unloaded condition and without cooling water.221/ That fact, coupled with the subsequent block damage resulting from the overload test, suggests that other components of EDG 103 may have been damaged. LILCO has committed to repeat the entire start-up test program with EDG 103 after installation of its replacement block, and then disassemble and inspect the engine.222/ This

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220/ Letter dated April 24, 1984, from J.A. Notaro to W.E. Steiger. (Exhibit 65).

221/ Id. at 2.

222/ LILCO's Response to Suffolk County's Filing Concerning Litigation of Emergency Diesel Generator Contentions, June 21, 1984, at 55.

commitment is very important. The inspection should be subject to the scrutiny of all parties in this proceeding.

Q. Do you agree with FaAA's conclusion that the cracks in the camshaft gallery areas of the blocks will not grow to any significant degree?

A. No. FaAA gave one example applying its formula for fatigue crack growth, which predicted the assumed crack to grow but at a slow rate.[223] In its analysis, FaAA uses the simple Paris empirical relation, which does not take into account important parameters such as mean stress effects on fatigue crack propagation. In addition, FaAA evaluated the parameters in the Paris evaluation based on gray cast iron without the defects apparently present in the EDG 103 block. The conclusions presented on crack growth are meaningless without presenting the sensitivity of initial crack size to fatigue life and the physical properties of the actual block material. We should also point out that our general comments on the limitations of a fracture mechanics analysis discussed above with regard to the AE piston skirts also apply to the FaAA predictions for the growth of the camshaft gallery area cracks.

223/ FaAA Block Report at 4-6 to 4-7.

Q. Did you also discover other inconsistencies in the FaAA evaluation of the camshaft gallery cracks?

A. Yes. First, FaAA assigns different values to n (Paris Law exponent) in their cumulative damage index (n = 9.6) and in the camshaft gallery crack analysis (n = 5.37). Since the same material is used in both cases, this change in exponent value confuses the results. Second, the value of "n" should be evaluated for the specific material used in the EDG 103 block and Table 4-1 should be recalculated. FaAA failed to obtain the "n" value from testing of specific block material. Further, FaAA failed to provide the basis for its selection of generic "n" values. Third, crack growth rate is very sensitive to the value of "n." For example, if n = 9.6 is used in the gallery crack growth rate example given on page 4-7 of the FaAA Block Report, the rate is increased by 10,000.

Q. Have the cracks in the camshaft gallery area of the EDG blocks been mapped and measured for propagation?

A. (A) Apparently LILCO did map these cracks and some appeared to have grown.224/ The FaAA Block Report does not

224/ Museler Deposition at 98-99 (Exhibit 57); Morning Report, NRC Region 1, March 20, 1984. (Exhibit 55).

report any empirical data concerning propagation of these cracks.

Q. How could cracks in the camshaft gallery area of the cylinder block affect the operation of the EDGs?

(C,E)

A. If the known cracks propagate (and there is no reported metallurgical evidence that they will not) the first effect will be increased flexing of the camshaft. The flexing will then increase the load on adjacent bearings, which could further increase the propagation rates of cracks at these locations. As flexing of the camshaft takes place, the load on the cylinder where camshaft flexing is occurring will be reduced. Consequently, the loads on the other cylinders will be increased, and cylinder balance will be lost. As there appears to be almost no reserve of power in the EDGs, the ability to take full load will be seriously affected by the unbalance. In the worst case, the cracks could result in a broken camshaft leading to irreparable damage of the cylinder block and loss of engine.

Q. How is the load imbalance evaluated by FaAA?

(A,B,C,E)

A. The interaction resulting from changing loads due to crack propagation in one location and increased loading in

other locations is not part of the crack growth forecasts made by FaAA.

Q. The DRQR authors conclude that cam gallery support cracks "are predicted to grow very slowly at full load and not at all at 75 percent load."225/ What is the basis for this conclusion?

(A)
A. No basis for the conclusion is provided in either the DRQR Report or the FaAA Block Report. Further, the information provided by FaAA does not support, and in fact contradicts, a conclusion that cracks will not grow "at all."

Q. Will FaAA's recommendation that the cracked blocks on EDGs 101 and 102 be examined for cracks between stud holes by eddy current after each operation ensure the safe and reliable operation of the EDGs?226/

(A,C,E)
A. No. As discussed previously, cracks between stud holes can initiate rapidly during a LOOP/LOCA event and lead to catastrophic failure. Inspection of the block after periodic testing does not therefore ensure reliable operation in an

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225/ DRQR Report Vol. 4, Cylinder Block, at 3. (Exhibit 56).

226/ FaAA Block Report at 5-2.

emergency. Moreover, as discussed above, ligament cracks can cause leakage of coolant which itself can result in catastrophic failure. The propagation of the large crack down the front of EDG 103 running from a stud hold in cylinder no. 1 (which had a ligament crack) demonstrates that unanticipated and dangerous crack propagation, other than of cracks between stud holes, may occur rapidly during a LOOP/LOCA event. Ligament cracks similar to that on the stud hole for cylinder no. 1 currently exist at two stud holes for cylinder no. 8 of EDG 101 and at one stud hole for cylinder no. 8 and another for cylinder no. 1 of EDG 102.227/

Q: Aside from the radial/vertical ligament cracks, the cracks between stud holes, and the cracks in the camshaft gallery area, have other types of cracks been found to occur in the R-4 and RV-4 series TDI cylinder blocks?

(B,H)
A: Yes. The FaAA Block Report refers to cracks in the blocks of TDI DSRV-16-4 engines at Comanche Peak Steam Electric Station. These cracks appear to extend down the counterbore and through the counterbore landing.228/FaAA also refers to

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227/ Id. at Figures 1-2 and 1-3.

228/ Id. at 1-3.

"circumferential cracks in the liner counterbore at the liner landing ledge."229/

Q: Has FaAA determined the causes of these cracks and addressed whether they could occur in the EDG blocks at Shoreham?

(A,B,H)

A: No. FaAA states that the cracks at Comanche Peak have been "metallurgically examined and were identified as interdendritic shrinkage or porosity resulting from the casting process."230/ However, FaAA does not state who performed this examination, give any results in detail, or address whether similar cracks might occur at Shoreham. If the conclusion stated by FaAA is correct -- that these cracks are due to casting defects -- it supports our view that castings by TDI, including the blocks, piston skirts, and cylinder heads, are not reliable. The Block Report FaAA does not discuss the circumferential block cracks at all. When questioned about the circumferential block cracks, Mr. Robert Taylor of FaAA, who headed the block study, testified that the FaAA report would not address the circumferential cracks:

229/ Id. at 1-1.

230/ Id. at 1-3.

> [B]ecause I am receiving pressure from management and LILCO to put a report out so that they can start a dialogue with the NRC. It's my understanding there have been promises made to NLCA (sic -- NRC) a block report will go out in the very new (sic -- near) future. And I just can't -- it just won't be a complete analysis, but it will start things moving.231/

Q: Are you concerned about circumferential cracks developing in the EDG blocks?

(B, C, E)

A: Yes. Such cracks could be very dangerous and lead to EDG failure. There is no reason to believe they will not develop in the EDGs. The causes of the circumferential cracks have not been determined.

Q: Did FaAA determine the causes of the ligament cracks and stud hole to stud hole cracks in the block tops of the EDGs?

(A)

A: Not precisely. FaAA only concluded that these cracks were service-induced and identified "three possible mechanisms of crack initiation (acting separately or in combination) in the block top, . . . low cycle fatigue . . . , high frequency fatigue . . . , [and] overload rupture."232/ These same

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231/ Taylor Deposition at 67. (Exhibit 59).

232/ FaAA Block Report at ii.

mechanisms could cause the initiation of the circumferential cracks.

Q: Do you agree that the cracks in the block tops of the EDGs were service-induced?

(ALL)

A: All of the evidence available to us certainly supports that theory. We believe these cracks are indications that the EDGs are over-rated and undersized. They cannot operate at rated and required loads without the cracking of the blocks and other components. Dr. Chen, the diesel consultant to LILCO and the TDI Owners Group, testified that the high firing pressure of the EDGs contributes to the block cracking, and recommended that peak firing pressure be reduced to 1,500 to 1,550 psi.233/ Of course, such a reduction in firing pressure would reduce the horsepower of the EDGs to below the required amount for service at Shoreham.

Q. What is the basis for your assertion that the replacement block for EDG 103 is of an unproven design and has not been adequately tested?

233/ Deposition of Simon K. Chen (May 15, 1984) ("Chen Deposition") at 129. (Exhibit 66).

(B,C,E)

A. Mr. Lowrey of TDI testified that the design of the replacement block was only developed in the last two months of 1983, in an attempt to solve the block cracking problems of the R-4 series engines.234/ The newly designed replacement block was never tested by TDI, according to Mr. Mathews, the general manager.235/ Rather, TDI relied on the fact that the top portion and boss section of the replacement block design was the same design as similar portions of the block of the TDI RV-5 engine, and the RV-5 block had been tested.236/ A block is a single casting. We do not believe that a new design of an engine block is adequately tested simply because a portion of the casting is the same as a portion of an entirely differently designed block.

Q. Do you believe that the replacement block for EDG 103 is likely to crack?

(A)

A. Even if the design were adequate, and we believe such has not been demonstrated, the material properties used in all

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234/ Lowrey Deposition at 15-16. (Exhibit 24).

235/ Mathews Deposition at 106-107. (Exhibit 32).

236/ Id. In 1981 TDI decided to use the RV-5 blocks in current production for RV-4 engines, to address the block cracking problems. See Memo dated 4/1/81 from Lowrey to Pratt (TDI). (Exhibit 67).

of FaAA analyses are dependent on the casting process. The casting process can introduce defects such as porosity, tears, inclusions, and degenerate phases which critically effect the results of analysis. From the results of our inspection of the TDI casting processes and review of pertinent documents relating to changes made in those processes, we are not satisfied that TDI can produce a defect-free block. Therefore, any new replacement block must be completely inspected and tested.

Q. Have you recently received documents cited in the "Component Review" section of the DRQR Report on cylinder blocks?

A. Yes. A number of the underlying documents were recently received by the County. We have only had time to preliminarily review these documents. Many are illegible or have missing pages.

Q. What do you conclude based on your initial review of some of these documents?

A. Contrary to the conclusion in the DRQR Report that the "Owners Group has completed its review of the TDI diesel generators installed at SNPS" (p. 4-1) and that the Report

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provides the results which provide the basis for the conclusion that the EDGs "presently installed are fully capable of reliably performing their intended safety function" (Executive Summary, p. iii), we have discovered that final resolution of a number of unsatisfactory conditions documented on LDRs had not occurred when the Report was issued. Further, our review has disclosed that objective standards were not applied to resolve identified deficiencies. Thus, rather than documenting the completion of the DRQR assessments, the Report in fact provides only a status of the ongoing investigation. Should further review reveal additional information relevant to our testimony, the testimony will be supplemented.

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JUDGE BRENNER: All right. And now, presumably starting a new transcript page, we can bind in following this page the identified supplemental testimony of all of the witnesses except Mr. Bridenbaugh concerning cylinder blocks dated October 18th, 1984 consisting of, I guess, 14 numbered pages. And we will do that at this point.

(The supplemental testimony follows:)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

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

SUPPLEMENTAL TESTIMONY OF DR. ROBERT N. ANDERSON, PROFESSOR STANLEY CHRISTENSEN, G. DENNIS ELEY, AND RICHARD B. HUBBARD REGARDING SUFFOLK COUNTY'S EMERGENCY DIESEL GENERATOR CONTENTION CONCERNING CYLINDER BLOCKS

SUFFOLK COUNTY
October 18, 1984

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I. INTRODUCTION

1.Q. What is the purpose of this testimony?

A. (All). This testimony addresses new information on cylinder blocks disclosed by Supplemental Testimony filed on September 20, 1984, on behalf of LILCO's witness panel and by subsequent discovery. That information concerns: (1) cracks in the cam gallery area of all EDG cylinder blocks, including the replacement block for EDG 103; (2) circumferential cracks around the cylinder counterbore landing; and (3) changes in LILCO's measurements of cracks in the blocks.

2.Q. What conclusions have you reached as to these matters?

A. (All). Our conclusions may be summarized as follows:

(1)(a) Cracks in the camshaft gallery area of the original EDG 103 cylinder block have been found to be far more extensive and more than twice as deep than first represented by LILCO and FaAA. Analysis of fractography and metallography of crack samples shows that these cracks were originally formed as hot tears during the casting process, were unsuccessfully attempted to be repaired with welding, and have since propagated.

(b) Similar cracks are in the cam gallery areas of the blocks of EDGs 101 and 102. These cracks will continue to propagate, and those blocks are therefore unsuitable for nuclear service.

(c) Cam gallery cracks have been found in the replacement block for EDG 103 after operation of that engine during testing. Inspection records show that no such cracks were present before the replacement block was placed into operation. Accordingly, these cracks occurred due to operating stresses.

(2) Circumferential cracks were recently discovered during destructive examination of the original EDG 103 block. LILCO and FaAA did not thereafter reinspect EDGs 101 and 102 for circumferential cracks, but assume they are present extending continuously 360 degrees around the circumference of the liner landing of each cylinder. Examination of sections of the original EDG 103 block shows the circumferential crack to be relatively deep and propagating. Circumferential cracks in EDGs 101 and 102 may cause EDG failure.

(3) Sectioning of the original EDG 103 block disclosed that the large stud-to-stud crack between cylinder numbers 4 and 5, which LILCO and FaAA had represented to be 5-1/2 inches deep, was really 3 inches deep. The erroneous measurement of this crack suggests other crack measurements may be wrong. Further, the inability of LILCO, FaAA, and TDI Owners Group inspections to discover the circumferential cracks or the nature and extent of the cam gallery cracks casts considerable doubt on the reliability of those inspections.

II. CAM GALLERY CRACKS

3.Q. What cracks were found by FaAA and/or LILCO in the camshaft gallery area of the original EDG 103 block?

A. (Hubbard, Anderson). The FaAA Block Report issued in June 1984 and LILCO's cylinder block testimony stated that there were "crack indications" in the cam galleries of all three EDGs, with the longest measuring 4-1/2 inches long and 0.375 inch deep in EDG 103.[1/] This information proved to be erroneous when, in late August, FaAA sectioned portions of the original EDG 103 block. Inspections showed cracks in all nine camshaft gallery saddle areas; there was a single 3 inch long crack, while the other eight cracks ranged in length from 4-1/4 inches to 5-3/8

1/ See Exhibit 7 to Suffolk County EDG testimony at 4-6; see also Testimony of Roger L. McCarthy, et al., August 14, 1984, at 62-63, and Exhibit B-52 (since deleted by LILCO).

inches.[2/] Some of these cracks were measured by FaAA after sectioning and found to be from 0.5 inch to 0.906 inch deep in a block wall only 1.25 inches thick.[3/] FaAA found that all of these cracks had been ground and welded. Some representative photographs of these cracks are shown in Exhibit S-3.

4.Q. What do you believe initially caused the cam gallery cracks in the original EDG 103 block to form?

A. (Anderson). Based upon my examination of the sections removed by FaAA from the block and of numerous photographs of these cracks, they appear to be hot tears formed initially during fabrication of the block. This theory is supported by the fact that the cracks were filled with welding material in an apparent effort to repair them.

5.Q. Do you agree with FaAA's conclusion that these cam gallery cracks did not propagate after their formation during the casting process?

A. (Anderson). No. That conclusion is based upon FaAA's erroneous interpretations of a "dark oxide" on the surface of a crack sectioned from cam gallery No. 7, the presence of high concentrations of calcium on the surface of that crack, the absence of a "rust-colored oxide," and the appearance of the crack surface.

6.Q. Was the sectioned crack surface covered with a thick dark oxide?

2/ FaAA Liquid Penetrant Examination Report, 8/24/84 (Exhibit S-1).

3/ Exhibit S-2.

