ORIGINAL

# UNITED STATES
# NUCLEAR REGULATORY COMMISSION

---

**IN THE MATTER OF:** **DOCKET NO:** 50-322-1 (OL)

LONG ISLAND LIGHTING COMPANY

(Shoreham Nuclear Power Station)

**LOCATION:** HAUPPAUGE, NEW YORK **PAGES:** 26675 - 26905

**DATE:** THURSDAY, NOVEMBER 15, 1984

---

TR-01 0/1
additional 2 copies to ASLBP, E/W-439

ACE-FEDERAL REPORTERS, INC.

*Official Reporters*
444 North Capitol Street
Washington, D.C. 20001
(202) 347-3700

NATIONWIDE COVERAGE

WRBwrb

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the matter of:

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

(Shoreham Nuclear Power Station):

State Office Building,
Veterans Memorial Highway,
Hauppauge, Long Island, New York,
Thursday, 15 November 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.)

WRBwrb

APPEARANCES:

On behalf of the Applicant:

TIM ELLIS, Esq.,
HUNTON AND WILLIAMS
700 East Main Street,
Richmond, Virginia 23219

On behalf of the Nuclear Regulatory Commission Staff:

ROBERT G. PERLIS, Esq.,
Office of the Executive Legal Director.

On behalf of Intervenor Suffolk County:

ALAN ROY DYNNER, Esq.,
JOSEPH J. BRIGATI, Esq.,
Kirkpatrick, Lockhart, Hill, Christopher
and Phillips,
1900 M Street, N.W.,
Washington, D. C. 20036

WRBwrb

# CONTENTS

WRBwrb

(Page intentionally left blank.)

WRBwrb

(Page intentionally left blank.)

WRBeb

PROCEEDINGS

JUDGE BRENNER: Good morning.

Whereupon,

HARRY FRANK WACHOB,

CHARLES A. RAU,

ROBERT N. ANDERSON

and

SPENCER H. BUSH

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

JUDGE BRENNER: We have a preliminary matter regarding the issues remanded by the Appeal Board on which we have received reports from the parties yesterday. We are raising this now so that Counsel can consider it between now and Tuesday when we will have that conference of parties in Bethesda.

Incidentally, it will be Tuesday morning, and we will give you particulars as to the time and location as soon as we can, and that may be as late as Monday morning, in which case it will of course be phone notification.

We have reviewed preliminarily the written reports of the parties with respect to Unresolved Safety Issue A-47, which will be the subject, the primary subject of my remarks now. We find the County's answer to be unacceptably general, considering the request we made on the

WRBeb

transcript and the status of that item, the status being that the Staff completed their review and so reported back in September 1983.

We are unlikely to stay issuance of a low power license in the absence of a basis to do so presented by or at the November 20th conference of parties by the County such as a setting forth of a specific control system interaction within the scope of the two studies which had been required by the Staff and as I stated, approved by the Staff back in September, 1983.

Now while we may or may not be willing to consider any specific issues with supporting bases in a time frame beyond Tuesday for the purposes of litigation of the merits, my statement as to the possibility of our finding that a low power license may not be issued in the interim stands as I have just stated it.

That is all we have in terms of preliminary matters. If the parties have nothing, we can continue your questions of this combined panel, Mr. Ellis.

MR. ELLIS: Thank you, Judge Brenner.

EXAMINATION (Continued)

BY MR. ELLIS:

Q Good morning, gentlemen.

Dr. Bush, I don't think I gave you an opportunity yesterday, and I do want to give you one today.

WRBeb

Would you agree that in order to draw confident conclusions from an examination of the specimen that we were discussing yesterday that it should be metallographically polished?

A (Witness Bush) I presume we are discussing the crack that supposedly had further cracks or bifurcation at the root. Is that correct?

Q That's correct, sir.

A All right.

I would have difficulty-- Well, two options: I would either have to use an acceptable non-destructive examination to establish the crack morphology or, if I were to base it on visual examination, I think I would require a good degree of metallographic polish to get rid of artifacts as much as anything else.

Q Dr. Anderson, are you now aware that there was liquid penetrant examination of that area that disclosed only the three-eighth inch crack that was in fact discovered?

A (Witness Anderson) Yes. I did review a report which was done several weeks before I had an opportunity to examine that area, and I also reviewed some pictures of the area. The pictures do demonstrate-- The pictures of LP do demonstrate an organization below the crack, but they certainly do not have the depth that the crack -- that the

WRBeb

major crack has.

Q What picture are you referring to?

A There's a colored picture of the unpolished face that I looked at which is a side view, and there is dye penetrant on the surface. The major crack-- The circumferential crack is well developed in that picture, a good deal of bleed, and then there's a general background of color below that from the roughness of the unpolished surface.

Q This organization that you're referring to, is that roughness on the surface, or do you know?

A Well, it has to be associated with an artifact on the surface, yes.

Q Well, Dr. Anderson, are you now then satisfied that the only crack disclosed in that area was the three-eighth inch crack that was discovered by the liquid penetrant?

A The liquid penetrant has enhanced the circumferential crack that has been reported, and it certainly has considerable depth in that field. What it has done to the area below is unclear. There appears to be no cracks with the depth that the major crack has.

Q Dr. Rau, do those pictures, in your opinion, disclose any cracks other than the three-eighth inch crack that was discovered on sectioning and liquid penetrant?

WRBeb

A (Witness Rau) No, Mr. Ellis, they do not. In fact, the pictures show no indication of any organization of the artifact. In fact, if you look at the pictures, there are comparable artifacts all over that surface as revealed by the dye penetrant.

If you like, there's a photograph which I think clearly reveals that.

Q What photograph is that, so that the parties and the panel can look at it?

A There's a number on the face of the photograph, 18-17-34. And it's a photograph of the cross-section through the block top between cylinders 4 and 5 after the liquid penetrant and developer had been applied.

It reveals a circumferential crack indication in profile less than three-eighths of an inch deep. It also reveals some very light -- it looks like a mottled structure throughout the balance of the cross-section from the tears and pull-outs.

Q May I have the number on the back again?

A There are no numbers on the back, only numbers on the front.

MR. ELLIS: Judge Brenner, I think perhaps what I would like to do is to have this photograph marked and used as well, so that the record will be clear on it.

JUDGE BRENNER: I have no objection. I have

WRBeb

never seen the photograph. We have no copies, and frankly, I don't like looking at xeroxed copies while the witness is talking about all the amazing things the photograph purportedly shows, and then have to rely on my catching up later after the witness is no longer here, when you finally provide me with the original.

MR. ELLIS: Yes, sir. I think this photograph is in the album which I believe the Board has.

JUDGE BRENNER: No, we don't have it.

The procedure yesterday worked satisfactorily from our point of view, and I wanted to add that, that is, you had xeroxed copies marked for the record and you lent us an original photograph which we returned. And that gave us the best of both worlds, with your promise that you would replace the xerox with the originals for the record later.

Dr. Bush, you don't have it either?

WITNESS BUSH: I have seen it. The NRC copy seems to be somewhere.

MR. PERLIS: I believe it is our copy that Utility's Counsel is using now.

WITNESS BUSH: I have seen it, but I must confess that I don't remember the root.

JUDGE BRENNER: Perhaps one advantage of this combined witness panel is that you can kind of look over each other's shoulders and share it.

WRBeb

MR. ELLIS: Judge Brenner, I will have a xerox of this marked at the first break. I have handed the Board a copy of the photograph, and I believe Counsel for the County has a copy. And I would ask Dr. Rau to share that with the other members of the panel.

JUDGE BRENNER: All right, fine. When you do provide a xeroxed copy it will be LILCO Exhibit B-64 for identification. And we will do that when you have the xeroxed copy, but for now we can all know that that will be the number.

(Whereupon, Photo 18-17-34, section of block top was marked as LILCO Exhibit B-64 for identification.)

BY MR. ELLIS:

Q Dr. Rau, would you repeat briefly your description of what the photograph B-64 depicts?

A (Witness Rau) Yes, sir, Mr. Ellis.

If you hold the photograph with the numbers in the lower right corner, you are looking at a section where the block top is at the upper left and the counterbore runs vertically down, and the liner land is the short step from which, moving from upper right toward left and lower left, is the liquid penetrant indication.

You also see throughout the balance of this

WRBeb

cross-section which is a cut with an abrasive cutting wheel, a grinding wheel, you see very light indications throughout. In fact, you can even see that the light indications are aligned or more severe in arcs that run from right towards from right towards left or left towards right, and that is basically the shape of the cut-off wheel, which is a circular wheel which is used to abrasively saw through the cast iron.

And the artifacts are slightly more severe, slightly less severe, depending on the specific details of the abrasive cut-off wheel, how hard the technician was leaning on it, and things like that.

As you can see, the indications or the artifacts are relatively uniformly distributed, with certain variations from the cut-off wheel. And there is no indication, in my opinion, of any organization of such artifacts in any particular location except as correlated to the cut-off wheel arcs.

Q Does that complete your answer, Dr. Rau?

A Yes, sir.

Q Dr. Anderson, do you agree or disagree with Dr. Rau as to what the photograph and tests show, namely that there is only a three-eighth of an inch crack, and that any organization is related to the cutting tool?

A (Witness Anderson) I disagree. The three-eighth

WRBeb

inch crack of course is extremely deep and has the bleed that you see. There is cutting-tool organization; there is no question about that.

But in my observation of the part there was superimposed on that another organization, and I think it is faintly discernible on this picture.

Q Dr. Bush, do you agree with Dr. Rau that the liquid penetrant test and the examination of the piece do not reveal any cracks other than the three-eighth of an inch?

MR. DYNNER: Objection. There is no testimony--

JUDGE BRENNER: Sustained.

BY MR. ELLIS:

Q Dr. Bush, do you concur with Dr. Rau's opinion that he just expressed concerning what the photograph depicts?

JUDGE BRENNER: Why don't you ask him the other foundation question since, depending on the answer, that might be as interesting?

Do you understand why I sustained the objection?

MR. ELLIS: No, sir.

JUDGE BRENNER: You didn't ask him whether or not he had actually examined anything other than just looking at this photograph.

BY MR. ELLIS:

WRBeb

Q Dr. Bush, have you examined anything other than the photograph?

A No, and that would have been part of my answer, that I have not. The only thing I have seen is the macrograph in this instance. And in order to draw conclusions about another type of structure I think it would be necessary to look at both the sample and the macrograph, and I have not done that.

Q You said earlier, Dr. Bush, that in order to decide whether cracks were there you would like to have either a non-destructive examination or a metallographically polished sample.

Are you aware that there was a liquid penetrant examination of this area?

A Yes.

Q And have you had an opportunity to review that?

A Yes. You are talking about the macrograph now, or are you talking about an independent write-up that discusses it? I want to be sure what you're asking me.

Q I was asking about the report on the liquid penetrant results.

A Is this a part of the official record? That's what I'm having difficulty with. I have a large mass of paper, and included in it is a very large number of examinations by non-destructive examination. And I must

WRBeb

connss I cannot correlate one versus the other, so I really can't answer the question in that context.

Q These were documents produced on discovery, but I understand you don't recall it at this time.

A Not in that context, no.

Q Dr. Rau, do you have any further comments with respect to the examination of the photograph that you and Dr. Anderson have testified to that has been marked as Exhibit B-64?

A (Witness Rau) I don't believe I have any additional comments on the photograph itself.

I would just simply indicate that the visual examination of the as-cut surface I have also examined with a magnifying glass and confirmed that there are numerous artifacts from the cut-off process and that those are in fact what is revealed by the very light indications throughout the liquid penetrant inspection shown on LILCO Exhibit B-64 and that there were in fact no particular organization or relationship of those to the existing circumferential crack except to the extent that the cut-off process and the damage done by the cut-off wheel were in that location as well as elsewhere.

JUDGE BRENNER: Dr. Rau, this photograph that we have as LILCO B-64 for identification, was this taken under any magnification?

WRBeb

WITNESS RAU: Well, not very much, your Honor. The block top, as you know, is two and a half inches. If I had a ruler, which I do, -- or a liner land is an inch and a half. You can do either one. It looks like it is a little bit subsize, perhaps 75 percent of the full size magnification; something like that.

JUDGE BRENNER: Dr. Bush, I got slightly confused when you mentioned the macrograph, which I inferred is a photograph taken under magnification.

WITNESS BUSH: No, a macrograph is one that is essentially taken at 1 X, in other words very close to that. I would classify anything that either is slightly below 1 X or up to perhaps 5 X as a macrograph. And when they get up to 50 X and beyond, that's a micrograph.

JUDGE BRENNER: So you meant the same photograph--

WITNESS BUSH: Exactly, yes.

JUDGE BRENNER: Dr. Anderson, did you see anything significant that did not show in the photograph when viewed under a magnifying glass?

I should tell you, as you may have noticed, while we were up here we did look at it with a magnifying glass.

WITNESS ANDERSON: Well, when you look at the actual part, you are able to follow the structure, and at 60 X you can certainly look at organization much better than

WRBeb

you can here.

JUDGE BRENNER: And I guess you have already described what you think you've seen.

BY MR. ELLIS:

Q Dr. Anderson, are you aware that UT inspections of the 101 engine block were performed with respect to circumferential cracks?

A (Witness Andserson) Of which engine block?

Q 101.

A Yes, I believe I am.

Q And what did those inspections, UT inspections disclose with respect to the 101?

A I don't have them here. I would have to refer to them before I could tell you. I have looked at a lot of documents in this case.

Q Dr. Rau, can you help on that, what the UT inspections of the circumferential area on the 101 disclosed?

A (Witness Rau) Yes, sir. They disclosed nothing. They disclosed no circumferential crack indications.

And I would add that the ability of that particular ultrasonic technique to detect circumferential cracks if they were there was confirmed by evaluation of the old 103, on which there were destructive confirmations of

WRBeb

presence of the circumferential crack. So it was the same procedure and it indicated no circumferential indications in the 101, and of course did indicate the circumferential indications in the original 103.

Q Dr. Anderson, does that refresh your recollection on having reviewed the UT examination of 101?

A (Witness Anderson) No, it doesn't, on the particular document that would have specified that.

But I do recall during the deposition at Failure Analysis in October that the person that does that there made a statement that if the crack goes all the way around it would not be detectable. I don't have the reference to check that but there was some problem about its detectability.

I would like the reference to clear that up.

Q Dr. Rau, were you present at that deposition?

A (Witness Rau) Yes, sir.

Q And was any such statement made that you recall?

A There was definitely no such statement made with regard to ultrasonic inspection. We may have gotten into the discussion of the ability of liquid penetrant or magnetic particle to detect circumferential cracks. I don't know whether we did or did not.

But certainly we have testified in the hearing here, Dr. Johnson in particular, that because of the sharp

WRBeb

corner there you can get and will get artifacts from magnetic particle inspection. You get a perturbation of the magnetic field and you get a collection of the rust particles there and get a false call.

And the liquid penetrant, you can-- Similarly, because of collections of grit and grime in crevices, you can also get a false call with regard to that. In fact, I believe that there were such indications from the surface techniques in the original 101 which is one of the reasons they went back and did the ultrasonic and confirmed that there were in fact no crack indications in those locations, that they were in fact surface artifacts.

Q Dr. Anderson, do you have any basis for disagreeing with Dr. Rau's statement that UT is an accurate, reliable way of detecting circumferential cracks?

A (Witness Anderson) If I may, I will defer until I can review that deposition and recall more clearly, and then I will answer it at that time.

A (Witness Bush) May I comment on this item?

Q Yes.

A I suspect that the one discussion about the 360-degree crack was more relevant to eddy current than it was to ultrasonic because of the end effect or the lack of end effect.

Unless you define the ultrasonic technique that

WRBeb

you are using very carefully, you have a dead zone that goes down below the depths of this apparent crack, and therefore, you could continue to run ultrasonic forever and never detect such a crack.

So you have to be very careful. When you say "ultrasonic" you have to define the technique that you're using. Otherwise it has no meaning whatsoever.

For deeper cracks, yes, and in the other examinations we're discussing deeper cracks. Otherwise, making a statement about ultrasonics has no real significance.

Q Dr. Rau, would you tell us, please, again why this ultrasonic -- the reliability of the ultrasonic was verified by the examination?

A (Witness Rau) Well, it was verified by the examination.

Dr. Bush is completely correct, there can be and are dead zones from ultrasonic procedures. In this particular case the technique was done by interrogation from the counterbore side of the cylinder and it was verified that cracks substantially shallower than three-eighths could be detected.

Dr. Johnson I think testified about the precise depth, and I don't recall exactly what the lower limit of the dead zone was, but it was more like a sixteenth of an

WRBeb

inch or no more than a tenth of an inch, as I recall.