A. (Anderson). FaAA did not analyze the crack surface to determine the presence of oxygen, so the substance is not necessarily an oxide. Although it is possible that all or part of the coating is an oxide, I believe the darkness of its color is attributable to graphite from "graphitization" or graphitic corrosion of the surface of the crack, and not to oxidation at extremely high temperatures as hypothesized by FaAA. Graphitic corrosion occurs in gray cast iron in relatively mild (low temperature) environments.[4/] The graphite would have the effect of darkening a rust-colored oxide on the crack surface. The presence of minute particles of dirt and the oil to which the crack would be exposed could contribute to the darkness of the surface. The EDX chemical analysis of the surface performed by FaAA would not detect the presence of carbon (and hence, graphite).

7.Q. If most of the substance covering the crack surface is an oxide, is FaAA correct that the oxide could only have formed in high temperatures and in the presence of air during cooling at the time of the casting process?

A. (Anderson). No. First, I believe FaAA's conclusion is based in part on their misinterpretation of the cause of the "dark" color of the surface substance. As indicated above, I believe that the darkness of the color is attributable to the surface presence of carbon due to graphitization, and does not indicate that the substance was the product of oxidation at ex-

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4/ Fontana and Greene, Corrosion Engineering (McGraw-Hill, 1978) at 70-71.

tremely high temperatures. Red or rust-colored oxides, unlike dark oxides, are formed in low and moderate temperature environments and would have the dark appearance of the surfaces I examined if graphitization had taken place.

Second, the block casting is formed under strong reducing conditions where air cannot enter. Initially, the block casting mold is literally burning. If air did enter the cam gallery area, it could do so only by diffusion in small amounts over a short period before the surface metal cools to the point where any hot tears present would not form oxides. If this had occurred, there would only be a small amount of oxide with uneven distribution over the crack surface. Thicker layers of oxide would occur at the mouth of the crack than lower down, because the mouth would have been exposed to more oxygen during the cooling period than the bottom of the crack. However, the substance covering the crack appeared fairly uniform in thickness.

Third, the cracks in the sections I examined appear to have been ground and widened in preparation for the welding repairs, because they narrow abruptly below the weld material; a normal hot tear configuration would have a more uniformly V-shaped configuration. Thus, in the ordinary course of events, an oxide formed during the cooling process would have been removed in the upper area of the crack where the grinding took place; but the crack surface from which the weld had separated had a uniform layer of the dark substance from the top to the bottom of the crack.

Alternatively, if the oxide layer postulated by FaAA formed at the time of the casting process was not all removed by the pre-welding grinding, then the oxide should have been present on the side of the crack to which the weld material was still adhered. 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.

8.Q. Does the presence of high concentrations of calcium on the crack surface support FaAA's conclusion that the "oxide" covering that surface was introduced during casting while the crack was exposed to high temperatures?

A. (Anderson). No. FaAA's chemical analysis disclosed the presence of calcium in some, but not all, areas which were tested. In all samples where calcium was detected, sulfur was also detected in proportionate amounts. Therefore, I believe that the presence of concentrations of calcium resulted from exposure of the crack surfaces to calcium sulfide, which is often present in diesel oil lubricants and dye penetrants. Thus, the calcium was introduced after the block had been cast and cooled completely.

9.Q. Do you agree with FaAA's conclusion that the relative uniformity of the "oxide" layer on the entire crack surface shows that no crack propagation has occurred?

A. (Anderson). No. A relatively uniform layer throughout the crack's surface is consistent with graphitic corrosion. While the ferritic material corrodes or rusts at different points in

time as the crack propagates, the graphitic corrosion leaves a surface layer of graphite. This graphite forms a protective layer so that the corrosion stops and the surface becomes relatively uniform over time.

10.Q. Does the absence of any beach marks in the crack suggest that there was no propagation of the crack after it was initially formed?

A. (Anderson). No. Because of its brittle nature, cast iron does not form beach marks during the process of crack propagation.

11.Q. Is there additional evidence that the cam gallery cracks are propagating?

A. (Anderson). Yes. Exhibit S-4 is two photographs showing the magnified surface of a portion of a cam gallery crack that was sectioned by FaAA. The photographs show that the weld material (the white area in the upper left) has pulled loose from the cast iron surface of the crack, but that some cast iron was still adhering to the weld material. This shows that the weld material pulled free from the crack surface due to operating stresses, as opposed to heat shrinkage.

12.Q. Are there cracks in the cam gallery areas of the blocks of EDG 101 and 102?

A. (Hubbard, Anderson). Yes. LILCO has reported the presence of these cracks in all of the EDG blocks. The cam gallery area of the EDG 101 block was subjected to magnetic particle ("MP") examination on September 20, 1984 and to liquid

penetrant ("LP") examination the following day. The inspection reports (attached respectively as Exhibits S-5 and S-6) disclosed cracks in the cam gallery areas of all eight cylinders, ranging up to 2-3/4 inches long. Mr. Rau of FaAA examined the cam gallery bearing saddles Nos. 8 and 9 on the block of EDG 102 and found welded crack indications about 2-1/2 inches long in both areas.

(Anderson). Based upon photographs of the cracks in the camshaft gallery areas of the blocks of EDGs 101 and 102, the descriptions of those cracks by FaAA personnel, and LILCO inspection reports, I believe these cracks are similar to those found in the original block of EDG 103. While the lengths of the cracks in the EDG 101 block may be somewhat shorter than those in the original EDG 103 block, they are, like those in the latter block, propagating cracks. Hence, I believe the blocks of EDGs 101 and 102 are unsuitable for nuclear service.

14.Q. Were cracks found in the cam gallery area of the replacement block for EDG 103?

A. (Hubbard, Anderson). Yes. The areas of cam bearing saddles numbers 2 and 8 were inspected by LILCO both before and after grinding (on September 30 and October 1, 1984) while preparing EDG 103 for additional testing. The test reports show cracks in both of these areas, ranging up to 2 inches long.[5/]

15.Q. Were these cracks present in the block before it was used during operation of EDG 103?

5/ Exhibit S-7.

A. (Hubbard, Anderson). No. LILCO has supplied us with copies of reports of all inspections of the replacement block by or on behalf of TDI, LILCO, Stone & Webster, FaAA, and the TDI Owners Group, or any agent of LILCO, pertaining to the cam gallery area. None of these reports disclosed any indications in that area. Moreover, LILCO retained an expert, Mr. C. R. Isleib, to observe the casting of the replacement block and conduct a detailed inspection of it after cleaning and before it was painted. The Isleib inspection report concluded:

> Careful inspection revealed no cold or hot cracks or tears, nor any cold shuts visible to my naked eye, nor under the 5x glass I used. Special attention was paid to internal fillets such as in the camshaft bearing saddle areas.[6/]

We therefore conclude that the cracks in the camshaft gallery area of the replacement block initiated, or propagated from sub-surface defects, during and as a result of the operation of EDG 103.

III. CIRCUMFERENTIAL CRACKS

16.Q. Are there circumferential cracks in the original block of EDG 103?

A. (Hubbard, Anderson). Yes. The FaAA Block Report erroneously stated that none of the EDG blocks had circumferential cracks. Circumferential cracks are cracks at the corner formed by the cylinder liner counterbore and the cylinder liner landing; a representational drawing of a circumferential crack is shown in

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6/ The Isleib report is attached as Exhibit S-8.

Exhibit S-9.[7] After August 14, FaAA found "some" circumferential cracks when it sectioned portions of two cylinders of the original EDG 103 block, according to LILCO's Supplemental Testimony. Actually, the LILCO report of magnetic particle inspections conducted on September 19, 1984[8] shows circumferential cracks extending 100 percent around the circumference of all eight cylinders.

17.Q. Are there circumferential cracks in the blocks of EDGs 101 and 102?

A. (Hubbard, Anderson). Apparently LILCO and its agents have conducted no inspections since September to determine this. They claim that it is difficult to inspect for circumferential cracks, and simply assume that they are present in the EDG 101 and 102 blocks, running continuously 360 degrees around the circumference of each cylinder.[9]

18.Q. Do you agree with FaAA's testimony that circumferential cracks in the EDG blocks are "shallow"?

A. (Anderson). No. FaAA's statement that the cracks are "shallow" is based upon examination of sections of portions of only two cylinders from EDG 103, with a maximum depth which FaAA says is 3/8 inch. There is no data to determine whether circumferential cracks in other cylinders may be deeper. I have made an

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7/ Exhibit S-9 is Figure 1-1 of the FaAA Block Report.

8/ The Magnetic Particle Examination Report is attached as Exhibit S-10.

9/ Deposition of Charles A. Rau, Harry F. Wachob, and Robert K. Taylor, October 11, 1984, at 20.

examination of circumferential cracks in the sections analyzed by FaAA, and I observed that below the tip of the 3/8-inch crack are multiple small disconnected cracks branching out into the cast iron material. The linking up of the main crack with the branch cracks would in my estimation extend the crack to over one inch in depth. This would extend about 2/3 completely through the block material thickness running at a 45 degree angle from the corner of the counterbore landing to the cylinder between the stud bosses.10/

FaAA speculates that circumferential cracks in the blocks of EDGs 101 and 102 would be smaller than those in the original 103 block, because of the allegedly inferior mechanical properties of that block. I conducted a microscopic examination of a specimen of the liner landing ledge from the original EDG 103 block, and observed that it contained appreciably less amounts of Widmanstaetton graphite than appeared in other portions of the block as shown by LILCO's block exhibit B-33. Therefore, I do not believe one can validly predict that circumferential cracks are smaller in the blocks of EDGs 101 and 102.

19.Q. Do you agree with FaAA's conclusion that circumferential cracks will "grow slowly, arrest, and will not cause any operational problems"?

A. (Anderson). No. The fact that the original EDG 103 block did not fail due to the circumferential cracks by the time it failed and was scrapped for other reasons, does not support

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10/ FaAA estimates that the thickness is 1-1/2 inches at that point. Deposition of Rau, et al., at 14.

FaAA's conclusion that the circumferential cracks will not propagate to the point of impairing EDG operation. As described above, the circumferential crack I examined had numerous branches below its tip and appeared to be propagating. The operating history of EDG 103 is therefore cause for concern with EDGs 101 and 102 rather than evidence of their reliability.

20.Q. Can circumferential cracks cause operation of an EDG to fail?

A. (Christensen, Eley). Yes. A circumferential crack could permit some up and down movement of the cylinder liner relative to its position against the gasket sealing the liner to the cylinder head. Such movement could cause leakage of combustion gases, requiring premature shutdown of the engine. In the event the crack propagates through the counterbore, the cylinder liner landing would separate from the block, causing the cylinder liner to fall into the crankcase. This would cause serious damage to the EDG and probable catastrophic failure.

IV. CRACK INSPECTIONS

21.Q. What changes in crack depth measurements has LILCO made as a result of FaAA's sectioning of portions of the original block of EDG 103?

A. (Hubbard). LILCO sectioned the large stud-to-stud crack between cylinder numbers 4 and 5 of the original block of EDG 103 and found it had a depth of 3 inches, rather than 5-1/2

inches as previously reported in the FaAA Block Report and LILCO's written testimony.

22.Q. Is there any basis for LILCO's Supplemental Testimony that "the actual depth of the cracks in the original EDG block are shallower than previously thought"?

A. (Hubbard). No. The depth of only one single crack was revised by the Supplemental Testimony. The Supplemental Testimony does, however, cast considerable doubt upon the reliability of inspections for cracks in the EDG cylinder blocks carried out by LILCO, FaAA and the TDI Owners' Group. First, the erroneous measurement of the crack in the original EDG 103 block suggests that other crack measurements may also be wrong, whether over-stating or under-stating crack depths. Second, before last month neither LILCO, FaAA nor the TDI Owners' Group had discovered the existence of circumferential cracks in the EDGs, despite numerous inspections. Third, before last month none of those organizations had discovered that the camshaft gallery cracks were twice the assumed depth and had been welded. The final DR/QR Report for Shoreham was issued and LILCO's testimony was filed in this case in reliance upon faulty inspection data.

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JUDGE BRENNER: We will also admit into evidence Suffolk County's exhibits to the joint direct testimony on cylinder blocks provided in the revised package which include some deletions from the originally provided exhibits and the exhibit number being admitted into evidence, as noted by Mr. Brigati, and there is an index at the beginning of the volume, in addition we will admit into evidence Suffolk County Diesel Exhibits S-1 through S-10 which are related to the supplemental testimony primarily.

(Whereupon, Suffolk County's Exhibits to Joint Direct Testimony were received in evidence.)

(Whereupon, Suffolk County Diesel Exhibits S-1 through S-10, having been previously marked for identification, were received.)

JUDGE BRENNER: And that completes the evidence that we have admitted.

Off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

Did you have anything further with your witnesses, Mr. Brigati?

MR. BRIGATI: Yes, Judge. I would like to, number one, point out that as Mr. Dynner mentioned this

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morning, we have some additional direct testimony that we would like to introduce at this time before cross-examination commences based upon a new analysis presented during the testimony of the FaAA witnesses --

JUDGE BRENNER: The magic word is "rebuttal," but that's okay, I know what you mean.

MR. BRIGATI: I understand, Judge, and I sort of have a little bit of confusion over the order of proceeding because we, of course, prepared our direct testimony first and then LILCO prepared its direct testimony and then we have had cross-examination of LILCO witnesses and in the ordinary course of events we, in presenting our testimony today, would probably have a considerable amount of follow-up direct testimony to meet points or address points that have been brought up in the testimony of the LILCO panel.

Now we haven't prepared at this point the relatively scattered bits and pieces of information or testimony that would deal with new information that has come up in the testimony of the LILCO witnesses. And I assume that we would be permitted to do that as part of rebuttal at the end of the cross-examination of the panel on the direct testimony as well. Am I correct?

I am assuming we would be restricted to reasonable limits, of course.

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JUDGE BRENNER: I'm not sure I understand everything you have said but let me try something and maybe that will answer some of your questions.

MR. BRIGATI: Fine.

JUDGE BRENNER: As I understand it, you want to get some testimony from your witnesses in response to the cross examination. Are all of the questions of the LILCO witnesses that we have had orally on the record here?

MR. BRIGATI: That's correct, Judge.

JUDGE BRENNER: And your unsure of whether to do that now or whether to do that after the normal examination of your witness Panel is complete; is that right?

MR. BRIGATI: That's correct. And frankly I was expecting to do it after the cross examination of our witness Panel.

JUDGE BRENNER: All right. Our strong preferences would be for you to do something like that now so then the examination of these witnesses can encompass everything they have to say on the subjects which are going to be related and to avoid followup rounds.

Now, if rebuttal is something that is at the discretion of the Board both as to content and scope and timing -- well, not both, as to many things. And I've stated what our preference is. If there is some reason why you cannot proceed that way, I'll hear you on it and then

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we'll hear from the other parties on whatever they have to say on the subject.

MR. BRIGATI: Well, frankly, we are not as well prepared as we would like to present that kind of testimony at this point, Judge. Because I believe any really seriously contested issues of fact would be addressed in the cross examination by LILCO and therefore I assume that we would tie it up in normal rebuttal following that cross examination. That is why we would prefer to defer it until that time and, in fact, at this point whatever examination we did in the subjects would be necessarily very, very brief.

JUDGE BRENNER: The problem is -- maybe I didn't hear you right, but it's not -- what you would do is not rebuttal to the cross examination of your own witnesses, that's redirect, what you have to do right away. So you should be prepared now to do rebuttal except for the fact that some of it may have occurred only recently, such as yesterday.

MR. BRIGATI: That's really the point, Judge.

JUDGE BRENNER: All right.

MR. BRIGATI: But we do have some additional direct testimony, it's fairly significant that we would be prepared to introduce now so that LILCO can cross examine on it. As I say, the other testimony is basically a point

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here, a point there, that probably -- that may not be addressed in cross that would then be appropriate for us to bring out in redirect just to make sure that the record has something from the County on it.

JUDGE BRENNER: What subject would you like to bring out now for your witnesses?

MR. BRIGATI: Dr. Rau's testimony yesterday morning about this analysis, the additional analysis, that FaAA contends corroborates their theory of how the cam gallery cracks were formed and show no evidence of propagation since the initial casting process.

JUDGE BRENNER: Mr. Farley, I'll hear you on the whole subject.

MR. FARLEY: Judge Brenner, I concede that this is my first experience with this type of proceeding. If I understand what Mr. Brigati is posing it is entirely contrary to what is contemplated. They are proposing to file additional direct testimony and they don't want to file it now and they want to file it after we complete our cross examination so it doesn't fall into the category of rebuttal. What he referring to about Dr. Rau yesterday or today, is not new. It was in our old testimony and finally I would state that in your scheduling you specifically give the County an opportunity for rebuttal, which they did not use.

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JUDGE BRENNER: Let me hear from the Staff. Mr. Goddard, sorry to disturb you.

(Laughter.)

MR. GODDARD: The Staff does not object to Suffolk County's proposal.

MR. BRIGATI: Judge, may I make -- maybe I should clarify something here. I am not talking about asking questions about testimony that was prefiled by LILCO. I'm talking about asking questions to clarify points that were brought out in cross examination in the last two weeks.

JUDGE BRENNER: In other words rebuttal.

MR. BRIGATI: In other words rebuttal, yes, Judge, but in the context that I assume these matters are of sufficient importance so that LILCO or the Board or the Staff are likely to want to examine the County's witnesses on them and rather to take the time now to devise a rather elaborate rebuttal examination that will cover points that are likely to be the subject of cross examination anyway, I felt that it would be appropriate to tie up the loose ends, if you will. After the cross examination by LILCO, the Staff and the Board is complete.

JUDGE BRENNER: All right. That's one category. And the other category is you did have some subjects you wanted to ask them about now?

MR. BRIGATI: I think that's one particular point

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that it would be appropriate to address now because it is fairly significant --

JUDGE BRENNER: Okay, I understand what you mean.

(The Board conferring.)

JUDGE BRENNER: All right. We are not opposed in general to the County's proposal and the reason I add the in general is as we hear particular subject areas there may be objections as to the legitimacy of that inquiry as tied into the purposes and the reasons as to the timing and necessity for it. But to the extent that what is going to come out is legitimate rebuttal to information that has been adduced on the record here, we will permit you to proceed with that part that you feel that you can proceed with now, because I think it would be efficient to get it in so parties can then cross examine on everything that is in evidence. I also understand that you have some professional judgment as to certain other subjects that you now know. If nobody else asks your witnesses about them you want to get out on the record but you have some basis for supposing that your witnesses may be asked about it in cross examination in any event. So the, if you will, the different timing depending on, I suppose, how warm your feeling is as to the practicalities of what might come out anyway and what might not, is a reasonable basis for us to permit you to proceed this way. And what you have warned us about, if I can put

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it in my own words is that, after all, a cross examination is done, there may be certain questions that you want to ask which is not legitimate redirect because, as it turns out, nobody asked about it.

And if it is legitimate rebuttal, we'll deal with it. But, I want to give you this warning, if it becomes very extensive, and yet is related to matters we covered and would have been much better hearing first. If it just becomes too inefficient based, not just on pure time, we base efficiency also on the value of the material to our record, we may exercise some judgment as to cutting you off. But we'll be able to apply those to specific situations and we'll deal with it then.

I suppose I should comment, Mr. Farley, that the opportunity for rebuttal testimony offered to the County before the hearing started was, as I recall, at the County's request, and we thought it was a good idea that to the extent the party could file written rebuttal based on just the written testimony, we would permit that and the other parties agreed that it was a good suggestion. And we adopted it.

But that was not meant to preclude rebuttal later, particularly when it arises from information that came out on the record subsequent to that time. But as I recall our prehearing scheduling order, although I'm not

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sure but as I recall it it wasn't even that restrictive. I think it would have permitted flexibility for oral rebuttal or later, well, basically oral rebuttal even based on material that was in the written testimony. But I suppose we might have had some words if it became extensive, as to why we didn't get it at that point in time.

But in any event this is based on the record as it developed and could not have been filed earlier, apparently. However, even that was not a prerequisite. And if you're unfamiliar with the provision for rebuttal testimony in our rules, Mr. Farley, I'm sorry, but it's in 2.743.

MR. FARLEY: I have read that.

JUDGE BRENNER: Okay.

MR. FARLEY: Excuse me, Judge Brenner, depending upon the extent to which the County proceeds as you have just indicated, I assume that LILCO will have an opportunity to respond to that.

JUDGE BRENNER: Yes. I don't know what you mean by respond; that's all I can say. Yes, and then we will deal with any concrete motion or proposal that you want to make. But you're aware that we judge the timeliness of motions. You have been reminded of that this morning in the full context of when the basis for the motion reasonably arose.

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All right, Mr. Brigati?

MR. BRITAGI: We can wrap up our additional direct before the noon break, Judge.

JUDGE BRENNER: My mind is an open book now. Go ahead.

BY MR. BRIGATI:

Q Dr. Anderson, did you have the opportunity to hear Dr. Rau's explanation yesterday morning in which he provided an additional analysis concerning why FaAA believes the oxide on the cam gallery crack of the old EDG 103 block was formed during cooling of the block immediately following casting rather than subsequent to that cooling time?

A (Witness Anderson) Yes.

Q Do you agree with Dr. Rau's conclusions as he explained them in his testimony?

A No.

Q Can you enlighten us as to why not?

A Well, I have prepared some brief comments on why I disagree, if I may.

Q You can read them.

MR. FARLEY: Your Honor, if he's going to do that, may I read them?

MR. BRITAGI: Judge --

JUDGE BRENNER: It would be helpful.

MR. BRITAGI: They're just notes and we asked

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for that opportunity many times or at least several times while the FaAA witnesses were testifying and we were advised that it is perfectly acceptable for witnesses to read --

JUDGE BRENNER: My comment so far is it would be helpful and I don't think anything I ever said along the way is inconsistent with that. You don't have extra copies right now and you would rather not do it in any event?

MR. BRITAGI: We don't have extra copies. It is, I think, scribbled on and we will provide a retyped version --

JUDGE BRENNER: That's not necessary. You have answered my question. We will let him proceed and then we will see how extensive things are.

MR. FARLEY: I move that they be produced. All I have to do is lay a foundation if a witnesses uses a document to refresh his recollection. This witness has already indicated that he is going to read from notes that he prepared.

JUDGE BRENNER: Yes. And Mr. Brigati is correct that recently LILCO was on exactly the other side of that argument when the County asked for some notes that one of LILCO's witnesses were reading from and I don't remember if it was you, Mr. Farley, probably not but, nevertheless, it is the same client. I don't care if it is different lawyers. So you have a seminar for evidence on all your

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lawyers on your team. My point at that time, Mr. Farley, was not inconsistent with the remarks just now and I think in essence your remarks are correct.

My point then was what's the prejudice. Let him read it and then we'll all know what it is and we have it, either in our hearing or on the transcript. If it becomes extensive so that you say just hearing it orally doesn't give you enough time to respond, then we might adjust. But the way this proceeding goes on day after day after day, by the time you're going to have to get to it you'll have the transcript anyway. And that was the practical basis for the ruling that Mr. Brigati has referred to, as I recall. And I would apply that same practical basis here.

But I made the inquiry on your behalf and if the parties had been willing that would have been okay with me, also. But there's only one copy here right now.

So, let's just let him read it and, as I said, I don't see how you'd be prejudiced. Your evidentiary point, Mr. Farley, only applies at trials that are going to be over that day or at least transcripts are not available in the next day and, you know, it's the difference between your ability to react to oral testimony, as opposed to having it in writing. In this case we're going to have it in writing one way or the other.

Dr. Anderson?

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WITNESS ANDERSON: Thank you. I understand that Failure Analysis has testified that they've examined the surface of the cam gallery cracks in old 103 using a microprobe and I found oxygen to be present. I have not been provided with the data but this observation would be consistent with the presence of high oxides. However, it is my understanding no analysis of the oxide structure which could be done by simple x-ray means has been carried out and that conclusively determine how the oxide had been formed. Failure Analysis has testified that the kinetics of cooling time and temperature immediately following the casting process caused the oxide on the surface of old 103 cam gallery cracks. I disagree, because carbon is more readily oxidized than iron at these temperatures and I would, therefore, expect no carbon in the vicinity of the crack.

However, the microstructure of the cast iron in the vicinity of the crack -- and we have one in our exhibit -- does not show a loss of carbon -- that's called decarborization. The lack of decarborization in the vicinity of the crack precludes high temperature oxidization from having occurred. I have examined Failure Analysis calculations on oxidation which they used to discount the possibility that the oxide formed because of low temperatue oxidization and found it inappropriate and without merit. It is an expression of the parabolic rate model of

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oxidation. And this model assumes that oxygen diffuses through the oxide film and reacts with the surface of the iron. The model does not consider the effect of carbon on the oxidation and it is not applicable to crack geometry. However, the basic laws of kinetics have been violated by extrapolating the model 2 temperatures where other mechanisms are in control.

In addition, the assumption of linear cooling is incorrect and misleading since a block cools quite rapidly at higher temperatures and much more slowly at lower temperatures.

The Failure Analysis analysis is completely contrary to empirical evidence that cast irons readily corrode at low temperature by either a graphitization or fretting corrosion mechanism. If we accept that low temperature graphitic corrosion did not occur, the only mechanism left to explain the appearance of the oxide of the crack surface is fretting corrision. The fretting corrosion is described as a corrosion occurring at contact areas between materials and their load, subjected to vibration and slip. Fretting corrosion is also called friction oxidation, wear oxidation and chaffing.

The basic requirements for the occurrence of fretting corrosion are, first, the innerface must be under load, compressive load. And two, the vibration must be

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repeated so that there's relative motion between the two surfaces.

Fretting corrosion only requires a relative motion on the order of an angstrom and that corrosion could easily come from vibration of the engine in operation. The forces holding the faces together would be the compressive forces described in Failure Analysis testimony. The presence of fretting corrosion would indicate that the cracks in old 103 cam gallery were moving and growing.

I heard Failure Analysis say that they observed no signs of fretting, however, such small motions as the order of an angstrom would not leave any signs that they could detect.

That's the end of my statement.

MR. BRITAGI: I now tender the Panel for cross-examination. Judge?

JUDGE BRENNER: All right. Let me follow up on one thing in the name of efficiency based on Mr. Farley's request before that he get the document. And I've indicated why I think he's not prejudiced by not getting it, due to availability of transcripts, among other things, and it's true ultimately. However, in the name of-- Because of efficiency, if Mr. Farley got... I'm sure he won't object to my revealing this much of his cross plan; that is, the subject that he would approach very early in his

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cross-examination bears on this subject. Am I correct?

MR. FARLEY: Yes, sir.

JUDGE BRENNER: And for that reason, I'm inclined to order that this statement be made available, subject to giving you an opportunity to delete any, if there are any, marginal marks that you might consider privileged or work product; but that the statement, the portions that he read out loud, to be made available to Mr. Farley during the lunch break, so that he can encompass it the first time he hits that subject; if he wants to do that: I'm not requiring him to do that; but at his option, rather than having necessarily to come back to it later.

MR. BRITAGI: Judge, we will have the material retyped as it was read by Dr. Anderson and make it available to Mr Farley as soon as we can accomplish that process. Now, I think that will be an hour, an hour and a half, but we don't have secretarial facilities readily available --

JUDGE BRENNER: You've said enough. I'm not sure why you can't just take what he read and delete anything you want to delete and run a copy. But I'll leave it up to you.

It doesn't have to be clean typing. It's just something to give to him, not to us. Just so it's accurate.

It's based on my own observation that what Dr. Anderson said was enough, so that if I was getting ready to cross-examine him on the same subject

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I would certainly feel more comfortable, to say the least, having it in writing in front of me rather than based on my notes that I just took now.

MR. BRITAGI: I'm not arguing --

JUDGE BRENNER: As I said, he wants to hit the subject first or near the beginning of his cross examination, I know that from his plan.

MR. BRITAGI: I'm not arguing with you. I'll get it to him as quickly as is reasonably feasible to do.

JUDGE BRENNER: All right. You made it sound a little more involved than I think it is. That's all I wanted to know.

But do you need additional time over the lunch break to get together on Mr. Ellis's favorite subject of the week, Mr. Dynner? Is there any reason why you can't meet with him --

MR. DYNNER: Even given some additional time, we heard a proposal of what Mr. Ellis intends to do last night, and I'm not sure that we're prepared to respond.

JUDGE BRENNER: I understand that. And if you recall, earlier this week I said we would discuss the scheduling for the response. But, nevertheless, what I imagine might occur is that Mr. Ellis would give us an outline of what he proposes and then he's going to file it in writing, so you're going to have time to respond either

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orally or in writing to his writing or both. But we're anxious to get some advanced insight into what he is planning in case we all have some reaction that might affect his proposal which he can factor in. But you're not going to be prejudiced if you have nothing to say. However, I thought sometime for you to hear from him what he's going to tell us would assist even their preliminary process this afternoon. So you don't react to some things after hearing it for the first time even though, as I say, you will have further opportunity beyond this week to respond.

MR. DYNNER: Yes, sir. In the interest of time unless Mr. Ellis is going to propose something that is different from what he told us about last night, I don't think we will be prepared to respond in any detail and I think that we don't need any extra time. We would need extra time if Mr. Ellis intends to say something other than he said to us last night.

JUDGE BRENNER: I don't know that. Let's do it this way. Let's go off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on. Let's recess until 1:35 and when we come back we will, I guess, hear Mr. Ellis make his preliminary presentation to us.

Whereupon, at 12:05 p.m., the hearing recessed, to reconvene at 1:35 p.m., this same day.)

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AFTERNOON SESSION

(1:30 p.m.)

JUDGE BRENNER: Back on the record.

Mr. Ellis

MR. ELLIS: Thank you, Judge Brenner.

I would like to report to the Board now on LILCO's proposal. Let me preface if I may with a few introductory sentences.

First, as I have indicated to the Board, LILCO firmly believes that this record should include and reflect the reality that the actual loads, measured loads, will not exceed 3300 for any of the three diesel generators in the event of a loop LOCA or an emergency.

LILCO also firmly believes that the record should include and reflect that the SER called for the definition of a qualified load and that the load has been defined as a qualified load at 33. The testing pursuant to the Owners' Group SER is being -- or will have been performed and completed.

But LILCO also believes that it has presented to the Board evidence of analyses and tests that are thorough-going and that demonstrate that the Shoreham diesels can perform their intended functions at the existing FSAR conservative design loads.

It is LILCO's proposal which I will outline in a

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minute here that is designed to accommodate these points and to give the Board a choice of finding the engines acceptable at 3300 Kw if the Board concludes that confirmatory testing is required, or at a higher load if the analysis without confirmatory testing is found by the Board to be adequate.

LILCO believes this goal can be achieved with a highly focused and limited reopening of the crankshaft and supplementation of the block. This assumes of course that pistons will be settled and if not, I can address that as well.

So LILCO proposes the following reopening and supplementation of the record:

First with respect to the crankshaft, LILCO proposes that the record be reopened on a very limited basis for two purposes: one, to receive evidence of the endurance tests and the results of the endurance test. This was the main focus of the SER testing recommendation and the confirmatory testing that is in the Staff's testimony. That is one thing we would want to reopen the record for with respect to the crankshafts.

Secondly, on the crankshaft, we would want to reopen the record to permit the parties, should they wish to do so, a chance to submit testimony of new DEMA calculations at 3300 and the effect of 3300 on various of the safety factors which the parties may have relied upon. And that is

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all that we would want with respect to the crankshaft.

With respect to the block, which record is not yet closed, we would request that the block -- that we be permitted to supplement the block testimony solely for the purpose of introducing the confirmatory strain gage tests and data which have already been the subject of discussion and ruling by the Board.