But certainly by the time you got to anything like the three-eighths inch deep which was present in the original 103, the ultrasonic procedure utilized was reliable for that detection and was demonstrated by the detection of such indications in the original 103.

Q Dr. Bush, does that respond to your comment?

A (Witness Bush) Unless it is precisely defined geometrically I would still have the same reservations. I have seen too many instances of an examination by using a block with, say, either a three millimeter hole, which is a fairly conventional one, or a notch, and then when you convert to the structure you establish that it is free of defects until you do a destructive examination.

I would reserve judgment, very definitely.

Q Dr. Rau?

A (Witness Rau) Just to make sure we're clear, the evaluation was done on the original 103 with the actual circumferential cracks, and the indications were detected and confirmed destructively. It wasn't a calibration block; it was the actual 103 circumferential cracks.

Q Go ahead, Dr. Bush.

A (Witness Bush) I think we are talking, though, of a different block now, are we not?

I was interpreting it in the sense of what I

WRBeb

call a relatively shallow crack versus the other one, and perhaps we're talking--

JUDGE BRENNER: You had it right, Dr. Bush.

BY MR. ELLIS:

Q Dr. Rau, then I guess I'm the one who made the....

Dr. Bush, did you understand that the ultrasonic method that was used on the 101 block had been used with respect to the original 103 block--

JUDGE BRENNER: Mr. Ellis, I think we've got that already. Let me try something.

Dr. Rau, are you saying that even very shallow circumferential indications on the 103 block were disclosable by the UT technique used there as confirmed by destructive testing, or are you only saying that the deeper 103 cracks were found and confirmed?

WITNESS RAU: Judge Brenner, my own personal recollection is that surely we confirmed it for the three-eighths or the slightly less than three-eighths.

Dr. Johnson has indicated to me that in his opinion it was confirmed for shallower cracks, and Dr. Wachob has a recollection, and I think he should tell it directly, that in fact there was some location where the circumferential crack on the original 103 was significantly shallower than that, and that was also detected with the

WRBeb

ultrasonic method.

I have no specific recollection of that.

A (Witness Wachob) I believe Dr. Johnson at one time had made a comment that they had indeed looked at cracks as shallow as a sixteenth of an inch on edges and made the determination.

MR. ELLIS: Judge Brenner, I am going to leave this particular point-- Well, let me ask one more question.

BY MR. ELLIS:

Q Dr. Anderson, in light of the evidence, would you agree that the assumption made by FaAA of a 360-degree circumferential crack is not one that is dictated by the evidence but one that is conservative?

A (Witness Anderson) I don't have that in context. I don't know what you're referring to. What assumption?

Q You realize that one the analysis that FaAA did, they assumed that there were 360-degree circumferential cracks in the 101 and the 102 blocks. Are you familiar with that?

A Yes. Okay.

Q And would you agree that that is a conservative assumption?

A I don't believe I have a basis to agree or disagree. I just haven't examined whether that is an

WRBeb

important parameter and its magnitude on the effect.

MR. ELLIS: I am going to switch to another topic now, Judge Brenner.

BY MR. ELLIS:

Q Dr. Anderson, look if you would, please, at page 1 of your rebuttal testimony.

Question Number 2 asks whether residual stresses create tensile forces in the block top in cam gallery areas of the cylinder blocks. And your response is Yes, followed by an explanation.

Have you done any analysis to enable you to reach a conclusion that there are residual tensile stresses in the block top?

A (Witness Anderson) No. That was my recommendation, that it should be examined empirically to see if there were residual stresses, because of the manner in which fabrication occurs, because apparently nobody really knows what is in there. So it was my recommendation for testing.

Q Are you familiar with any analysis that FaAA has done to consider whether there are residual stresses in the block top?

A I have seen some what I would call draft analysis, yes. I haven't seen a finished report by FaAA.

Q Well, do you know how FaAA took residual

WRBeb

stresses in the block top into account?

A I haven't reviewed that. I can go back and look at it and answer that. I mean I haven't reviewed it in the moment.

Q Dr. Rau, did FaAA take those stresses in the block top into account in its analyses?

A (Witness Rau) Yes, Mr. Ellis. The nature of the analyses we did to assess the possible consequences of block top cracks, because they were related to and based upon the demonstrated performance of the original 103, would in fact take into account any residual stresses in the block top if in fact any were there.

However, I don't want the record to be confused. I certainly have not performed, and I am not aware that FaAA performed any explicit calculations, draft or otherwise, with regard to residual stresses on the block top.

It is my opinion that, given the geometry, the relatively flat area, and the fact that there is material machined off the block top after the casting and before the -- you know, to make the finished block shape, that there is no reason to have very large, if any, residual stresses in that region. And I never saw a reason to even attempt any residual stress calculations.

Q Dr. Anderson, do you have a comment that you want to make, or do you have anything else to say on this

WRBeb

But I don't know any other way to handle it.

A (Witness Anderson) Well, I'm not sure the effect of machining off the surface eliminates residual stresses. I have not seen that.

I think my comment stands, that there should be some analysis to determine what they are.

Q Dr. Bush, did you have any comment in this area?

A (Witness Bush) One, I am unaware of any what I would call definitive analysis of residual stresses in either the cam gallery or the block top. It is inferential.

Two, I guess I can't get very worried about the top surface in the first place, if they machined as much as I understand they machined. And admittedly this is by inference only because I don't have a specific dimension. I would anticipate what limited residual stress would disappear.

The cam gallery is another matter entirely. I would anticipate that you have the possibility at least of substantial residual stresses there because of the geometric configuration and the change in dimension.

But I don't think we have any idea what the level of residual stress is, so about the only thing you could assume conservatively is that there is something below the ultimate or if you want to define it, that there's a yield

WRBeb

in such material if they're there.

But I don't know any other way to handle it.

Q But I take it, Dr. Bush, you don't consider residual stresses to be a cause for concern in the block top?

A Not in the block top; that's correct.

MR. ELLIS: Judge Brenner, I am going to move to another subject.

WRBwrb

BY MR. ELLIS:

Q Dr. Anderson, turn to the statement that you read into the record on November 1, I believe it was. Do you have that? The transcript page number --

A (Witness Anderson) Is it titled "Concerning the Surface Appearance of Cam Gallery Cracks?"

Q My particular copy is not. Let me give you a transcript page reference.

JUDGE BRENNER: That's it, Dr. Anderson, but I want to work from the transcript and not from the typed version, just in case.

Off the record.

(Discussion off the record.)

JUDGE BRENNER: On the record.

BY MR. ELLIS:

Q It begins, Dr. Anderson, at 25,578, and I want to refer specifically to the testimony of yours that begins at page 25,579 concerning FaAA's calculation on oxidation.

Do you have that?

A (Witness Anderson) I just have what I read in, I don't have the testimony.

JUDGE BRENNER: Point him to the particular paragraph and some of us will see whether there is a major difference.

MR. ELLIS: Yes, sir.

WRBwrb

BY MR. ELLIS:

Q It is the paragraph, Dr. Anderson, that begins "I have examined the FaAA calculation...."

A (Witness Anderson) I have that.

Q All right, sir.

You state in that paragraph:

"This model assumes that oxygen diffuses through the oxide film and reacts with the surface of iron."

A Yes, it is a parabolic rate law.

Q What basis do you have for stating that the oxygen diffuses through the oxide film and reacts with the surface of the iron?

A What basis?

Q Yes.

A Well the formation of the equation that was used is such that it provides a relationship between the thickness and the square root of the time, and that is referred to as the parabolic rate law. And the basis for the parabolic rate law is a diffusion through the oxide.

There are several rate laws that apply. There is a logarithmic, there is a linear, there is a number that can be chosen, and this is a common example of a rate law. But it is not the appropriate one in this case.

Q Dr. Rau or Dr. Wachob, do you agree that oxygen

WRBwrb

diffuses -- that the model assumes that oxygen diffuses through the oxide film and reacts with the surface of iron?

A (Witness Wachob) No, sir.

Q Will you explain why you do not agree?

A The literature from 200 degrees C through 600 degrees C or so definitely shows that iron is the diffusing species through the oxide layer.

Q Dr. Bush, do you agree with Dr. Wachob?

A (Witness Bush) Not necessarily. I think it depends on the tenacity of the film and the continuity of the film as to whether you can make that statement. Now if you are assuming idealized conditions, that may be something else again.

Q What were you assuming, Dr. Wachob?

A (Witness Wachob) The studies that have been done have assumed -- or have been involved in making measurements that were involved in having a uniform oxide thickness and in the growth of that oxide layer from those specimens.

Q Dr. Anderson, do you have anything you wanted to add to this subject?

A (Witness Anderson) Yes, I am aware of the study, and that is the correct interpretation, that there is a back-diffusion of metal atoms into the structure: there's no question about it. However the model, the model that is used is based upon a one-way diffusion. And I'm not

WRBwrb

characterizing the other work that has been done.

Moreover, in the analysis that was done, this high-temperature oxide was extrapolated to a condition to which you cannot extrapolate. It's a basic law of kinetics that you cannot extrapolate beyond what you have determined the mechanism is operating at. At other temperatures there's other mechanisms operating. And that is a very serious violation of kinetics to do so.

Q Dr. Anderson, is what you've just said, what you read into the record, "the basic law of kinetics has been violated" by extrapolating the model to temperature where other mechanisms were in control?

A That is correct. And that is one of the basic laws that every student learns early, not to extrapolate beyond the area which they can definitively determine the mechanism.

Q What other mechanisms did you conclude might be in control?

A Did I conclude? I did not do the analysis. I looked at the analysis and found that it was faulty. I looked in the reference that was proviced, and the more current edition has omitted the equation that was used by Failure Analysis.

The mechanism uses a very high purity iron at an elevated temperature. It was apparently empirically derived.

WRBwrb

derived. To extend it to other temperatures is inappropriate completely.

Q Dr. Rau or Dr. Wachob, do you agree that the basic law of kinetics has been violated by extrapolating the model to temperature where other mechanisms are in control, as stated by Dr. Anderson?

A (Witness Wachob) The growth of the oxides that we're discussing fall into the range primarily of magnetite. They do have oxides as high as 600 degrees C., and they do go down as low as 2 or 3 hundred degrees C. There are problems in extrapolating over that region, however, the activation energies for that process are only slightly changed, and the oxide thickness are only changed by factors of 10 or 20.

So that over the range that we're talking about, the application of that data is quite appropriate.

In addition, we're not dealing with just one isolated piece of research in the literature, there are several other substantiating articles, and technical as well as experimental verifications of that.

A (Witness Rau) I'd like to add one thing.

I think it's very important to realize that the physical evidence, that is, the coloration of the oxide indicates magnetite. There's absolutely no indication, as I indicated yesterday, of any of the rust color you'd expect

WRBwrb

if, in fact, the low temperature form of oxidation interrupted the mechanism.

Dr. Anderson is quite correct, it's not appropriate, if another mechanism becomes operative that causes the oxidation to occur in a different way, to extrapolate.

But, in point of fact, the physical evidence is quite convincing. There is none of the low-temperature rust, what there is on the casting shrinkage crack is a uniform, tenacious dark oxide, magnetite. And the analysis and the extrapolation is completely appropriate for the formation of magnetite. Now, whether or not it forms very significantly at low temperatures comes directly out of the calculation. And, as we indicated in our testimony, for all intents and purposes there's no significant formation of that dark oxide at low temperatures, it drops off to almost nothing. But, in point of fact, the model is completely appropriate.

I also think it's-- Dr. Anderson suggested that the model is only appropriate for high purity iron. That's definitely not the case, either. And I would ask Dr. Wachob to discuss that point further.

A (Witness Wachob) There have been, in addition, several studies which involve a variety of steels, but, in addition, there have been studies in cast iron. And the

WRBwrb

cast iron study also shows that a parabolic oxidation rate occurs after the initial few minutes of oxidation, and that all the principles that we're applying-- And, again, the calculations are estimates of the thickness to give us a ballpark estimate of how thick that oxide is. In both cases we find that the numbers are in reasonably good agreement.

So I don't see a problem with different materials, high purity irons, we're dealing with the oxidation of iron in this instance, and that's what we've observed, as well as using analytical and experimental results that are in the peer review literature.

A (Witness Anderson) May I jump in here a minute?

Q Yes, by all means.

A First of all, there a mention of activation energy. It changes dramatically, as well as does the frequency factor, when you go from the pure iron that the equation was based on to a carbon system, tremendous changes. And therefore, the extrapolation which was before not allowed becomes even rougher.

Second, the parabolic rate law has never been applied to a crack in the literature. And if Failure Analysis has a piece of literature they can show me where they have ever seen a parabolic rate law in a crack, I'd love to see it. I'm not aware of it, and I'm very, very well versed on that literature.

WRBwrb

Q Dr. Anderson, what is your basis for your statement that the activation energy changes dramatically?

A And frequency factor. If you look at the data that is available where you're going to use an Arrhenius approach, and they give you the frequency factor and an activation energy so that you can get the rate constant at different temperatures, you will see that they are a function of composition, and those functions of compositions change them significantly.

Q Well, are you referring to a specific article or book?

A I'm referring to the general literature. I can certainly find a reference for you.

Q Dr. Rau and Dr. Wachob, do you agree with Dr. Anderson in this respect?

A (Witness Wachob) Will you repeat the question? I'm sorry.

Q Yes. My question was whether you agreed with Dr. Anderson on the issue of activation energy and frequency changing dramatically?

A The activation energies do change. But as I said before, the final outcome of that oxidation rate is not significantly changed. It is changed, but, again, we're dealing with very thin oxides being produced near room temperature and very thick oxides being produced in the

WRBwrb

temperature range of 1000 degrees F.

In addition, there are statements in the literature that the oxidation rate of iron itself does not seem to be influenced by carbon level. So I feel that, again, what we have done, and what we're using as our basis to show that at low temperatures you get very thin oxides and at high temperatures you get thicker oxides, I think is consistent.

Q Dr. Rau or Dr. Wachob, do you agree, then, with Dr. Anderson's statement that appears on page 25,579 that the FaAA analysis is completely contrary to empirical evidence that cast irons readily corrode at low temperature by either a graphitization or fretting corrosion mechanism?

A (Witness Rau) I strongly disagree with that statement, Mr. Ellis.

There's no such evidence that in air, and certainly in lubricating oil, that cast irons readily corrode. There's no such evidence that it occurs by graphitization in lube oils or at low temperatures, and there's no such evidence that it occurs quickly or rapidly.

There's also no physical evidence whatsoever that the reddish rust colored oxide which would form if in fact we had low-temperature oxidation is, in fact, present on the cam gallery cracks.

And there's absolutely no basis for reaching that

WRBwrb

conclusion, in my opinion.

Q My question, though -- you may have answered it -- is: Do you agree that the Failure Analysis analysis is contrary to empirical evidence?

A No, sir.

Q And your basis for that is what you just stated a moment ago?

A Yes, Mr. Ellis. You have to compare apples and apples. If you put cast iron in an acidic soil environment it will corrode. Whether it corrodes rapidly is a matter of how you define "rapidly." But in lubricating oil or in dry air there's no evidence that cast iron corrodes rapidly; in fact, the evidence is quite to the contrary, that it has higher corrosion resistance than steels and irons because of the additional chemical constituents, the silicon and the chromium, in the cast irons. There's no basis. The analysis is clearly appropriate.

Q And I think you said that in a lubricating oil environment there's no evidence. Suppose that lubricating oil had water in it, would that change your view?

A You'd have to be more specific, Mr. Ellis. It depends on how much water.

Q Well, let's take the case at hand where we have lubricating oil in the Shoreham diesel generators and you have cam gallery cracks.

WRBwrb

A Okay. In the case of the original 103 in which the cam gallery indications have been examined thoroughly, that engine was run with Mobil Delvac 1240, a 40-weight diesel-rated lube oil with anti-oxidants, antacids. And LILCO, in particular, has a specification not to use that oil with any more than .05 percent water.

At those levels of water my statement would hold, I would not expect any significant oxidation of cast iron under those conditions. And, in fact, there are examples of iron and steel components, unpainted, in the cam gallery region which indicate negligible amounts -- bright, shiny metal -- negligible amounts of corrosion.

WRBbrb

Q Well, Dr. Rau, would four to nine gallons blow-by per hour cause more water in the oil than 0.5 percent?

A No, it would not, Mr. Ellis. In fact, there is blow-by in the cylinder rings, which does produce, from the combustion process, water which gets down into the crank and, in fact, some of which gets into the oil. But due to the temperature of the oil, the vast majority of those four to nine gallons per hour of moisture don't stay in the oil.