There will also be, at the conclusion of the confirmatory testing at 3300, inspection results relating to the cam gallery and inspection results relating to the block top. LILCO does not believe those tests are necessary for it to make its case, but I think it is fair to-- As you know from SNRC 1094, those will be run. It is fair for the Board to have those in mind because it may be that the Staff or the County may want to make use of those findings.

There is no need, in LILCO's current view, to do any more analyses or calculations with respect to the block. I don't think-- I may be incorrect in this but I don't think that the County or the Staff really have done any calculations with respect to the block. I think chiefly the County focus and the thrust of their focus has been to criticize the analytical and calculational work done by FaAA.

And we believe-- LILCO believes that the same conclusions obtain on an a fortiori basis for 33 as would

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obtain for the loads that are currently the premise for the decision or the testimony by FaAA and LILCO on the block.

So that would be the sole purpose for which LILCO would want to supplement the record, namely, the confirmatory strain gage tests and data although, as I have indicated to you, Judge Brenner, there will be other inspection results relating to the block, the cam gallery and the block, which I think we can anticipate some party will want to at least look at.

The pistons we hope we can settle. I have submitted a proposal, another proposal, to the County. And I think in fairness to Mr. Dynner, who has been preoccupied here, I am not sure that that have had an adequate opportunity to review that proposal, so I cannot give you any sense of how likely settlement is in that area.

Perhaps he will address that, or perhaps he and I will have to talk about that later this week.

But if it is necessary to try that particular issue, then it seems to me that the very limited purpose for supplementing that record would be a recognition that the firing pressures would be diminished from the existing design loads to the 3300. The diminution-- I cannot give the Board or anyone else specific, quantitative value now, but it is not an overwhelming diminution. And I think that the calculations that FaAA has done and the analysis that

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they have done would all be -- continue to be valid. The conclusions would remain the same. The margin of safety would only increase as a result of that.

Now let me turn to the schedule.

JUDGE BRENNER: If I could ask a question on the last point, it may become academic and it may not:

Am I to understand that on pistons, LILCO would not seek to reopen the record or supplement the record, given what you have just said?

MR. ELLIS: Judge Brenner, no, sir. That particular decision I must tell you has not finally been made because we focused on the other two, and probably out of an excess -- an unwarranted amount of optimism that we might settle.

But what I do want to convey to you is that if it were necessary to do it, not to reopen but to supplement with respect to the pistons, it would be a very limited supplementation. The only thing that changes, as I now understand the issue, is a diminution in firing pressure.

JUDGE BRENNER: All right.

MR. ELLIS: It is not a world-shaking diminution. But the conclusions of FaAA would also remain--

JUDGE BRENNER: All right. You've answered my question. You have not stated one way or the other whether you would seek to reopen on pistons.

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MR. ELLIS: That's right. But I did want to give you some sense of how I viewed the issue at this time.

Now with that as background, the schedule:

The endurance test at the present time is likely to be completed by the 2nd of November. That's tomorrow.

Post-test inspections on the crankshaft we hope will be completed between the 15th to the 20th of November.

Inspections of block top and cam gallery, roughly the same period of time.

The cam gallery strain gage data has already been made available to the parties. That test has already been completed and it has already been distributed to the Board and the parties.

The basis for the 3300 kilowatts as the qualified load, that data we are assembling and hope to make that available if the County wishes it some time by the end of next week, and perhaps sooner if we can do it.

Mr. Dynner has indicated that in his view that is the first step; there is no point in hearing all the rest if the 3300 is not valid. So we are going to make an effort to assemble the information on which the 3300 is predicated.

Given those dates, we would anticipate that the following would be a reasonable litigation schedule in light of the fact that we would have a limited reopening. And I would also point out that we would probably have smaller

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panels to focus just on this additional information:

First, we would suggest 15 days of discovery on this information. If those 15 days were to begin on the 20th, that would roughly put discovery ending on the 5th of December.

Then we would suggest a one-week period of time for LILCO to file all of its supplemental and reopening testimony. That is by roughly the 12th of December, all of these dates being rough. I am not even sure, I haven't checked to see whether some of these fall on Sundays.

We would then say the County should file its testimony one week thereafter, roughly the 19th of December.

And the Staff -- I was going to say Christmas Day, but they voiced an objection and therefore, out of great affection for the Staff and great feeling for their holiday spirit, we decided that the 4th of January might be a good date on which they could file their testimony.

Then we would think that motions to strike and that sort of thing should be done five days after receipt of testimony, so that we know early on what motions to strike there are. Of course this gets into the kind of detailed scheduling that is really I think far better fixed by the Board.

But then in terms of litigation, we would anticipate that the litigation should not take longer than

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two to three weeks. Now it is not without trepidation that I make that prediction in light of the last nearly three years, but as I think I have expressed, our goal and our intention is not to have an unlimited, unfocused reopening or supplementation.

We have had a tremendous amount of testimony which is very relevant to the 33 as it is to the existing loads, and there is no need to go over a lot of that old ground. What is needed is to relate it to the 33. And if the County chooses to litigate the 33, we will also of course have to, if they wish to, litigate whether 33 is accurate, and we would also have a panel on that.

Two other points I suppose I should raise:

One, in our meetings the suggestion has been made that the crankshaft findings which are underway should be held up so the findings can be consolidated. I indicated then and I indicate now that that view has a certain amount of appeal. On the other hand our finding process is well along. I might point out to the Board that my judgment on how many pages it would take was not close, and the Board's was far closer, but that--

JUDGE BRENNER: That's the first good news I've heard in a long time.

(Laughter.)

MR. ELLIS: But in any event, the process is

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underway and we would be prepared to finish that, and we think that might be useful for the Board to have that. But we would not object and would not think that it would be unreasonable to have it all at one time.

The second point I would raise is that there is some suggestion that we not complete the block testimony or the piston testimony in the event that this is done, and that I do think is not a good idea. I do think that we should proceed and finish the testimony that we have in the time remaining and then at the reopening and the supplementation, build only on the existing record focused on 33.

I hope this responds to the Board's concern on this. It certainly seems to resolve the issue for LILCO.

JUDGE BRENNER: Yes. I think you have covered many of the things that we would have asked you about very thoroughly.

There are some details. I don't know whether it is appropriate for me to pursue that now or not. As I understand your plan, Mr. Ellis, you would file the proposal in writing which you have just outlined to us, I guess in the form of a motion.

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

JUDGE BRENNER: When would you seek to do that, or when would you expect to do that?

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MR. ELLIS: I would hope to be able to do that very early next week, unless your desire to receive a writing on Monday remains firm, in which case I will file it on Monday.

JUDGE BRENNER: No, that was never firm. I realized that that was a tight time frame and I only mentioned it. So Monday is not a requirement.

Well, let me ask you one or two questions.

LILCO's status report of October 17th referred to the then-anticipation that the test and post-test inspections of these confirmatory tests -- is the way you labeled them I guess -- will not occur before December 2nd, 1984, and the dates you have given us are slightly ahead of that. You have given us your estimate for when the inspections would be completed.

Would there be a report prepared by LILCO after that November 20th date and if so, when would that be?

MR. ELLIS: I think the December 2nd date, Judge Brenner, was a date by which the inspections we hoped would be completed and some overall-- There are lots of other inspections that are being done and other work being done on components that are not in issue in these contentions.

And the answer to your question is Yes, there will be an overall report. We do not think that the

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proposal we make should await such a report but, rather, that the results that are pertinent to the proposal we have made will be made available sooner and that that ought to be the basis on which we proceed.

JUDGE BRENNER: And then I take it from LILCO's point of view, all substantive information material to the litigation before us would be filed on whatever time might be set for testimony as opposed to a potential situation that we believe may have occurred where we've gotten testimony from one party and then it turns out what we thought was just the procedural work left of putting the same substantive information in a report, it turns out that there may actually be some further substantive work being done.

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You don't have to answer me now but what occurs to me is here we are with LILCO seeking to supplement and re-open the record and then there is still some further report work being done and what assurance is there that some of that work being done in fact is further substantive work related to the issues in controversy.

I mention that really for no -- I mention that for the immediate purpose of your considering it when you put together your written proposal and any further discussions you might want to have with the parties.

MR. ELLIS: Yes, sir, we will be sensitive to that.

Right now we set the 15th to the 20th of November premised on our view that the substantive work with respect to the areas that I mentioned would be completed then, while the substantive work on some other areas might not be completed by then and a full report might not be done by then.

JUDGE BRENNER: I understand what you intended and I tried to point out the concern that the Board or the other parties or LILCO itself might have; in other words, rushing out right after some results are out of inspection which are thought to be final and then turn out not to be final when the experts take another look at it in the context of doing their further report work.

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Under your proposal the hearing would not start any earlier than the end of January, correct, near the end of January?

MR. ELLIS: No, sir, mid-January is the way I had it if the Staff filed their testimony on the 4th of January I would think we could begin soon, relatively soon thereafter.

JUDGE BRENNER: Okay. Mid-January.

Well I have other questions but there's no point in pursuing it at this time, I don't believe.

Do any of the other parties wish to comment at this time?

MR. DYNNER: I will repeat for the Board my initial comment on LILCO's proposed motion. The main thing that jumps out at us is that there is a threshold issue here which is critical, and that issue doesn't have anything to do with the particular capabilities of the blocks and the crankshafts, it has to do with whether or not 3300 Kw is in fact an adequate load to operate what has to be operated by these diesels for meeting GDC 17 requirements.

And as the Board knows this was mentioned to the County a couple of days ago and we have since proceeded immediately to obtain -- to request information from the Staff on the LILCO FSAR amendment as well as backup documentation, and we received some of these documents from

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the Staff today. The consultants we will be using to do that analysis are, in part, testifying before the Board but we intend to move quickly. And of course, as the Staff has said, the Staff has not yet approved that level.

It would seem to us to be ludicrous to start litigating anything to do with 3300 Kw before that load level is found to be the appropriate one. I could foresee a situation in which the Staff or the County finds that the appropriate load level might be 3380 or 3400 to run the equipment with appropriate safety margins. And here we would have again spent an awful lot of time and money and effort only to find that there is another change that is required that nullifies a lot of work that has been done by everybody.

I just throw that out as what seems to me to be a basic consideration. If the analyses on the appropriateness of the load levels are completed by all parties and the parties sit down with each other and agree at that point one could move on, it seems to me, to the second part of what is being proposed. But if there is not agreement it seems to me there is a threshold issue to be litigated potentially which would save us all having to sit through another hearing in another set of pleadings on a matter which becomes moot.

The other thing that strikes me -- and again

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these are preliminary remarks -- is that it would be very, very difficult for me, and I'm sure it was very, very difficult for LILCO to try to set any kind of schedule for this potential litigation without knowing what's involved.

And obviously Mr. Ellis might be quite right that there may be very narrow issues involved, but once all of the results of the tests and other information and analyses concerning other load levels come out, it is of course possible that discovery might take longer and it is possible, of course, that the time frames he is suggesting would not be appropriate.

I would just throw that out because I have to point out that it is always difficult to schedule litigation but it is particularly difficult when one does not have the facts, and I say that not in criticism at all of LILCO, because I think the Board probably wanted to see what their thought process was, but only because it is a fact that that schedule is done at this point it seems to me with a minimum of information available that one would usually input to get up a realistic schedule.

Finally, I understand what Mr. Ellis has been asked to do and has done is to outline a motion that LILCO proposes to file and the County obviously will have, I'm sure, other views and may take other actions concerning the plans that LILCO has for re-opening, supplementing and

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testing.

In the context of all of this I have in mind -- and I am just again throwing a balloon up in the air -- that we will be facing at the end of these hearings an extremely concerted period of work for the lawyers involved in getting up findings of the block contention, possibly of the piston contention based upon the 3500, 3900 criteria under which this litigation has been carried out.

It will be no mean trick to do that simultaneously with all of these other things when it is readily apparent to me, at least, that the issues are and will be so intertwined and intermingled that it would be extraordinarily wasteful and maybe even impossible to bring in new lawyers and get them up to speed and familiarized with everything that we all carry around in our heads in the kind of time frame that is encompassed by LILCO's proposal.

JUDGE BRENNER: You reminded me of one detail, and I am going to go to Mr. Ellis for this, and then I do want to come back to you.

Have you otherwise finished your remarks though, Mr. Dynner?

MR. DYNNER: Yes, sir.

JUDGE BRENNER: Mr. Ellis, you addressed some thoughts on the schedule for crankshafts but if you said anything about the finding schedule for the blocks and

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possibly the pistons, I certainly missed it.

MR. ELLIS: No, Judge Brenner, I didn't -- I thought about that and I think LILCO would be amenable either to proceeding with the findings schedule based on the record as it is and supplementing that in order to give the Board finding information earlier -- that's one interest that I think should be considered, namely getting to the Board finding information as early as possible than then supplementing it with the supplemental stuff.

Or in the alternative, the other interest is the one that Mr. Dynner mentions, the convenience to the lawyers. That is another interest. I don't think that LILCO has a strong feeling about that, but it is prepared to have a finding schedule proceed.

JUDGE BRENNER: Mr. Dynner, if you know I would appreciate some insight into the County's thinking, and if you don't know I'll accept that:

If a schedule -- assuming a reasonable Board sets a reasonable schedule -- although I don't go so far as to ask you to assume that we set a schedule that you absolutely like -- but staying with the assumption of some reasonable schedule being set, does the County agree with LILCO's motion that this further information should be permitted to come into the record?

Mr. Ellis is careful with the way he phrases

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things and I don't have to necessarily decide whether I deem certain things a re-opening as opposed to a supplementation on certain issues but the point is whether or not some mechanism should be permitted by which this information is considered on this record.

MR. DYNNER: I don't think it would be -- I don't think I'm in a position to respond to that yet, sir.

JUDGE BRENNER: I'll mention one other thing and not ask for any response.

You mentioned the need for the County to get information and inquire into what you consider a threshold matter of the justification for the lower loads for the diesels.

I will point out to you what I see -- and it may be wrong -- but what I see is the possibility that not only is there maybe a threshold issue as to that but within that issue there is a claimed fact by LILCO on which much of the load change turns on, and that one part could be looked at right away by the County.

In other words, they have done a lot of things to adjust the loads, but if you look at it the big change -- I hope I get it right, if I get it wrong somebody will correct me -- but the big change is whether or not you need the reactor building service water -- the second reactor building service water pump tied to the 103 diesel to start

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automatically. And it is when you drop that load out that you get the greatest change, I think.

In any event, I suspect that you could look at one or two of the major effects on the load change right away as opposed to trying to look at all of the different things, because whether or not the actual operation of a certain motor generator set is just slightly different than what the nameplate rating was is not going to make a major difference, I suspect. I probably got the name of the piece of equipment wrong, but....

MR. DYNNER: I don't think I'd know the difference, sir.

JUDGE BRENNER: I think it is the service water, the reactor building service water pump.

MR. ELLIS: You have it right, Judge Brenner.

JUDGE BRENNER: Staff?

MR. GODDARD: With possibly minor variations as to schedule, the proposal as made by Mr. Ellis is acceptable. We feel that in view of the FSAR amendment which is before the Staff at this time it would clearly be appropriate to re-open or supplement the record as indicated.

JUDGE BRENNER: All right.

You say possible minor schedule variations.

MR. GODDARD: A reasonable schedule from a

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reasonable Board would be within our thinking here.

JUDGE BRENNER: Well but you see, for example, we mentioned the other subject that may turn out to be related for all I know on the Staff's SER and crankshafts and the letter as recently as October 10th says that issuance of that is targeted -- quote/unquote -- for the end of December 1984.

When would the Staff finish its entire substantive review of the confirmatory -- well the tests being run -- not confirmatory tests, endurance tests is the word I was looking for -- endurance tests being run, and I will ask the same question as to the proposal for the lower load for the diesels and the same question as to any substantive work on the crankshafts, now that we have raised that. I'm trying to see if they truly are only minor schedule adjustments.

MR. GODDARD: Yes, the technical staff is far enough along in its review that it has submitted formal questions back to the Applicant with regard to these lower loads. As soon as we receive the answers to those questions we should be able to evaluate the entire question of lower loads in a relatively short period of time.

JUDGE BRENNER: You didn't answer my question.

MR. GODDARD: I have been advised that the FSAR amendment review is to be considered near term. I can't

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JUDGE BRENNER: Would it be less than a month?

MR. GODDARD: As soon as we receive our response from the Applicant it will definitely be less than one month before the Staff has fully reviewed the proposed FSAR amendment. I might stated we have already approved the removal of the pump which you discussed from automatic loading on EDG 103.

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

MR. GODDARD: And copies of that documentation have been provided to Mr. Dynner in the package I presented him with today. Mr. Dynner, in fact, is in possession of all documents which the Staff has with regard to the FSAR amendment as proposed by the Applicant.

JUDGE BRENNER: Well, if you remember that pump, what does the load come out to, approximately, assuming no other changes.

MR. GODDARD: I'll let Mr. Berlinger speak to that.

JUDGE BRENNER: If you know. And I'm not taking this as testimony, I'm just trying to get a feel for whether there is the possibility of a preliminary cut of the issue in some way.

MR. BERLINGER: The loads would be -- all three of the diesels would be below 3300 ranging from, like, 3235

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to --

JUDGE BRENNER: Did you hear my question. The only change I'm talking about is the elimination of the requirement for automatic start of the second reactor building service water pump which is currently tied to the 103 diesel.

MR. BERLINGER: I couldn't give you that specific number, I don't know that. The LILCO people would know.

JUDGE BRENNER: Mr. Ellis?

MR. ELLIS: Yes, we know, Judge Brenner. It would be on the order of 3520 with just that removal. That of course -- that 3520 is the design. That is not the actual measured which is what Dr. Berlinger --

JUDGE BRENNER: Yes, I understand there are other adjustments which LILCO believes are appropriate.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: But that 3520 is the maximum.

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

JUDGE BRENNER: All right, you've answered the question.

MR. ELLIS: That would be the maximum design load without going and taking into account the integrated electrical test and the other measurements and the other analyses.

JUDGE BRENNER: All right.

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Well, procedurally, the crankshaft findings from LILCO are due to be received November 5, correct?

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

JUDGE BRENNER: So we need to make some decision about that now?

MR. ELLIS: Yes, sir. As I indicated before we are well along in that process and that was the basis for my confession that my estimate was of what would be needed was far more than what we have found, in fact, needed so we are far along and we can either proceed and meet that schedule or not, as the Board sees fit. There is some benefit, we think, to the Board having information in front of it to that extent but, no the other hand, we also see some merit to Mr. Dynner's point, and Mr. Goddard's point, that it all ought to be in one package. It really is a matter for the convenience of the Board, I think.

JUDGE BRENNER: Well, another point that you may not be focusing on is the fact that we might deny your motion to supplement and to reopen the record or at least hold our ruling in abeyance on it. And I don't think it would be good to defer the finding schedule for long, if at all, with that possibility.

MR. ELLIS: We agree, Judge Brenner.

JUDGE BRENNER: That's one reason I asked Mr. Dynner the question I did which he couldn't answer yet.

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And I understand that in my view it's reasonable that he couldn't answer.

JUDGE BRENNER: Given the timeframe, we feel that it's fair to the parties that we make immediate decisions on -- procedural decisions at least and they would be as follows: That LILCO's findings on crankshafts still be due on the date we set. And, of course, regardless of what we might rule on this motion to supplement and reopen the record that would be the case.

For the time being and maybe for always we will keep the crankshaft schedule for the other parties as well especially given the close timeframe for those dates of November 15 for the County and the State combined and then so on for the other parties after that. But we might, as we get to the point of if we make pertinent rulings, in the timeframe where we can adjust the schedule it's possible that we may make some adjustements in the crankshaft findings schedule for other parties. Nevertheless, we will keep that November 5 schedule for LILCO. I think it will help us, it will help the Board no matter what develops in terms of the others, in fact. If it worked out well, which is has not always, I would be in favor of getting findings before the hearing.

I suspect for the County's benefit that we would be unlikely to vary that November 15 date also. It's just

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too close. I'm thinking ahead as to where the County's answer might be scheduled to LILCO's motion and I suspect -- well, let's think about that now.

I might point out now while we're on the subject of findings, we also want to continue the litigation on blocks and pistons. We're very close to the end not taking into account possible reopening and supplementation. I just want to proceed, we're all here, we know what the facts are and we can just adjust to the record if we have to. If we were way at the beginning of the litigation my decision might have been different on that score.

So we will do that. Our ruling that we are keeping the crankshaft finding schedule for now should not be taken as a ruling that we would do the same for the finding schedule on blocks and pistons are not settled on pistons. In other words, because of the different timeframes it might be appropriate if we know more what the party's positions and our ruling would be on LILCO's anticipated motion that we would defer the finding schedules on the other matters for a number of reasons including Mr. Dynner, your point, that if we were to grant LILCO's motoin efforts should be devoted towards that further work rather than writing the findings in that timeframe.

Just as everyone else pointed out that their remarks are preliminary to the extent that the Board will

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have time to adjust because certain events will not take place when we, again, revisit the subject, we may change our thinking on certain matters, also.

I would like to try to schedule the County -- the answers to the motion obviously keyed from a day of receipt. Do you want to suggest something, Mr. Dynner?

MR. DYNNER: Well, of course, normally there is a 10-day period, as everybody knows. We would -- given the fact that we know the basics of what LILCO is going to propose in its motion, we obviously have an edge on being able to start thinking about these points, and that's why it was very helpful to us to proceed with the Board, to have us proceed in this way.

I would only point out that LILCO's motion is likely to come in, I think, Mr. Ellis said mid-week next week when we will be, I'm sure, still in litigation and in terms of filing a written response and I feel there will be a written response, whether it goes along with LILCO or does not, even if it does to some extent I am quite sure that there will be some differences of opinion and modifications that will be suggested.

We won't, as a practical matter, the lawyers working on this will not be back in Washington in a position to respond in writing until the weekend so that we would get our response in writing to the Board and parties as early

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the following week as is feasible. But I just wanted to point out we will all be here in litigation at the time that LILCO's motion is delivered.

JUDGE BRENNER: Yes, I understand. You're correct in that and, presumably, one or more of your colleagues will also be busily engaged in the crankshaft findings right at that timeframe, having just received LILCO's crankshaft findings.

MR. DYNNER: That's quite true, sir.

JUDGE BRENNER: It's a busy time, there's no doubt about it.

All right. Let's leave some flexibility in it. We would very much like to receive the County's answer as soon as possible, as you've indicated you would strive for, and we appreciate that and as early the following week as possible. We may be in hearing all week, too, depending on what happens.

But as you may recall there will be no hearing Monday, November 12th.

I know, that's not much, but --

(Laughter.)

I just wanted to mention it.

You mentioned you will have to write fast in a jocular vein but I'll point out I mentioned that you could file a written answer and an oral answer combined -- not

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combined, both. That gives you some flexibility of hitting your major points in writing and indicating in writing that you have some other more detailed adjustments along certain lines, but not requiring you to make sure you've included all those detailed adjustments or else be barred from raising them and then we can discuss it again on the record.

And I'll let you -- give you flexibility to supplement your answer and what I have in mind is that after we get the written filings in from all parties, as has been our practice, we'll require the parties to talk with each other based on those written answers and then they'll have another discussion about it.

So you'll have that opportunity, too, and hopefully that will help cut down on the burden of preparing the initial written answer.

I'd like to schedule the Staff's answer for the same timeframe and I'd like to ask, although, not require, that to the extent feasible if the State wishes to take any position on it, that as has been done in the past which we have appreciated, that those positions be coordinated among the County and the State and that would help us.

But if the State ends up with a different position on certain matters, Mr. Johnson, you certainly have the right to file something separately, but we would want it

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in that same timeframe in order to consider it.

Mr. Ellis, when we receive your motion everybody will then have looked at it and will know the date, of course, that it came in and then we can maybe talk more definitively as to what day the following week we might expect the answers. But the parties should be thinking of the timeframe of, hopefully, no more than a week after receipt of LILCO's motion.

And another reason for that desire is if we are in hearing the week after next, we could make use of being in hearing to discuss the answers.

I don't think there's any point in discussing anything further on this now unless any party thinks there's another factor that could be discussed now.

(No response.)

All right. Of course, Mr. Ellis, when LILCO files next week we would expect copies to be delivered to the parties and the Board up here as well as the normal mailing and you need to get a copy to Judge Ferguson at his office, also.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: All right, thank you all very much. And let's just take -- are the witnesses here? All right, let's just relax for about 5 minutes and get them in place.

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(Brief recess.)

Whereupon,

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

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

JUDGE BRENNER: Back on the record.

MR. BRITAGI: I don't know how many copies are to be distributed, Judge. Do you want one?

JUDGE BRENNER: Not necessarily. If you have it we'll take it. But I was more concerned with Mr. Farley immediately and then less immediately Mr. Goddard, just because of the sequence of when it would be their turn to question.

(Mr. Brigati distributing documents.)

JUDGE BRENNER: Mr. Farley, is it premature, sir, to ask you for a time estimate?

MR. FARLEY: I indicated earlier that I thought approximately two days and I still think that that is an approximation. Of course, there has been a lot of additional testimony since I made that estimate not being

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preoccupied with getting ready for cross examination.

CROSS EXAMINATION

BY MR. FARLEY:

Q Dr. Anderson, did you and the rest of the Panel strike the original testimony beginning on pages 162 and extending through 163, because you were not an expert and had not had any experience with finite element analyses?

A (Witness Anderson) No.

Q You have testified that you do not have any experience performing finite element analyses, haven't you?

A Do you have a reference for that? It doesn't sound like anything I testified to.

Q Well, do you recall the depositions that were taken of you in connection with this proceeding?

A I recall there was a deposition.

Q And on May 10, 1984 didn't you tell me what you had consulted with an organization called ANAMET to help you on finite element analysis?

A Yes.

Q And that effort was never pursued, was it?

A No.

Q And you have nothing independently or in consultation with anyone else since the middle of May on an independent review investigation or calculation with respect to finite element analysis; isn't that true?

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A No, that isn't true.

Q I see, sir.

When did you first make a calculation or collect data on finite element analysis?

A Concerning this case?

Q Yes.

A With the material that we provided on the supplementary work that Failure Analysis did on the block received several documents which included finite element calculations and I turned them over to an engineer to examine the format and the procedures that had been followed to evaluate for me.

Q Let's start at the beginning. Are you talking about when LILCO filed its original testimony in these proceedings on August 14, 1984 you began this effort?

A No.

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Q Well, you hadn't begun it before then, had you?

A No.

Q Are you referring to the supplemental testimony that was filed by LILCO in about the middle of September of 1984?

A Yes, I am.

Q Now what portions or parts of the cylinder block did you request help on from an engineer in connection with the finite element analysis?

Are you referring to a document to refresh your recollection, Dr. Anderson?

A Yes. I thought I should give you the name of the document so that we would know what I was talking about.

The document is apparently done by a Scott Rau, designated with the date 9/22/84. The title is "Task: Determine Stress Fields in Region of Liner Landing for Finite Analysis."

Q Now Rau, Mr. Scott Rau, doesn't work for you, does he? He works for Failure Analysis?

A This is the Failure Analysis document that I have analyzed.

Q I understand.

But I asked you-- So that document contains the portions that you had an engineer work on? Is that right?

A Yes.

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Q All right.

Can you identify that particular engineer for me?

MR. BRIGATI: Objection. I don't understand the relevance of this line of examination. The document he is referring to is not in evidence, wasn't put in evidence by LILCO, hasn't been put in evidence by the County or the Staff.

JUDGE BRENNER: Well, I understand the relevance of the line of inquiry. I don't understand the relevance of the last question, so I will apply your objection just to the last question.

Mr. Farley, why is that material?

MR. FARLEY: It would help us, your Honor, in, again, inquiring about the qualifications of Dr. Anderson.

JUDGE BRENNER: I am going to grant the objection as to the last question, but I do understanding your inquiring into his qualifications. That is why I made the other comment I made to Mr. Brigati's objection as applied to the line. But surely there is a more efficient way of getting at his qualifications.

BY MR. FARLEY:

Q It is a fact, isn't it, Dr. Anderson, that the only part of the testimony now being sponsored by you on FaAA's finite element analysis showing the effects of stresses on the top of the block is the first sentence in

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the answer on page 163?

A (Witness Anderson) I believe the document speaks for itself. It does appear to be the residual of that -- of the initial comments, yes.

Q All right, sir.

What specific ligament cracks or stud-to-stud hole cracks did you refer to this engineer for him to analyze in connection with your answer on page 163?

A None. At the time the testimony was written I have not referred to anybody else.

Q But today you are sponsoring this answer. You have adopted it, haven't you? And you said it is true and correct? Isn't that right?

A The answer on page 163 has a reference to the Failure Analysis Block Report 36.

Q I asked you, Dr. Anderson, if you in fact had performed any finite element analysis on any part of the block tops at Shoreham and you told me No. Isn't that right?

A I have not performed any tests; that's correct.

Q But you did state in an answer that subsequent to the receipt of the LILCO supplemental testimony you consulted or requested advice from an engineer on FaAA's finite element analysis of the block tops of the Shoreham EDGs. Isn't that correct?

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A Yes, it is correct insofar as I have identified the single document which I asked that test to be performed on.

A All right, sir.

Now you specifically state in your answer,-- And you are the only one sponsoring it -- isn't that correct? -- on page 163?

A Yes.

Q All right.

Now please identify specifically for the Board and the parties the particular cracks that you are referring to in that answer.

MR. BRIGATI: Asked and answered. He has already answered that it comes from the Block Report.

JUDGE BRENNER: Yes, but that's not the pending question.

Overruled.

MR. FARLEY: Your Honor, I object to Mr. Hubbard conferring with Dr. Anderson. Hubbard doesn't have anything to do with this testimony.

MR. DYNNER: Mr. Hubbard.

MR. FARLEY: Mr. Hubbard.

JUDGE BRENNER: If anybody should know by now, your Counsel is an expert on the way he wants the panel to perform, and he has admirably explained his view to

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LILCO's witnesses, and if he hasn't explained those same views to his own witnesses I would be surprised. But some of you were here, and obviously Mr. Farley wants to apply those same rules to you.

And Mr. Hubbard, we have discussed it before. You can follow up if you want to if you feel you have some pertinent information, but right now Mr. Farley has just told us that he wants to limit the question to Dr. Anderson.

WITNESS ANDERSON: Is there a question pending?

JUDGE BRENNER: Yes. Mr. Farley wants to know what cracks you are referring to in your answer on page 163.

WITNESS ANDERSON: Yes. I believe I answered that by saying I was referring to the Block Report and the cracks that they refer to which they did not further specify in that document at that location.

BY MR. FARLEY:

Q You are unable to tell me today which specific cracks you are referring to. Is that correct?

MR. BRIGATI: Objection. Asked and answered.

JUDGE BRENNER: No, we'll permit the question. It is a fair follow-up on cross-examination.

WITNESS ANDERSON: Yes. This question is directed in reference solely to the Failure Analysis Block Report.

BY MR. FARLEY:

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Q I want you to tell me now, Dr. Anderson, which ligament and stud-to-stud cracks you are referring to in this answer.

MR. BRIGATI: Objection. Counsel is badgering the witness.

JUDGE BRENNER: No, I don't think he is that sensitive, the witness. I don't think he is badgering the witness.

I do think you got the answer, Mr. Farley.

I will back up to Mr. Brigati's previous objection and grant it as to this, now that it was asked again. You got a "yes" as the first word to the previous answer, and I'm going to match that "yes" up with your question.

MR. FARLEY: I know.

BY MR. FARLEY:

Q You cannot tell me today, can you, Dr. Anderson, which are the Shoreham EDGs involved in your answer appearing on 163 of the prefiled testimony. Is that correct?

A (Witness Anderson) Yes, my previous answer stands.