And, in fact, you know, if the engine is running continuously you're going to have 24 times that number. You're going to be putting in 100 or 200 gallons of water a day into the oil environment. And, basically, it doesn't stay there; it boils away, and the oils don't develop any more than 0.5 percent water in the oil.

Q Dr. Anderson, did you want to comment on Dr. Rau's testimony?

A (Witness Anderson) The calculation that was done previously at higher temperature does not apply to a low temperature system; it's a different mechanism.

Now, the susceptibility of cast iron at low temperature: Failure Analysis continues to draw an environment that's not a crack environment. We're talking about what happened in the crack. The simple expedient is to analyze appropriately, inexpensively and rapidly the material on the surface and determine how it was formed.

WRBbrb

The crack environment is not the large areas that are being bathed in oil. In a crack environment, your anti-oxidants can act differently, because we're looking at an oxygen-deficient area. In a crack environment, even corrosion inhibiters can act against you.

So we've got to consider -- we don't want to hear an explanation about the general basis of oil on flat surfaces; we want to hear it about what's in the crack. And the best, and only, way that I know of is an analysis of the material on the surface.

Q Dr. Rau?

A (Witness Rau) I don't know whether we've been through this sufficiently or not, but yesterday I think we stated quite clearly that the weld shrinkage crack is a crack. It's connected to, it's immediately adjacent to the casting shrinkage crack. It's in the cam gallery. It's exposed to whatever environment the casting crack was exposed to. It does not have a thick dark oxide.

And you can't have it both ways. There is no evidence that that crack environment is any different than the environment immediately at the surface in this lubricating oil.

The fact that it's an oxygen-depleted region at the tip of a crack is a true statement, as a general statement. But, in point of fact, the entire cam gallery

WRBbrb

area is an oxygen-depleted area because of the presence of lubricating oil. The surfaces themselves are maintained oxygen-low, and that's why it doesn't oxidize. And, quite frankly, there's no physical evidence for things being different in that crack, in that cam gallery, in that lubricating oil.

Q Dr. Anderson, I want to give you the last --

JUDGE BRENNER: Could I jump in for a second, Doctor?

Doctor Rau, you did say that yesterday, and I heard you, and I think you've said it other times over these many days. But does that statement necessarily assume that what you've called the weld shrinkage crack is just that, as opposed to a later induced operational crack?

WITNESS RAU: No, Judge Brenner, it doesn't.

I think I also said this yesterday, but maybe I didn't. There's only two options: either it was a weld shrinkage crack, and it was there, and it was exposed to the oil environment just like the casting shrinkage crack, or it formed later, as you just postulated.

If it formed later, then the casting shrinkage crack was not exposed to the surface. It was not exposed to anything. So it cannot oxidize in service; it is not in contact with the environment.

So either way you want to postulate it, the

WRBbrb

conclusion comes out the same: that the casting crack was oxidized during the fabrication process. There are no other options.

BY MR. ELLIS:

Q Dr. Anderson, I want to give you the last opportunity, if you have anything to add. You may not have anything to add, but I do want you to have the last opportunity.

A (Witness Anderson) I can't think of anything at the moment.

Q My last question to you, Dr. Anderson, is: I know you have given a substantial amount of testimony yesterday and today, and I know you have considered it, and I assume that --

JUDGE BRENNER: Mr. Ellis, I'm sorry to interrupt. I have been too slow on this one by about ten minutes.

Did you purposely not invite Dr. Bush to comment on your questions regarding Dr. Anderson's testimony on the parabolic rate model of oxidation and extrapolation questions?

MR. ELLIS: I guess I just figured we had covered the subject enough. If I has a comment, I'd be delighted to have it.

JUDGE BRENNER: I don't know. I don't recall

WRBbrb

Dr. Bush ever saying anything on that subject, even during his initial testimony.

Do you know what I'm talking about?

WITNESS BUSH: Yes.

Very briefly, I did touch on it with regard to the other factors that might affect it. My personal opinion, as I think I have expressed, is that I believe that it is predominantly a high temperature mechanism.

I disagree with a few statements I have heard. Cast iron is not necessarily better than steel. In fact, if one looks at the British Journal of Corrosion -- not journal, but book on corrosion authored by, I believe, Shite, you'll find that, in fact, a whole series of data -- Shreir, S-h-r-e-i-r -- that would indicate that the room temperature mechanism -- I dismiss this because I don't think that room temperature is a controlling factor, based on an analysis of all of the different parameters. But, just for the record, cast iron as such is not necessarily that much better in atmospheric environments; that's rural environments or urban environments or marine environments, things of that nature.

JUDGE BRENNER: All right.

What I really wanted your comment on, if you want to offer one, is: do you have Dr. Anderson's testimony, either in a transcript or in that excerpt that was handed

WRBbrb

out?

WITNESS BUSH: Yes, I do.

JUDGE BRENNER: The paragraph that begins, "I have examined the FaAA calculation..." which Mr. Ellis asked everybody but you about.

WITNESS BUSH: I have problems. There are too many statements that aren't tied to something. If one does not understand which way one is extrapolating, and what models or mechanisms are supposedly different -- I can't answer the question intelligently because I don't have a base, an inferential base to work from; so I guess I can't answer that question.

JUDGE BRENNER: Do you have an opinion of what Dr. Wachob said with respect to the fact that given the type of precision he felt he needed, which in his view was not very precise, to estimate the dimensions of the coating and the range of temperatures that he talked about, whether his use of the model is totally inappropriate, as stated by Dr. Anderson?

WITNESS BUSH: I wouldn't say "totally inappropriate". I can raise questions, because continuity of film is a critical factor. But I would say, by and large -- as I think I mentioned yesterday -- that I would strongly suspect that we would see what I would call a composition and crystallographic gradient from surface of film towards

WRBbrb

metal, which I think is generally in general agreement with Dr. Wachob's statement.

JUDGE BRENNER: I'm sorry, Mr. Ellis. That was a little awkward because I was too slow; and one reason I did it, though, is to remind the parties -- because I wasn't very vigilant there myself -- that it's easier to try to get it all at the same time when we can, which you've been doing very well. I'm not criticizing you; I'm criticizing myself for being so slow.

MR. ELLIS: Thank you, Judge. I'm sorry I overlooked it in that instance.

BY MR. ELLIS:

Q Did you have anything further, or can we leave this, Dr. Rau?

A (Witness Rau) I just wanted to add one quick statement.

All of the discussion about the oxidation models is appropriate, but I think we should keep in mind what the purpose and intent of that model was.

The intent was to get a qualitative feel for the temperature at which the oxidation of the casting crack may have occurred; and it was designed to deal with the higher temperature regimes and cooling down through -- things stopped happening, you know, at temperatures like 500 degrees and 400, and the extrapolation down to room

WRBbrb

temperature was just to indicate that -- not much should be drawn from that kind of extrapolation; that wasn't the main point of the calculation.

The only other point I would add is with regard to Dr. Bush's comment, and I don't really disagree with what he's saying, except that there are definitive references in the Iron Castings Handbook which clearly show that, in atmospheric corrosion, that the cast irons, the gray irons, are significantly more corrosion resistant than mild steels, and of the same order as low alloy steels.

I think Dr. Bush would agree with that. I mean, I'm not disagreeing, really.

Q Two more.

Dr. Anderson, look, if you would, please, at page seven of your supplemental testimony -- I'm sorry, page eight. Up at the top of the page, you have a statement: "This graphite forms a protective layer so that the corrosion stops and the surface becomes relatively uniform over time."

What was your basis for that statement, sir?

A (Witness Anderson) I'm sorry. Do you want a reference to that to support it, or do you want an explanation of it?

Q An explanation, and a reference, if you have it, Doctor.

WRBbrb

A I think you would find that in any of the standard textbooks -- Fontana and Green, and Eulig, would be two to go to. It's a basic understanding of corrosion, what the mechanism is, and how the corrosion occurs.

Q Given that explanation, Dr. Rau or Dr. Wachob, do you concur in this context that the graphite forms a protective layer so that corrosion stops and the surface becomes relatively uniform over time?

A (Witness Rau) Given the characteristics which we have observed on the cam gallery cracks in the original 103, I disagree with that statement.

There's no evidence that graphite covers the entire surface. There is evidence to the contrary. Quite frankly, there's no way in which the graphite in an air-oxidizing environment can protect the adjacent perlite -- or the steel, if you like -- in between the graphite flakes.

The graphite is cathodic. That means it is more resistant to aqueous corrosion, if it were occurring, than the adjacent steel. And therefore, it is not going to retard but, rather, to accelerate the corrosion of the adjacent steel. And, in fact, when graphitic corrosion occurs, it basically eats away the steel and leaves a network of the graphite that was there originally in the cast iron.