Q The only thing you know is--

JUDGE BRENNER: Wait a minute. I want to make sure you two are communicating.

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He changed the question, Dr. Anderson. Do you realize that?

WITNESS ANDERSON: Oh, at this time?

JUDGE BRENNER: Do you want to ask it again, Mr. Farley?

MR. FARLEY: Yes, sir.

BY MR. FARLEY:

Q You cannot identify for me right now the particular EDG at Shoreham that you are referring to in this answer on page 162 of the prefiled testimony. Isn't that a fact?

A (Witness Anderson) I am not sure I distinguish between the different EDGs so that I haven't make the specification of which EDG.

Q What is the power or the load or the level that you are referring to in the first answer on page 162?

JUDGE BRENNER: Do you mean 163, Mr. Farley?

MR. FARLEY: Excuse me?

JUDGE BRENNER: 163?

MR. FARLEY: Yes, sir.

WITNESS ANDERSON: Again the reference stands for itself, but it is my belief the power is 3500 kilowatts.

BY MR. FARLEY:

Q And what was the "above" that you are referring to?

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A (Witness Anderson) That is a modifier to the words "90 percent power," so it would be "above 90 percent."

Q Of 3500?

You said that the power level you are referring to was 3500 Kw, and then you say "or above." What is the level that you are referring to there?

A Above the 90 percent.

Q Was there any limit?

A If I recall, there was an upper limit of 110 percent. Whether it is at that point of reference I don't know.

Q Now finally in connection with that same answer, you refer to a block having minimum material properties. You don't describe those in the prefiled testimony, do you?

A I believe I gave written testimony-- I'm sorry. I read into testimony a statement about properties in Widmanstaetten and that is at the beginning of the examination.

Q I understand that, Dr. Anderson. But in the first answer on page 163 you refer to a block having minimum material properties, and I am asking you:

Isn't it a fact that nowhere in your prefiled testimony do you tell the Board what are the minimum material properties that you're referring to?

A No, that is not a fact. There is a reference

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and in the reference there is a statement of material properties. I can read it if you wish.

Q Do you know what the minimum material properties of any of the EDG blocks at Shoreham is?

A Yes.

Q What is it?

A 33 Ksi with a thick section of 32.

Q Is that-- For what blocks?

A That is the reference on -- to the Failure Analysis Block Report.

Q You do nct have any independent knowledge or information that you have derived from any calculation or investigation as to what the minimum material properties are of any of the EDG blocks at Shoreham. Is that correct?

A That's correct, yes. I have not done independent testing.

Q Have you personally, Dr. Anderson, on your own, independently of any assistance or help from anyone else, performed a finite element analysis on any structural component?

A No.

Q Okay.

Have you ever, for example, constructed a three-dimensional finite element analysis on any particular structural component?

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A You're looking at "any," not to do with this case, or--

Q Any, including this case.

A Yes.

Q All right.

Which one?

A Well, we at the University, have a KENCAN system. There is a finite element program, and there are some programs that when I took training in, had to be used.

Q Well, subsequent to your training, have you ever had occasion to personally construct a three-dimensional finite element analysis of any structural component?

A No.

Q Have you ever personally constructed a two-dimensional finite element analysis on any structural component?

A Other than the training?

Q Yes.

A No.

Q Are you aware of any-- Strike that.

Isn't it a fact that there are and there were available to you before your review of the FaAA preliminary report commercially available programs for 2D and 3D finite element analyses?

A Yes.

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Q But you did not make available of any of these. Isn't that right?

A No, that's not correct.

Q All right. Which ones did you make available?

A There was a reference to BIGIF, and I went through that documentation.

Q Is it your testimony today that BIGIF is a finite element analysis code?

A You in your question asked if I had done anything, and therefore I would include it under that. It is not a formal finite element.

Q It is a fact, is it not, that you do not consider yourself an expert in finite element analyses?

MR. BRIGATI: Objection. What does he mean, expert in finite element analysis? Expert in performing one?

JUDGE BRENNER: I will let the witness handle it. So the objection is overruled.

WITNESS ANDERSON: The finite element analysis is something that I'm aware of but do infrequently. It is not done in the normal course of my activities.

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BY MR. FARLEY:

Q Do you remember being deposed on this subject on May 16, 1984?

A (Witness Anderson) No.

MR. FARLEY: I have a copy of the transcript of that particular deposition, and I would refer counsel to page 91.

BY MR. FARLEY:

Q And I ask you if you recall this question and answer:

"Do you consider yourself an expert or qualified in the mechanics of finite dynamics?

"A: Finite dynamics? No, I seldom work in that area."

Do you recall that testimony?

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

Q Was your testimony -- Strike that.

Professor Christensen, you originally sponsored a portion of this answer --

JUDGE BRENNER: Mr. Farley, if I may interject, I'm sure you don't need any advice from me but from time to time I remind counsel for all parties of certain things. You realize that that portion of the deposition is not in evidence just because you asked the witness about it, given his answers?

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MR. FARLEY: Yes, sir.

JUDGE BRENNER: Okay.

BY MR. FARLEY:

Q Professor Christensen, you originally were one of the sponsors of this answer on page 163 as now filed by the County and you have been removed as a sponsor in the filed testimony.

Was that because you are not an expert in finite element analysis?

A (Witness Christensen) I cannot recall.

JUDGE BRENNER: Was your answer I cannot recall?

WITNESS CHRISTENSEN: Yes, the answer was I cannot recall.

BY MR. FARLEY:

Q It is a fact, is it not, Professor Christensen, that you did not perform a finite element analysis of your own on the cylinder block or any portion of the cylinder block at the Shoreham station?

A (Witness Christensen) When you asked me that question you asked me it is a fact, is it not. Is that two questions? I would like you to rephrase that so that I can get that correctly, please.

Q Is it not a fact that you did not personally perform any finite element analysis on the cylinder blocks or any portion of those blocks at Shoreham?

WRBagb

MR. BRIGATI: Objection, relevance. He hasn't testified that he has. What difference does it make?

JUDGE BRENNER: Mr. Farley?

MR. FARLEY: Your Honor, we went through the same thing on our testimony where they were permitted to cross-examine extensively about people who were removed and the reasons for which they were removed, and all I am doing is following up with the fact that Professor Christensen was an original sponsor of this testimony and how he has been removed.

JUDGE BRENNER: Let me see if I understand what you said, Mr. Brigati.

The County makes no claim that Professor Christensen has any expertise in finite element analysis?

MR. BRIGATI: The County claims, or contends that Professor Christensen has not performed or testified about performing a finite element analysis in the block area and therefore doesn't understand why the question is remotely relevant to his testimony.

JUDGE BRENNER: I will sustain the objection given that statement by counsel.

MR. FARLEY: Judge Brenner, may I inquire if I could have the same statement from counsel with respect to Mr. Eley, who was also an original sponsor of this testimony?

WRBagb

MR. BRIGATI: It is also true as to this testimony, Mr. Eley is no longer sponsoring the testimony and has performed no finite element analysis concerning it.

JUDGE BRENNER: All right. The questions that -- I should let him speak for himself but the questions that Mr. Farley are pursuing are broader than just whether or not he has performed any finite element analysis himself.

MR. BRIGATI: That's the question I objected to insofar as Professor Christensen was concerned. He was inquiring into whether Professor Christensen had performed any finite element analysis in connection with this testimony, and I objected to it.

JUDGE BRENNER: It wasn't just performing, it was "and is providing no testimony whatsoever on the subject of finite element analysis."

MR. BRIGATI: That's correct.

JUDGE BRENNER: But they're not the same thing.

MR. BRIGATI: I know they're not the same thing.

JUDGE BRENNER: Okay. We have your statement now.

BY MR. FARLEY:

Q Mr. Bridenbaugh, have you ever performed a finite element analysis on any structural component?

A (Witness Bridenbaugh) No, I have not.

Q Mr. Hubbard, have you ever performed a finite

WRBwrb

element analysis on any structural component?

A (Witness Hubbard) No, I have not.

Q And, Mr. Bridenbaugh, you do not consider that you have, by training, education, knowledge or experience, the qualifications to perform a finite element analysis of any structural component; isn't that true?

A (Witness Bridenbaugh) I have never been called upon to do so, and I do not at this time have that training.

Q Mr. Hubbard, do you do not have by training, knowledge, education or experience, the qualifications to perform finite element analysis on any structural component, do you?

A (Witness Hubbard) No, other than the general training that a graduate engineer has in all fields of study.

Q Your degree in engineering has nothing to do with metallurgy or mechnical engineering or material properties, do it?

A No, sir; my degree is in electrical engineering, but you have basic courses in all the engineering disciplines.

Q Dr. Anderson, isn't it also a fact that you have never done a fatigue crack propagation rate calculation with respect to the cylinder blocks at Shoreham?

A (Witness Anderson) Yes.

WRBwrb

Q Further, you have never performed a fracture mechanics analysis on any structural component, have you?

A In this case?

Q Is this the first time you did it?

A No; I have had to perform structural analysis, fracture mechanic analysis, on other litigation.

MR. BRIGATI: Just so the record is clear, I think Dr. Anderson should be asked whether his statement "In this case" was a statement of fact or a question. It was not clear to me. And in the context it could be confusing.

JUDGE BRENNER: From his tone of voice I thought that Dr. Anderson's statement "In this case" was a question.

Is that the way you intended it, Dr. Anderson?

WITNESS ANDERSON: Yes, it is.

MR. BRIGATI: Thank you, Judge.

BY MR. FARLEY:

Q Dr. Anderson, you have not done any independent calculation, or compiled any data, in connection with fatigue crack propagation in the Shoreham EDG blocks, have you?

A (Witness Anderson) That's correct.

Q Mr. Bridenbaugh, do you consider yourself qualified by training, education, experience or knowledge, to perform a fracture mechanics analysis on any structural component?

WRBwrb

A (Witness Bridenbaugh) I would say no, I have not had the training or experience to actually perform the fracture mechanics analysis. But I have had a substantial amount of experience in reviewing the results of such analyses and determining the relevance of the results to the operability, or likelihood of failure of structures or machines.

Q Well, did you make any independent investigation or calculation in connection with the fatigue crack propagation in any of the EDG blokes at Shoreham?

A I'm sorry, Mr. Farley; did you say did I do any calculations?

Q Yes, sir.

A Was it limited to that?

Q Yes, sir.

A No, I have not.

Q Dr. Anderson, you have not had any training, education, experience, and you are not possessed of the necessary knowledge, are you, to perform fatigue crack propagation analyses?

A (Witness Anderson) I have taken courses in that subject. I have applied it in other litigation. I do not teach it, nor is it commonly taught in my department.

Q And, in any event, you did not perform any independent calculations, or compile any data, on the

WRBeb

Q Mr. Eley, have you?

A (Witness Eley) No.

Q Mr. Hubbard, have you ever performed any fracture machanics analysis of a structural component?

A (Witness Hubbard) No, I have not. Like Mr. Bridenbaugh, when I was manager of quality assurance at GE, I was involved in the analysis of field failures as part of my responsibilities.

Q It is also true, isn't it, Dr. Anderson, that the extent of any analysis or review of the fracture mechanics evaluation on the cylinder blocks at Shoreham by you has been limited to an examination of the FaAA report of June 1984?

A (Witness Anderson) Yes, that is all I've had available to me.

Q Mr. Bridenbaugh, you are not sponsoring any testimony in this proceeding, are you, dealing with a fracture mechanics evaluation on the cylinder blocks at Shoreham?

A (Witness Bridenbaugh) I think, Mr. Farley, you asked that same question of Dr. Anderson with regard to the answer on page 163, and I believe he responded that that is about the only area where fracture mechanics is discussed.

Q So the answer to my question is No?

A The answer to your question is no, as far as

WRBeb

fracture mechanics.

There are, however, some general conclusions that we have reached on the testimony that we jointly sponsor, but it does not specifically address fracture mechanics.

Q We'll get to those. Thank you.

Professor Christensen, you are not sponsoring any fracture mechanics evaluations of the Shoreham cylinder blocks in this testimony, are you?

A (Witness Christensen) I cannot recall now. I'm sorry.

Q Mr. Eley, are you sponsoring any testimony in this proceeding pertaining to a fracture mechanics evaluation of the EDG cylinder blocks?

A (Witness Eley) Not that I can recollect, no.

Q Mr. Hubbard, you are not sponsoring any testimony in this proceeding, are you, dealing with the performance of a fracture mechanics evaluation of the EDG cylinder blocks?

A (Witness Hubbard) No, other than the reliance on some of the FaAA conclusions.

Q But you have not made any independent investigation or analyses of any of those opinions, have you?

A No, other than reading the underlying documents, inspection reports, and non-destructive examination reports, LDRs, the various Q reports and things that back up the

WRBeb

DR/QR report; things of that sort, the underlying documents.

Q Dr. Anderson, isn't it a fact that you have never done any cumulative damage analysis calculation with respect to any structural component?

A (Witness Anderson) I can't recall doing any cumulative damage. I'm aware of the concept and its applications.

Q You have not performed any independent investigation or analysis of the cumulative damage analyses by FaAA with respect to the cylinder blocks at Shoreham, have you?

A Well, I have examined what they have done as best as they have documented it, and I came to the conclusion it was inappropriate and I haven't gone beyond that.

Q But you have not made any independent analysis or investigation on your own that would indicate whether or not that cumulative damage analysis is correct or incorrect, have you?

MR. BRIGATI: Objection. Asked and answered.

JUDGE BRENNER: No. Overruled.

WITNESS ANDERSON: Well, there are two "corrects" and "incorrects." That's why I'm having problems.

There is: is it numerically correct? Does it give a correct answer when cranked through the equation? I don't challenge that, and I haven't looked at the numbers.

WRBeb

Is it correct in its application? And that I do challenge. I believe it is incorrect in its application.

BY MR. FARLEY:

Q My question, Dr. Anderson, is:

You personally have not performed any independent review or analysis or investigation of the cumulative damage analysis calculations with respect to the cylinder blocks at Shoreham. All you've done is read the preliminary draft report of FaAA. Isn't that correct?

A (Witness Anderson) That is part of what I've done.

Q Have you, on your own, independently gone out and made a cumulative damage analysis with respect to the cylinder blocks at Shoreham?

A Numerically I have not.

Q Do you consider yourself, by training, education, experience, or knowledge, to be qualified to perform a cumulative damage analysis on any structural component?

A In part, yes.

Q What is the MARCO-STARKEY cumulative damage theory?

A I don't recall.

Q What i· the HENRY cumulative damage theory?

[illegible] ar that.

[illegible] lative damage theory.

WRBeb

A HENRY? I'm not familiar with that.

Q What is the GATTS cumulative damage theory?

A I don't recall.

Q What is the COURTEN-DOLAN cumulative damage theory?

A I don't recall.

Q What is the MARIN cumulative damage theory?

A I don't recall.

Q Have you ever published any peer-reviewed technical papers in the field of cumulative damage analyses?

A No.

Q Mr. Bridenbaugh, am I correct in assuming that based on the answers that you have given to me in connection with finite element analyses and fracture mechanics analyses that you do not have any training, knowledge, experience or education that would qualify you as an expert in the field of cumulative damage analyses?

A (Witness Bridenbaugh) My answer to you, Mr. Farley, on that is basically the same as the answers that I have given to you on finite element analysis and fracture mechanics, that I have not performed them but I have utilized the results of such analyses.

Q And you did not make any independent investigation or calculation using any type of cumulative damage analysis in connection with any of the Shoreham

WRBeb

EDGs. Isn't that right?

A I did not perform any independent calculations, no.

Q Professor Christensen, have you ever performed any type of cumulative damage analysis calculations with respect to any structural component?

A (Witness Christensen) No. But I did make it my business to go up to the library, the engineers' library, in New York and review some of the literature written on this subject, and I find myself perhaps not an expert in this subject but an expert in supplying data which would allow somebody who is an expert to work in this area.

And when I look at a diesel engine, particularly Shoreham engines, I would have extreme difficulty in finding or obtaining data which would be pertinent for input into such equations.

Q Professor Christensen, do you know what the MARCO-STARKEY cumulative damage theory is?

A No, I do not. But I reiterate what I said just now. I spent quite a lot of time in the engineers' library in New York, and I cannot remember all the names.

Q Do you know what the HENRY cumulative damage theory is?

A No.

Q Do you know what the GATTS cumulative damage

WRBeb

theory is?

A No.

Q Do you know what the COURTEN-DOLAN cumulative damage theory is?

A No.

Q Do you know what the MARIN cumulative damage theory is?

A No.

Q Mr. Eley, have you ever performed a cumulative damage analysis in connection with any structural component?

A (Witness Eley) During courses that I had in the U.K. I have done some experimental work with various materials, particularly destructive testing, but I have not in this case done an independent cumulative damage analysis, nor am I familiar with the MARCO-STARKEY, the HENRY, the GATTS, or COURTEN-DOLAN or MARIN theories.

Q Thank you, sir.

Mr. Hubbard, have you performed any cumulative damage analysis in connection with any structural component?

A (Witness Hubbard) Not with respect to structural components.

Q Have you performed any independent investigation or analysis by use of cumulative damage calculations in connection with any of the EDGs at Shoreham?

A No, other than to review the calculations that

WRBeb

were done by FaAA and the underlying data that was used as input to those.

JUDGE BRENNER: Mr. Farley, would this be a good point to take the afternoon break?

MR. FARLEY: It certainly would, your Honor. I am getting ready to switch subjects.

JUDGE BRENNER: All right. Let's break until 3:50.

(Recess.)

AGBpp

JUDGE BRENNER: Mr. Farley, we're ready now.

Do you have a lot more questions in the nature of qualifications-type questions in terms of time.

(Pause.)

It's my perception that some of the points you brought out since you began your cross examination at approximately 2:30 could have been gotten at more efficiently. Maybe that is an erroneous perception and maybe if you had tried it more efficiently you would have gotten answers that then would have required you to back into some of the detail. But why don't you try that first and depending on some of the answers you might -- don't have to ask all the questions on the list.

But I interrupted your answer to my first question.

MR. FARLEY: I would estimate, your Honor, that it would probably be the rest of the afternoon.

JUDGE BRENNER: All right.

I would hope that it would not -- that direct qualifications questions would not have to continue into tomorrow morning. I certainly understand that an inquiry at any time could require backing into qualifications related questions and I'm not talking about that. But you understand, I think, what I'm saying.

MR. DYNNER: Yes, sir.

AGBpp

BY MR. FARLEY:

Q Starting with you, Mr. Hubbard, and proceeding to your left I would ask each member of the Panel, have you ever installed strain gages on a diesel engine?

A (Witness Hubbard) No, I have not.

(Pause.)

A (Witness Eley) I have installed torsiographic equipment on diesel engines.

A (Witness Anderson) No.

A (Witness Christensen) No.

A (Witness Bridengaugh) I have never installed strain gages on a diesel engine. I have installed them on steam turbine parts.

Q Again, starting with you Mr. Hubbard and proceeding to your left, has any member of the Panel ever installed strain gage rosettes on a diesel engine?

A (Witness Hubbard) No, I have not.

A (Witness Eley) No.

A (Witness Anderson) No.

A (Witness Christensen) No.

A (Witness Bridenbaugh) No.

JUDGE BRENNER: Mr. Farley, I don't want to make a big deal out of it but that's one example. Those witnesses at least who answered no to your first question, if I understand what a strain gage rosette is, necessarily

AGBpp

had to answer no to your second question.

MR. FARLEY: I understand, your Honor.

JUDGE BRENNER: Okay.

BY MR. FARLEY:

Q Dr. Anderson, are you a certified penetrant inspector in accordance with the recommended practice of the American Society of Non-Destructive Testing?

A (Witness Anderson) No.

Q Are you a certified magnetic particle inspector?

A No.

Q Are you a certified ultrasonic inspector?

A No.

Q Are you a certified eddy current inspector?

A No.

Q Starting with Mr. Hubbard and proceeding to your left with the exclusion of Dr. Anderson, is any member of the a Panel a certified penetrant magnetic particle ultrasonic or eddy current inspector in accordance with the recommended practice of the American Society of Non-Destructive Testing?

A (Witness Hubbard) No, I'm not, Mr. Farley. However, I used to do the certifying at GE. We have level 1, 2, and 3 NDE personnel and I was the person that approved the certifications for the level 1, 2, and 3. I had those type personnel on my staff.

AGBpp

A (Witness Eley) No, I'm not.

Q Professor Christensen?

A (Witness Christensen) I'm not qualified in the United States to do this work, but I am in England.

A (Witness Bridenbaugh) I am not certified in any of those fields but I have had such people working under my supervision.

Q Dr. Anderson, prior to this particular proceeding, have you ever evaluated the microstructure of gray cast iron containing degenerate Widmanstaetten graphite?

A (Witness Anderson) No. I have looked at a number of cast iron failures but it is very rare to find such a degenerate structure, Widmanstaetten-type structure. It is astonishingly rare and therefore now I have not seen one before.

Q Dr. Anderson, have you ever correlated mechanical properties of gray cast iron to fracture fatigue crack initiation or crack propagation analyses?

A No, I haven't. But I have observed techniques in which that has been done and I would be happy to provide a reference for the appropriate manner in which it should be done.

Q You have never worked in a foundry where large gray cast iron castings were made; is that correct?

AGBpp

A That's correct.

Q And it's also true, isn't it, that you don't have any experience with the design of large or medium sized diesel engines and particularly with the design of cylinder blocks?

A That's correct.

Q You are not a registered or certified welding engine, are you?

A No, I'm not.

Q Have you ever performed any welding on gray cast iron class 40?

A Yes, I would imagine I have.

Q When did you do that and how did you do it?

A My father had a welding shop and about 40 or 50 welders with him and I spent a lot of time there.

Q Dr. Anderson, are you a registered corrosion engineer in any state in the United States?

A No. I have used up my professional licenses in being a registered professional metallurgical engineer and a nuclear engineer. Each one requires approximately 8 to 10 years of your experience which you can't re-use. So as soon as I have had more experience I make up for that.

Q The State of California where you work does register corrosion engineers, doesn't it?

A They recently have separated out such a status;

AGBpp

that is correct.

Q When?

A I would say within the last four years.

MR. FARLEY: Judge Brenner, I am now going to page 3 of our supplemental cross plan.

BY MR. FARLEY:

Q Dr. Anderson, what is a hot tear?

A (Witness Anderson) In the cooling process when you are casting after the initial transformation to a solid has occurred, there are stresses that can set up. These stresses are due to the shape of the part. They are due, in part, to the cooling and contraction that occurs. And that the metal though it's hot and has these stresses on it is not strong enough to resist the stresses and therefore tears apart. It is different, for example, than a shrinkage crack which is due to the fact that you do not properly feed metal, due to a riser, into the area that is shrinking.

Q At what temperature, approximately, do hot tears form in gray cast iron class 40 material?

A Without looking at the references, I'd have to rely on my memory. The best I can do at this point would be somewhere around 4 to 600 c.

Q And what fraction of the melting point do they form?

A The fraction would be somewhere around 50 percent.

AGBeb

Q Do you know what the metallurgical phase is present in the cast iron ore when they form?

A If they form in equilibrium there should be ferrite and cementite. If they form in non-equilibrium conditions there should be labdebdurite and some ferrite and some cementite.

Q Dr. Anderson, would hot tears which you would find formed with the hot tear exposed to air at the temperature that you have described and cooled at a constant rate to reach room temperature in four or five days have a thick oxide on the cracked surface?

A It is likely that it would have. And I don't know what you mean by "thick," but it would have observable oxide. Its characteristics would be reddish -- normally reddish going into chocolate.

Q Would you define what you understand is a shrinkage crack?

A I believe I did but I will do it again.

A shrinkage crack is caused when the metal contracts upon cooling, which is a phase transformation from the liquid to the solid, and that there is inadequate feed of liquid metal, and that would be due to pore riser or pore feed of some manner.

And what happens is the metal physically pulls apart. It has characteristics which generally are rather

AGBeb

clean and bright and discernable from hot tears and other types of defects.

Q Would the temperature range at which shrinkage cracks occur in Class 40 gray cast iron be the same as those that you have described for hot tears?

A It could encompass that. Generally it is at higher temperatures because we're talking about a feeding problem when there is a transformation occurring, so we'd be talking about, normally, generalizing, more elevated temperatures.

Q Dr. Anderson, have you ever, personally, examined a failure of any structural component resulting from graphitic corrosion?

A Yes, I've seen graphitic corrosion. I don't recall the exact circumstance around it, whether it was a case or a demonstration. But yes, I've seen it.

Q What was the structural component?

A Essentially the iron has corroded away leaving a graphite structure which is -- you can stick a pencil through.

Q What type of structural component was it? A pipe? A machine? A bicycle handlebar?

A To my recollection is was a cast iron pipe.

Q Isn't it true, Dr. Anderson, that graphitic corrosion occurs in water and soil environments?

AGBeb

A It is true it is principally electrochemical corrosion of the iron, and seldom found without some presence of salts or water.

Q And it is commonly associated with cast irons which have been subjected to aggressive environments such as underground sewer and water pipes. Isn't that true?

A Whether it's common, yes, it does happen quite often.

Q Isn't it a fact, Dr. Anderson, that all of the examples of graphitic corrosion cited by Fontana and Green Corrosion Engineering or Corrosion Emergency, which is the reference you gave in your supplemental testimony, were associated with groundwater, soil corrosion, and other mildly aggresive environments?

A I'll check that. Just a moment.

(Pause.)

May I have the question, the sense of the question again, please? I can answer it.

Q Yes, sir.

At page 5 of the County's supplemental testimony you refer to a reference, Fontana and Green Corrosion Engineering, McGraw, Hill, 1978, at page 70 to 71.

And what I asked you was in that reference, are the examples of graphitic corrosion associated with groundwater, soil corrosion and other mildly aggressive

AGBeb

environments?

A Yes, that's correct. I believe the emphasis is on "mildly aggressive" which could be a galvanic-driven or a stress-driven. Stress is one of the driving forces.

I would be delighted to explain this in great detail. Any of those driving forces can be used to cause this, so that is correct.

Q Isn't it also true, Dr. Anderson, that graphitic corrosion does not occur in a dry air environment?

A No, I have not seen it occur in an absolutely dry air environment.

Maybe I should point out what I mean by "dry air." We're talking about relative humidities, and normally the humidities that are controlled to prevent corrosion are kept below about 15 percent. If we get above 15 percent relative humidity then we can have enough non-dry air to cause a corrosion situation.

Q Have you personally seen any example of graphitic corrosion in a structural component or any part exposed to a dry air environment?

A Yes, I have. Again the problem is "dry air." If I can say the relative humidity exists that is above 15 percent, I have seen a cast iron pipe that was brought to me that never touched the soil but was inside a rather humid area.

AGBeb

Q Isn't it a fact that any examples of graphitic corrosion that you are familiar with, the cast iron was pourous or spongy?

A Yes. All cast iron is pourous and spongy. Any cast iron is markedly pourous and spongy by its very nature of having the second phase of carbon present.

Q Isn't it more porous and spongy, resulting from graphitic corrosion?

A That's what happens when the iron matrix is removed by corrosion operation. Then what you are left with is the poorly connected graphite structure and that is both weak and extremely porous.

Q Now the cross-sections that you observed of the surface indications or the cracks in the cam gallery areas of the original EDG 103 at Shoreham, they were not spongy or porous, were they?

A Yes, they were. All cast iron, by its nature, has that characteristic.

Now if you mean it had observable porosity, I did not see observable porosity. But by its nature it is spongy and porous.

Q Did you see-- Did you observe whether or not the oxide that existed in the cross-sections of the cracks or surface indications in the cam gallery of the original EDG 103 was spongy or porous?

AGBeb

A You are referring to the oxide alone, the oxide which is characterized on the surface of the cast iron?

Q That's my question now.

A You know, it did not appear to be porous or spongy that I could detect. It did not smudge easily. It had a characteristic that made it appear harder than a disconnected graphite structure. I don't believe that it was porous.

AGBpp

Q You did observe, did you not, that the repair weld interface with the cast iron in the cam saddles of the original EDG 103 was cracked?

A Yes, it was cracked on one side, yes.

Q And the crack occurred in the heat affected zone of the cast iron adjacent to the interface with the repair weld; didn't it?

A Well, that's the interesting thing about this weld. It almost looked like it had been puddled on because the amount of heat affected zone was tre minimum.

Q Well did it, in fact, occur in the heat affected zone of the cast iron adjacent to the interface with the repair weld?

A Well, I have just said that I can't find the heat affected zone and I see no microprobe line across to determine where the weld ends precisely, so I really can't make a statement that it did fail in the heat affected zone.

Q Do you know whether or not it was in the weld or in the cast iron adjacent to the interface?

A Very definitely, I know.

Q Where was it?

A It was in the cast iron.

Q Did you observe from the samples that were made available to you that the surface indications or the cracks that you observed in the cam gallery areas of the original

AGBpp

EDG 103, that the surface oxidized or corroded as heavily as the crack surfaces of the original shrinkage crack which extended beyond the repair weld?

A I must have been wool-gathering. Would you excuse me and repeat the question?

Q You've already told me that you're familiar with the oxide that was in the cross sections of the cracks in the cam gallery of the original EDG 103; correct?

A Correct.

Q You've also told me that you're familiar with the repair welds; right?

A Right.

Q Now, I'm asking you was the crack surface oxidized or corroded as heavily as the crack surfaces of the original shrinkage crack which extended beyond the repair weld?

A In the sense of the question as I see it is the area of the crack by the weld, the relative amounts of oxide, were they different and deeper down into the crack. My recollection was that in the area of the weld, the amount of oxidation that I observed in the face that nad pulled away from the cast iron, there was less or diminished amount of oxide and deeper.

Q How much less?

A I couldn't characterize it.

AGBpp

Q Is it important to characterize it?

A I don't see that the characterization difference is important, no.

Q With the exception of portions of numbers 6 and 7 cam saddle areas, you inspected all the cam gallery locations of the original EDG 103 at Shoreham; did you not?

A As far as I know, everything was provided to me by Failure Analysis.

Q And isn't it true that unpainted areas of the original EDG 103 block that had been exposed to the air surface was scrapped and rusted?

A What was the first word?

Q The unpainted areas.

JUDGE BRENNER: I think the word before "and rusted" is what he meant.

WITNESS ANDERSON: Scrapped and rusted?

MR. FARLEY: Scratched.

WITNESS ANDERSON: Scratched. Thank you. Yes, I believe it was true.

BY MR. FARLEY:

Q Isn't it true, Dr. Anderson, that graphitic corrosion would be present on other unpainted cast iron surfaces in the cam gallery area in the unlikely event that this corrosion process did occur during service of the old 103?

AGBpp

MR. BRITAGI: Objection to the question. He is characterizing it as an unlikely event. Objection to the form of the question.

JUDGE BRENNER: I just don't understand the objection. I'm sorry. Maybe it is too late in the day for me.

MR. BRITAGI: There is no basis in the record for the proposition that it is an unlikely event that this graphitic corrosion occurred during operation of the engine yet Mr. Farley has incorporated that concept as an essential element of the question.

JUDGE BRENNER: I've got you now. Can you rephrase the question, Mr. Farley?

MR. FARLEY: Yes, sir.

BY MR. FARLEY:

Q Dr. Anderson, on October 3, 1984 you inspected the original EDG 103 at Shoreham along with Mr. Dynner and representatives of LILCO; didn't you?

A (Witness Anderson) I don't recall the date but I did do that inspection.

Q Now when you went there it was obvious, was it not, that the original EDG 103 block had been exposed to air and it was scratched and rusted; isn't that right?

JUDGE BRENNER: Mr. Farley, that was asked and answered. All you had to do was rephrase the question that

AGBpp

was objected to by starting it with an "if."