So I therefore disagree that that's appropriate

WRBbrb

to the oxidation which we have seen in the cam galleries, and even generally applicable.

Q Dr. Bush, did you want to comment on this particular point?

A (Witness Bush) Well, I'm afraid we're comparing apples and oranges here.

If we're talking about the cam gallery per se, I don't agree that it's graphitic corrosion. If we're talking about graphitic corrosion as a mechanism and how it behaves, that's another situation because there can be circumstances where, essentially, you get into a decreasing rate on there; but if I relate it to the cam gallery, then I guess I don't visualize this mechanism as controlling for several reasons, environmental primarily.

I don't necessarily agree, however, that it doesn't, because I believe that it has been observed. In fact, Fontana has reported it in the context -- in a totally different set of conditions, that you may have a decreasing rate or a blockage of rate after a period of time.

So I'm trying to decouple one from the other. I don't believe in the graphite corrosion mechanism in this specific instance; but if we're talking about graphite corrosion per se, then I think one can have a different one. So I'm trying to decouple it.

Q Do you have anything further you want to add,

WRBbrb

Dr. Anderson?

A (Witness Anderson) No.

Q Let's, then, turn to page seven of your supplemental testimony; and this is, I think, to conclude.

Dr. Anderson, you say in the middle of your page seven that -- and I'm paraphrasing -- that calcium sulfide is often present in diesel oil, lubricants and dye penetrants.

Is it present because it's an additive to these substances -- that is, to the oil lubricants and dye penetrants?

A (Witness Anderson) Or an impurity. I'm not sure what you mean.

Q Well, tell me what your basis is for the statement that calcium sulfide is often present in diesel oil lubricants and dye penetrants.

A Well, talking to the manufacturer of dye penetrants, they said that there would be calcium present. It was not purposefully added -- that it hopefully wasn't in the sulfide form; it may be as an oxide form. But they would expect its presence.

In oils, lubricants, it can have -- it can be added purposely or it can be accidentally.

Q Is it calcium sulfide that you are saying?

A No. If it is added on purpose, it is not calcium

WRBbrb

sulfide.

Q Well, then, am I correct that you are not saying in your testimony that calcium sulfide is often present in diesel oil, lubricants and dye penetrants?

A Well, no. There are calcium compounds and sulfur compounds, and that can be a result.

But I am not saying that -- no. I'm definitely not saying that calcium sulfide is added on purpose to lubricants.

Q Are you saying that calcium sulfide is often present, for whatever reason, in diesel oil, lubricants and dye penetrants?

A Well, the thrust of this question was that there was a relationship between the calcium and the sulfur that was observed. Not all areas were analyzed, but the areas that were were, where calcium was present sulfur was present; and therefore I was looking for an explanation which could explain a calcium sulfide. That explanation could be from oils; and it could have calcium sulfide present, yes.

Q Well, can you tell me how the calcium sulfide comes to be present in diesel oil, lubricants and dye penetrants?

A Well, I think I've explained the dye penetrant: in talking to the manufacturers. They say it's as an

WRBbrb

impurity, as something that gets in without purpose.

Q But I thought you said it wouldn't be calcium sulfide.

A In the dye penetrant, calcium compounds are expected. They try to limit sulfur. The dye penetrant manufacturers felt that there could be calcium sulfide as an impurity, or calcium in other forms.

Now, with petroleum products there's both calcium and sulfur present.

WITNESS BUSH: Could I make a comment here?

I will defer to someone else with regard to the lubricants, but with regard to the penetrants, at least for nuclear applications -- and there's no reason to change from one penetrant to another because you tend to use it throughout the plant -- there's a very rigorous control on both sulfur and chloride, sulfide ions and chloride ions, for the simple reason that both of them are very, very bad with regard to certain materials, particularly the stainless steels.

And so I won't say Yea or Nay with regard to the presence of calcium, but I would certainly be extremely surprised if anything were used with the penetrants that had perceptible levels of either sulfur -- or sulfide ions, more specifically, or chloride ions. That is very, very definitely prohibited.

WRBbrb

WITNESS ANDERSON: I agree. The dye penetrant people say they try and limit, to the best of their ability, the amount of sulfur that's present.

BY MR. ELLIS:

Q Dr. Rau, do you agree that calcium sulfide is often present in diesel oil, lubricants and dye penetrants, sir?

A (Witness Rau) Do I agree "is present"?

Q Yes.

A No, I don't agree. I agree with what Dr. Bush and Dr. Anderson has just said -- that is, that there are very strong specification limits on the allowable impurities for dye penetrants for nuclear application.

We're talking levels below 20 parts per million as an upper bound on the total of all impurities: sodium, calcium, everything together. I mean, really small numbers compared to, recall, calcium levels which we measured on the fracture surfaces of 30,000 parts per million calcium. So I agree there might be some there, but it's trivial in the penetrants.

With regard to the oils, nobody in their right mind would add calcium sulfide to an oil. There are, in fact, calcium additions to the oils, and sulfur may develop as an impurity in the oil through usage. But it's certainly not added as calcium sulfide.

WRBbrb

And, again, the levels of calcium which are added to the oils are nowhere near the 30,000 ppm measured on the fracture surfaces; they're in the range of 1000 to 1500 ppm calcium.

And I think, as we testified previously, I can envision no concentrating mechanism whereby you could increase from the levels of calcium, for example, that might be in the oil up to the levels which were measured on the cracks, during operation. And therefore I have concluded that that high level of calcium which is present on the cam gallery cracks was introduced during the fabrication, either from the casting and/or the weld repair process.

Q Would you agree with that statement by Dr. Rau, Dr. Bush?

A (Witness Bush) Well, quite frankly, I have always considered that the weld repair process is the most logical one because, even though I don't have the details, the most common technique for making such repairs with this particular electrod -- it uses a coated electrode, and the standard material is usually a calcium compound of one form or another.

And normally when you lay this down, certainly the first bead, there's nothing you can do about the coating that is below. So that, by definition, is exposed to the crack surface. You tend to try to brush off, or remove, as

WRBbrb

you lay down bead after bead thereafter; but, again, it is not a 100 percent process, so there is inevitably a movement downward into an open crack surface of the flux material that you're using.

I have to infer this because, again, I have no specific details. But I do know that the, what I would call one of the more common methods of welding, weld repair, with the 50-50 iron nickels, uses coated electrodes and is conventionally used for such repair.

Q But in any event, Dr. Bush, you would disagree, I take it, with Dr. Anderson's conclusion that the calcium detected resulted from exposure of the crack surfaces to calcium sulfide which is often present in diesel oil, lubricants and dye penetrants?

MR. DYNNER: Objection. That mischaracterizes the testimony.

MR. ELLIS: Let me restate it and see if I can satisfy Mr. Dynner's --

JUDGE BRENNER: I guess if there was any gross mischaracterization, I missed that, frankly, Mr. Dynner.

If you want to restate it, you can do it. Otherwise, I'll overrule the objection.

MR. ELLIS: I'll stick with the question.

WITNESS BUSH: I don't know that much about lubricating oils. I would infer that the levels were quite

WRBbrb

low and, quite frankly, I don't see a possible concentrating mechanism.

I confess I usually try to take the simpler one, and if I have a source that I can leave in that clearly can account for thousands of parts per million, then I would tend to accept this rather than have to go through a very complicated mechanism of concentration.

So the answer is that I wouldn't espouse the lubricating oil as the source. I would look elsewhere.

BY MR. ELLIS:

Q Dr. Anderson, do you have any further comment?

A (Witness Anderson) Well, I think I should clarify the fact that the probability of there being a sulfide is based upon the analysis that I saw. It may not be a sulfide. But the examination -- the ratios appear very likely that it is.

But in any respect, there are several operating mechanisms for calcium, and I see no problem in its presence being generated by those, and therefore I don't believe that that is an adequate basis to determine that the crack has not grown. I feel the adequate basis, again, is the testing of the surface in the manner that we've previously discussed.

Q Dr. Anderson --

JUDGE BRENNER: Dr. Anderson -- I'm sorry, Mr.

WRBbrb

Ellis -- what about Dr. Bush's inference that one likely source of the calcium is the welding process?

WITNESS ANDERSON: The fluxes that are normally used are sort of clays and salts, mixtures of salts for greater ionization and clays for thermal stability, which ends up in a glass-like material. I have no problems believing that there is calcium present in those materials.

When I saw the procedures, the weld procedures, being done on a head, I did not see that they were using coated rods; but I do not rule that out as having occurred at an earlier time when these blocks were made. So that is a possibility. I cannot rule it out.

JUDGE BRENNER: All right. Maybe I lost you somewhere.

Is it correct that even if they were not using coated rods that you're saying that calcium could reasonably be present in the flux material?

WITNESS ANDERSON: No. They have to use coated rods.

JUDGE BRENNER: Okay.

BY MR. ELLIS:

Q Dr. Wachob, did you have a comment on this?

A (Witness Wachob) Yes. The heads themselves are steel, so therefore the rods that they would use and the welding procedures might be significantly different than

WRBbrb

that that were used on the block.

Q Dr. Anderson, what concentrating mechanism did you --

JUDGE BRENNER: I'm sorry, Mr. Ellis.

Dr. Anderson is probably not a very good poker player; he's shaking his head "No" in response to Dr. Wachob's last statement. So I'm going to give him an opportunity to say something.

WITNESS ANDERSON: Dr. Wachob said that they were steel. The ones I saw that were bead cast definitely were cast iron. Maybe they have changed it since then.

WITNESS BUSH: I think we have semantic problem as to what is a head.

I believe you were talking about the cylinder heads, were you not --

WITNESS WACHOB: Yes.

WITNESS BUSH: -- as contrasted to the head of the block?

I've certainly understood, from everything I've seen, that these were a cast steel material.

JUDGE BRENNER: Dr. Anderson, what are you talking about?

WITNESS ANDERSON: I was talking about the heads that are bolted on the top of these blocks.

WITNESS WACHOB: I have examined,

WRBbrb

metallographically, the block cylinder heads, and the cylinder heads are cast steel.

BY MR. ELLIS:

Q Dr. Anderson, given the assumption -- let's assume they're cast steel. Does that change you view with respect to a source of calcium?

A (Witness Anderson) No. I continue to say that if there was a coating on the rod, then that would be a source of calcium.

JUDGE BRENNER: I think the question that Mr. Ellis meant to ask is: If you assume it was cast steel, would that account for the fact that in that process an uncoated weld rod would tend to be used, as opposed to a welding process for cast iron -- if you know?

WITNESS ANDERSON: I don't think I can say. I just didn't see their process with anything other than cast iron.

BY MR. ELLIS:

Q Dr. Anderson, what concentrating mechanism did you envision in your testimony concerning the calcium and calcium sulfide?

A (Witness Anderson) I don't think I need one. You're talking about concentrations that exist in a liquid volume, and then you're trying to apply it to a surface. And so what we are seeing is we have just destroyed two

WRBbrb

dimensions -- or one dimension of the volume.

So if you have some porosity in your coating, if you have some oil uptake, if you have blanked out that your cutting solvents had no calcium in them so that you're sure that that wasn't an artifact contamination, then the fact that they're there would certainly give you the type of values that you would see.

WRBeb

Q Dr. Rau, do you agree that a concentrating mechanism is not necessary?

A (Witness Rau) I strongly disagree, and I don't understand what Dr. Anderson just said.

If oil is on the crack and on the surfaces, then the concentration of calcium is the concentration which is in the oil, and -- to the extent that crack is opened.

If it is closed, then nothing happens. It is just that that is the concentration. If it is open then the oil goes in and out and it is constantly flushed with whatever level of calcium is in the oil. And to get from, you know, to the order of 1,000 ppm in the oil up to 30,000 on the surface, you've got to have a concentrating mechanism. It just doesn't magically appear.

Q Dr. Anderson, did you want to respond?

A Witness Anderson) Well, parts per million volume or parts per million in an area are different. I am not aware that this crack is working as a pump that is -- maybe it is -- that is essentially pulling oil in and squishing it back out.

I would imagine that's an unusual model. That would certainly indicate that there is some severe motion there. I would think it would be more likely that we have a very stagnant oil existing in there.

Q Dr. Anderson, I'm not sure I understood from your

WRBeb

answer, though, why you disagree with Dr. Rau's statement that a concentrating mechanism is needed in order to get the concentration of calcium up from the values in the oil to the values that were found.

A The values that you have given for the oil are in the volume. It would be equivalent to saying we release something in this room and we tell what the concentration is in the volume in the room.

When it is a stagnant film on the surface and we no longer have the dimension or the volume that we essentially absorb into my layer, my dark layer, the components that are in that volume of oil, then we have changed it. We have put what was in a volume into a surface. And I guess in effect that's a concentration.

I believe that Failure Analysis mentioned the tremendous ability of carbon to absorb materials. I would expect that any carbon in this dark film would tend to absorb the materials that are in the oil. And we are just essentially extracting it from the volume.

You see, we've gone from some volume to put it all onto a surface.

Q Dr. Rau, do you have any additional comment, focusing specifically on Dr. Anderson's point that you go from a volume to a surface, whether that makes any difference?

WRBeb

A (Witness Rau) Well, again from a first-principles, theoretical point of view, sure, you can get some additional concentration, you know, if something settles out of the liquid and ends up on the surface, but not at the levels we're talking about.

And of course to the extent that oil is sucked in by holes in the cast iron or sucked down into the graphite flakes, that's a volumetric effect. And it is not just a surface layer. There is a surface layer of the oxide and that's a tight crack.

What we're talking about, if in fact there is any concentration, and I don't believe there is, but if there were any, we're talking about perhaps a factor of two, and we need a factor of 300 concentration mechanism. In my opinion there isn't any. There isn't any mechanism for it to happen.

Q The last time, the last round. Dr. Bush, do you have anything you want to add to the subject?

A (Witness Bush) Well, I would visualize that you would have to have a chemical absorption mechanism in order for this to occur, in order to get a concentration. You would have to get a very substantial concentration. Otherwise you will have a finite amount of oil there, and presumably in a limited volume.

So unless you can selectively remove it and

WRBeb

replace it, I don't see how you can get the buildup. I guess that's my problem with this mechanism.

Q So am I correct that in light of this discussion, it is still your view that the calcium, the presence of calcium is more consistent with a pre-operational origin than a post-operational origin?

A That's my feeling, yes.

Q Dr. Anderson, did you want to say anything further on this subject?

A (Witness Anderson) Only my contention that there are other sources, and I think it should be tested.

MR. ELLIS: Judge Brenner, that completes our questioning.

JUDGE BRENNER: On that last point, Dr. Anderson, I'm not clear on what would be tested.

WITNESS ANDERSON: Well, what we want to do really, the bottom line is to see if the crack is as it was at the time of fabrication or if there has been any extension, so it's the x-ray analysis to see what is on the surface, characterize it, and then definitively we all know and can agree.

JUDGE BRENNER: All right. It's different than your immediate point about calcium?

WITNESS ANDERSON: I think the only reason that I bring up calcium is that it was used as the foundation -- as

WRBeb

one of the foundations of saying that this was a fabrication crack. And if that was truly the only way that calcium could have been produced was by this welding repair, I would accept it. But I see other mechanisms.

JUDGE BRENNER: All right.

I asked because you mentioned testing in the context of these questions about calcium. You are not suggesting that some tests for calcium would prove anything?

WITNESS ANDERSON: I think calcium has no value. I think we want to test the layer.

MR. ELLIS: Judge Brenner, I have the exhibits that I wish to move into evidence at this time, if I may.

I wish to move into evidence LILCO Exhibit B-61 and B-62, which were schematics or drawings prepared by Dr. Rau and which he referred to in his testimony at some length. We would like to move those two into evidence. I am going to take them one at a time unless you want to--

JUDGE BRENNER: Take them all together.

MR. ELLIS: All right, sir.

The next is LILCO Exhibit B-64, which are two photographs -- 63, I'm sorry, which are three photogrpahs -- two photographs, I'm sorry, and LILCO Exhibit B-64, which will be a single photograph.

In addition we would move into evidence LILCO Exhibit B-60, which is a graph entitled "Preliminary Cam

WRBeb

Gallery Strain Gage Data," as to which there was substantial testimony.

JUDGE BRENNER: You are not going to get B-60 into evidence, so let's save the argument on that one.

MR. ELLIS: All right, sir.

JUDGE BRENNER: What about the others?

MR. DYNNER: I have a technical objection to B-61 and B-62, arising from the fact that I have not yet had an opportunity to cross-examine Dr. Rau on these two items and I would like to do so to establish some facts about them.