MR. FARLEY: All right.

JUDGE BRENNER: Instead of, "in the unlikely event."

BY MR. FARLEY:

Q Isn't it true, Dr. Anderson, that graphitic corrosion would be present if the cast iron surfaces in the cam gallery area had been -- if the corrosion process had occurred during the service of the engine?

A (Witness Anderson) I'm sorry; I didn't follow that.

Q Did you observe any graphitic corrosion on any other unpainted cast iron surfaces at Shoreham?

A In the old block which was mounted on the back of a flatbed and obviously was scratched and rusted as characterized, I did not observe any black formations of graphitic corrosion. I did not look at all areas but I do not recall observing any.

Q Did you observe whether or not there was any graphitic corrosion in any of the cam gallery areas of the original 103?

A My comment was for the whole block. I don't recall seeing any.

Q The oxide that you observed on the samples at Failure Analysis that were provided to you was relatively

AGBpp

uniform in thickness along the depth of the crack; wasn't it?

A Well, I don't want to be cute and ask you to define relative but I would say that it was -- it had a uniformity that was not unremarkable.

JUDGE BRENNER: I'm sorry. I just don't understand what you mean by the uniformity that it was not remarkable. You mean it had a remarkable uniformity?

WITNESS ANDERSON: It is late. What I was saying is that there were some differences in different locations but there is nothing I would remark on. It was essentially uniform.

AGBagb

BY MR. FARLEY:

Q Did you observe any difference between the uniformity of the thickness of the oxide on the shrinkage crack as distinguished from the weld crack?

A (Witness Anderson) Yes, I believe I addressed that. I felt that there might have been less in the area of the weld than in the crack below the weld.

Q Did you make any estimate of that?

A No.

Q Dr. Anderson, if the cam gallery cracks had extended in service of the original EDG 103 wouldn't, in fact, the oxide be thicker at those portions which grew in service than those portions -- than those formed during the fabrication process?

A Possibly but not necessarily. If I may explain, the mechanisms which they would grow an oxide during service would be affected by exposure to, say, oils that would be on the surface -- might be present on the surface, and therefore I would expect a lessening would be possible in the upper area, the area that I described by the weld, than further down in the crack.

Q Do you know whether or not the high nickel electrodes for manual metal arc welding have calcium compounds incorporated in the coverings of those electrodes?

A No, not directly. I observed the repair welds

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when I toured the TDI facilities. I saw the welding facility and the operation was being carried out at that time with uncoated electrodes.

Now there may have been a flux addition that I wasn't aware of but the uncoated electrodes in that particular case would suggest that the calcium wasn't -- or that fluxes were not present. I can't say what was done in this particular case.

Q I was just going to ask you: you saw those in 1984 then, right?

A That is correct.

Q And you don't know of your own personal knowledge whether or not the electrodes used for the welding at the time of the manufacture of these engines had calcium compounds, do you?

A That's what I said in answer to the last question and I affirm that again.

Q Did you observe that the thickness of the oxide present in the crack surfaces of the old 103 cam gallery No. 7 saddle area -- Did you see that?

A Did I see the thickness?

Q Yes, sir.

A Yes, I saw the cracks from the side view which would indicate the thickness.

Q What was the thickness of the oxide layer present

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in the cracks at that particular area?

A I didn't measure it.

Q Was there oxide on the crack surfaces at approximately 0.8 inch beneath the cam gallery surface?

A I don't recall. I believe that there was a coating of oxides, both original and artifact, throughout the length of the crack up into the point that it had been separated for inspection. I have no other recollection.

Q You do agree, do you not, that the matrix between the graphite flakes of the cast -- of the class 40 gray cast iron is perlite?

A You said the matrix --

Q Yes, sir.

A -- between the iron flakes is perlite?

Q Between the graphite flakes.

A I'm sorry, the graphite flakes.

Probably perlite as opposed to banite. I would expect in a Widmanstaetten structure that I would think that the cooling would have been a little bit faster and I would have expected a banite but I don't see that.

Q Dr. Anderson, what color would the oxide be if perlite had oxidized in air at 150 degrees Fahrenheit approximately?

A Under what conditions?

Q Under the conditions that you saw the matrix

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between the graphite flakes of the class 40 gray cast iron.

A Well then I have --

Q Dry air.

A With that question I have to make up my conditions.

At low temperature, the material would be expected to form a hematite, would would tend to be a rouge-red oxide. There are some signs of secondary oxidation on the surface of the structure, which I dismissed as artifact -- there were some red oxides which I dismissed as artifact But I would principally look for a reddish oxide at low temperature.

Q Would there be any difference in the color if the perlite had oxidized in water rather than air at 150, 160 degrees Fahrenheit?

A Well in that case I am producing first a hydrous oxide and the hydrous oxide can give a slightly different coloration. And I might go in, from less rouge I might go in to some more oranges, but essentially not.

MR. FARLEY: Excuse me a minute, Judge.

(Pause.)

BY MR. FARLEY:

Q Dr. Anderson, what color would the perlite be if it oxidized in air at higher temperatures above 500 degrees Fahrenheit?

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A (Witness Anderson) Above 500 degrees -- actually I want to go a little higher than that, I prefer 600 and then I am going to start to bring in the wustite which is going to give me a darkening agent, it is going to be a suboxide, non-stoichiometric oxide of iron and that material is stable at higher temperatures, so we would go from the reds to the darker colors: chocolate with a mixture and then finally to black.

Q And as I understand your testimony you now believe that it is more probable than not that the thick dark material covering the crack surface that you observed is an oxide, isn't that right?

A That is consistent with what I read into the record. Failure Analysis has carried out an analysis showing it is an oxide, so that took care of my original concerns.

I might point out where my concerns were: that there was an unusual smell to the oxide surface and that was somewhat alleviated by the assistance of Dr. Wachob to explain that certain solvents had been used in cutting and those were residual solvents that we were seeing. But that would have also been explained by sulfides or other materials. So it was really necessary I believe that the oxide be examined.

I do concur -- I haven't seen the data and I

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understand it will be provided to me, but I do concur that if a microprobe has been run and shows oxygen that it is an oxide.

Q You weren't provided with the calculations or the data that we furnished to Mr. Dynner last night pursuant to the Board's order dealing with the results of the superprobe?

A Yes, I was woken from a sound sleep and provided with it last night.

What I said was I do not have information on the microprobe analysis.

MR. FARLEY: I'm sorry, I'm thinking about a different result, your Honor.

MR. BRIGATI: For the record, I think that we should understand that the microprobe analysis has not been provided to the County.

MR. DYNNER: Yet.

MR. BRIGATI: Yet.

JUDGE BRENNER: Just for my own reference is that the same as the so-called superprobe?

MR. BRIGATI: That's what I was referring to, Judge.

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JUDGE BRENNER: Usually my memory is better than this. At least, I hope it is and I apologize. The data that we ordered be provided was, I thought, the data showing the probe for the presence of oxidation or an oxide. Is that right?

MR. FARLEY: I thought it was something else, your Honor. That was provided yesterday. I know we were supposed to give the results of the microprobe also.

JUDGE BRENNER: All right. I'm not sure. Let's bring up to you today instead of worrying about the history of yesterday since I can't recall it. You are going to provide that?

MR. FARLEY: Yes, sir.

JUDGE BRENNER: Okay. Do you have a timeframe in mind?

MR. FARLEY: I'll get it as soon as I can, your Honor. If you say tomorrow, I'll get it tomorrow.

JUDGE BRENNER: I'm not saying tomorrow. I asked you if you have a timeframe in mind.

MR. FARLEY: No, sir, I don't know.

MR. BRITAGI: Judge, just to clarify or eliminate any confusion on your part, the data that was provided to the County last night related to a study that Dr. Wachob and Dr. Rau did pertaining to the formation, possible formation, of oxide at various temperature ranges

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over various times. That was testified to yesterday morning fairly early in the game.

JUDGE BRENNER: That's what I thought. What I'm having difficult is distinguishing that from what we are now talking about. I thought they were the same thing.

MR. BRITAGI: No, they aren't.

JUDGE BRENNER: Okay. Judge Morris just straightened me out. Go ahead.

BY MR. FARLEY:

Q Dr. Anderson, isn't it a fact that dye penetrant materials do not contain calcium and sulphur additives?

A (Witness Anderson) Well, there is a sulphur specification for low sulphur in nuclear work. When I talk to the dye penetrant manufacturers they felt that there would be calcium and sulphur present.

Q Are you personally familiar with the dye penetrant materials that were used by LILCO or FaAA in connection with the examination of the Shoreham EDG blocks?

A No, I am not.

Q Do you have any personal knowledge of whether or not the dye penetrant materials used by LILCO or FaAA in connection with their inspections of the EDG blocks at Shoreham can name calcium and sulphur impurities?

A No, my work was only associated with talking to some manufacturers and assuring myself that it was

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reasonable that it be present. I do not know what was used by LILCO by Failure Analysis or by TDI.

Q You are aware, are you not, that supplies limit or there are limits on allowable levels of calcium and sulphur and dye penetrant materials?

A I'm only aware of the limit on suphur?

Q What is that, approximately?

A I don't recall. They say low sulphur -- I don't recall what the numbers were.

Q Isn't it important to know the limits specified by suppliers for calcium and sulphur to reach conclusions about whether or not dye penetrants could introduce calcium or sulphur on the crack surfaces?

A I don't believe so. The fact that it is present and in fact since we are talking about a limit on unattached sulphur the calcium can be added to dry up the sulphur and keep the sulphur content low. I don't see the limits are really necessary. They provide, I think, a sound bit of information on where this calcium normally came from.

Q Don't you know, Dr. Anderson, that calcium sulfide and both calcium and sulphur are prohibited in dye penetrants by narrow composition restrictions?

A No, I don't know that.

Q Do you know that the total of all contaminants including calcium and sulphur must be less than 0.002

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percent in dye penetrant?

A No, I have never heard that number.

Q Do you know whether or not LILCO specifies a maximum of that percentage for all dye penetrants it utilizes?

A No.

Q Would that information affect any of your opinions or conclusions?

A No.

Q You have testified previously, have you not, that the coverings -- strike that.

Are you familiar with the microstructure of the class 40 gray cast iron?

A I suppose so. I've seen it in various --

Q Describe it, please?

A Typically, we have a ferrite structure with the carbon innerpenetrating matrix and the carbon is principally in the form of cementite with perhaps some precarbon, depending upon the cooling conditions.

Q Are you familiar with how cast irons are characterized by ASTM specification A-247?

A I don't recall that.

Q Do you know what type of graphite is present in the EDGs at Shoreham?

A I don't think anybody knows right now. The old

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103 that's been taken apart has been characterized as having a graphite of a degenerate nature and a Widmanstaetten, I believe the 101s and 102s are still an unknown quantity since, from what I can determine from my reading of Failure Analysis work, less than 100 grams of the material has been analyzed, which is roughly a part per million. And in the new 103, I'm not sure that any appropriate characterization has occurred there, either.

Q Aren't there classifications of graphite-type by metallography?

A Yes, there are, also grain size and other characteristics.

Q Well, are you familiar with those classifications?

A I've seen them. I have no recollection.

Q Have you applied any of those to the EDGs at Shoreham?

A No, I don't believe sufficient metallography has been done.

Q Dr. Anderson, do you know what percentage of the surface of gray cast iron at low temperature is if you break -- strike that.

When you break gray cast iron at low temperature and you examine the fracture surfaces, what percentage of the surface is graphite and what percentage is perlite,

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approximately?

A It could be very high graphite because they will break along graphite plates.

Q Can you give me an approximate percentage?

A You didn't give me how much carbon is present.

Q I see. When exposed to oxygen or any acquiesce corrodent, can the graphite prevent corrosion of the perlite?

A It definitely can, yes. It happens that it has a characteristic of being cathodic and therefore it can prevent by an anode cathode relative area consideration. But since it is cathodic it also can increase it. So it kind of depends on how much is there.

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Q If the presence of graphite on a fracture surface inhibits and stops corrosion, as you have just testified, how do you explain the failure of thick cast iron pipe via this leaching corrosion mechanism?

MR. BRIGATI: Objection to the form of the question, I don't believe that Dr. Anderson testifies that the presence of graphite inhibits corrosion. He said it can inhibit corrosion.

JUDGE BRENNER: Well the objection is overruled and he can answer the question. The question is not improper given the previous questions and answers, including some of about 45 minutes ago.

WITNESS ANDERSON: The word "inhibitor" refers to another area of corrosion and carbon and graphite in all of its forms are not inhibitors by any stretch of the imagination; in fact, they will exacerbate -- free carbon, free graphite on a metal surface will exacerbate corrosion.

What we are talking about is essentially a curtain effect. But as you recall from earlier statements on my part, this is a rather open structure and therefore it acts as a lace curtain, not as a shower curtain, and therefore corrosion will occur and it just depends on how much surface area I have.

BY MR. FARLEY:

Q It is true, isn't it, Dr. Anderson, that

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shrinkage or thermal stresses do develop in the cam gallery area during the cooling of the casting?

A (Witness Anderson) I have no problem with that statement.

Q And isn't it true that Widmanstaetten graphite substantially reduces the tensile strength of gray cast iron?

A I have no problem with that statement.

Q When you say you have no problem, would you say yes or no, please?

A Yes.

Q Have you ever personally tested the reduction of tensile strength caused by the presence of Widmanstaetten graphite?

A No, I attempted to obtain a sample of it in cast iron and was unable to do so. My colleagues say they have never seen it in cast iron and it just wasn't available in our library of specimens.

Q Would you also agree, Dr. Anderson, that everything else being equal, degenerate Widmanstaetten graphite reduces the fatigue crack initiation time of cast iron?

A Yes.

Q Do you know, based on your training and educational experience, by how much the presence of

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Widmanstaetten graphite reduces fatigue crack initiation time?

A No, I don't, but I have a reference for a procedure in which one can calculate the changes that occur based upon this condition in the metal.

Q You have not made any independent calculation of that with respect to the old EDG 103 at Shoreham, have you?

A With respect to what? I don't understand.

Q With the presence of Widmanstaetten graphite reduce the fatigue crack initiation.

A Have I done what with that?

Q Have you made any independent investigation or calculation of what the presence of that Widmanstaetten graphite does to reduce the specific fatigue crack initiation?

A Other than review the literature as I have specified and determine techniques which are normally used, I have not.

Q You are not personally familiar, are you, with any measurements of the effects of Widmanstaetten graphite on the fatigue properties of class 40 gray cast iron other than those performed by FaAA?

A That's correct.

Q And isn't it true, Dr. Anderson, that you don't have any basis to doubt or question the accuracy of the

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test results reported by FaAA with respect to the effects of the Widmanstaetten graphite on the fatigue properties?

A You mean do I question it or do I have a basis --

Q You don't have any basis...

A Well they have taken specimens of the 103 old and have made tests. We have to accept their testing procedures and results.

JUDGE BRENNER: Mr. Farley, excuse me. You can pick a convenient time to stop.

MR. FARLEY: Right now is fine, your Honor.

JUDGE BRENNER: I have the perception that maybe the UTS of participants in this proceeding is about five or ten minutes less today than yesterday for some reason.

MR. FARLEY: I agree with the Board.

JUDGE BRENNER: Maybe I am just projecting my own problem on everybody else.

At any rate since this is a fairly convenient time for you, let's recess for the day and resume 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.)

CERTIFICATE OF OFFICIAL REPORTER

This is to certify that the attached proceedings before the UNITED STATES NUCLEAR REGULATORY COMMISSION in the matter of:

NAME OF PROCEEDING:
LONG ISLAND LIGHTING COMPANY
(Shoreham Nuclear Power Station)

DOCKET NO.: 50-322-1 (OL)

PLACE: Hauppauge, New York

DATE: November 1, 1984

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission.

(Sigt) William R. Bloom / Anne G. Bloom
(TYPED) William R. Bloom & Anne G. Bloom

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