I have no objection to introducing into evidence the two photographs represented in LILCO's Exhibit B-63.

JUDGE BRENNER: I'm not sure I fully understand, Mr. Dynner, but I think it would be most efficient just to hold off on admitting B-61 and B-62, and we'll see what happens. I guess I can draw the inference that you think you might establish something that would provide a basis to strike them from evidence. And rather than go through that-- Maybe I'm reading too much into it. We will wait if that's your preference.

What about B-63 and B-64 as far as the Staff is concerned?

MR. PERLIS: The Staff has no objection to B-63 or B-64.

JUDGE BRENNER: All right.

WRBeb

Our ruling is that LILCO Exhibit B-60, to the extent there was an offer to move it into evidence, that is denied. So that is rejected on terms of moving it into evidence. I don't think I have to go through all the reasons.

You're nodding Yes, so I won't.

MR. ELLIS: Yes, sir. There are the same reasons you have given when it was offered before.

JUDGE BRENNER: Yes, when the testimony on the subject was offered and beyond that, it is including preliminary, and so on. We are going to come back to the whole subject. But it is an exhibit for identification; it was used in cross-examination.

(Whereupon, LILCO Exhibit B-60, having been previously marked for identification, was rejected.)

JUDGE BRENNER: Exhibits B-63 and B-64 are admitted into evidence.

(Whereupon, LILCO Exhibits B-63 and B-64, having been previously marked for identification, were received in evidence.)

JUDGE BRENNER: And we will hold off any ruling

WRBeb

on B-61 and B-62. But you will have to go back and renew the motion.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: We will take our morning recess at this time.

Could the County give me a time estimate on its questions of this panel?

MR. DYNNER: Two hours, Judge.

JUDGE BRENNER: The Staff? Can you give me a time estimate?

MR. PERLIS: Most of my questions have already been asked. I would anticipate maybe 10 or 15 minutes.

JUDGE BRENNER: Okay.

Let's come back at 10:55.

(Recess.)

AGBagb

JUDGE BRENNER: All right. We're back on the record. I can give you one of the two missing details as to the schedule for the conference of parties on Tuesday: We will start at 8:30 in the morning.

And the only uncertainty is the location, the particular location, but as I said it will definitely be in Bethesda. It is going to be in one of two places, it will either be in the NRC hearing room which you are all familiar with or it may be in a large conference room in the Maryland National Bank Building, it depends on whether a presently scheduled hearing for the hearing room stays with its schedule or not. And the parties will be advised by the Board secretary on either late-Friday or Monday as to the particular location.

MR. ELLIS: Judge Brenner, I have the temporary LILCO Exhibit B-64, if I may hand that to the Board and to the Reporter.

JUDGE BRENNER: All right. As we have discussed these are the Xerox copies and, similar to the procedure on B-63, they will be replaced with original photos.

(Documents distributed)

JUDGE BRENNER: Mr. Dynner?

EXAMINATION

BY MR. DYNNER:

Q Doctors Rau and Wachob -- I guess, Dr. Rau, you

AGBagb

can handle these, I've got some questions for you about LILCO's Exhibit B-61 and B-62.

Is it true, Dr. Rau, that these are representation schematic drawings made by you and are not drawn to scale?

A (Witness Rau) They are schematics and I made no attempt to check precisely the scale. The relative dimensions of cracks and wall thicknesses and fuel pump mounting bracket are intended to be approximately representative but they are not precisely to scale.

Q And am I correct that these drawings don't represent any pariticular crack?

A Well again they are intended to be representative of the cracks in original 103 block cam gallery saddle number 7 and in fact are based upon my examination of that particular cam gallery saddle as well as for number 6.

Q You're talking about Exhibit B-61 now?

A Yes, sir.

Q So generally representative of cracks that you personally saw in the saddles 6 and 7 on the old 103 block would be represented by B-61, is that correct?

A Yes. I don't mean to imply that each and every one looked exactly like this one but it certainly is very representative of some of them and generally representative of all of them.

AGBagb

Q And the labels on here, am I correct that these are your own words and characterizations of what the drawings show?

A I don't know what you mean by "drawings." What drawings?

Q On B-61 you've got three drawings, correct?

A Yes, three sketches.

Q And on those sketches, each of those sketches you have lables, if you will. For example, on the firs one at the top it says casting shrinkage cracks paretheses thick oxide close parentheses and I'm correct, aren't I, that that label and the other labels on these sketches represent your characterizations of what those sketches represent in those areas, correct?

A Yes.

Q And on LILCO Exhibit B-62, am I also correct that those three sketches are representative of cracks and are not an attempt to depict any particular crack, is that right?

A In LILCO 62 they are not intended to depict any particular one of the cam galleries on 101 or 102 but generally to be consistent with the non-destructive inspection and visual examinations made of those two.

Q And those are, in your view, consistent with what you saw in your personal observations of cam gallery cracks

AGBagb

on the EDG 101 and 102 blocks, is that correct?

A The schematic in B-62 is representative of the largest of the TSI depth gauge indications on the original -- excuse me, on the 101. It is not intended to be representative of all of the cam galleries because, as I have indicated, the reported crack depths from the TSI depth gauge are not nearly that large on most of them. There is only one which is larger than .1.

Q Does it represent what you personally saw on the -- observed as to the cam gallery cracks on EDG 101?

A Again only to the extent I have indicated. It is intended to be schematically representative of the largest depth of crack that was reported in 101, not all of the indications in 101.

Q Is it also supposed to represent what you personally saw on the cam gallery cracks of EDGs 102 block?

A I believe it is representative of what is in the 102. I do not have the TSI depth gauge measurements on 102 and I did not visually or with non-destructive inspection techniques personally examine all of the cam galleries in 102, I examined only some of them. But it is consistent with the observations with regard to location of the weld shrinkage crack that I did observe on 102.

Q And it's true, isn't it, that in fact there have been no TSI depth gauge measurements of the cam galleries on

AGBagb

EDG 102, have there?

A I'm not aware of any if they have been done.

Q Dr. Wachob, do you know of any that have been done on 102?

A (Witness Wachob) I agree with Dr. Rau, I am not aware of any.

Q And I'm correct, aren't I, that in the schematic sketches on LILCO B-62 that you have no way of knowing from direct evidence as to whether or not the cracks that are depicted in the sketch at the top of the page actually were completely ground out, isn't that right?

A (Witness Rau) I'm sorry, would you repeat that again?

Q Yes.

I am correct, aren't I, that you have no way of knowing that the cracks which are depicted in the first sketch were actually completely ground out prior to the weld, isn't that right?

A I have no firsthand destructive examination to indicate that any casting shrinkage cracks that might have been there were ground out. I have indicated that it is my opinion based on the fact that there are repair welds, the general size of the repair weld, the TSI depth gauge measurements on 101, that it is my opinion that the cracks would be ground out.

AGBagb

It is also my opinion that the cracks would be substantially, very substantially shallower in both 101 and 102 given my opinion that the shrinkage stresses would be comparable due to comparable molds but that the mechanical strength, in particular, the fracture strain would be of the order of a factor of three reduced in the original 103 and I would therefore expect substantially shallower shrinkage cracks and given the size of the repair weld, it is my opinion that they were in fact ground out.

Q How did you measure, if you did, the depth of the weld material in the 101 and 102 blocks?

A As I indicated yesterday, I made no measurement of the depth. I observed the width as you stand at the side of the engine and examine the repair weld from the side and indicated that the width of the welds in 101 and 102 were comparable to but slightly smaller than the width of the repair welds in the original 103. And from our destructive examination of the repair welds in the original 103 I inferred that the depth would be scaled down, if you like, in approximate proportion to the width and therefore that the approximate repair weld depths would be somewhat shallower than they were on the original 103.

Q Well the three blocks, that is, 101, 102 and the original 103 block were all cast within about a month of each other, weren't they?

AGBagb

A Yes, sir.

Q And the what you infer to be the grinding out of the cracks in the 101 and 102 blocks would have been a correct procedure for welding, wouldn't it, as opposed to a partial grinding out of the cracks?

A Well correct procedure would depend upon what the specifications are of the people making the repair welds. Different manufacturers have different kinds of procedures, they may have different procedures for structural repair welds compared to cosmetic repair welds. And I don't know what TDI's repair weld procedures were; as I testified, I asked and they were not made available to us.

Q I think you are going a little bit beyond the question I am trying to get at. It would be a more correct procedure to completely grind out the cracks before you weld than to only partially grind them out, isn't that right?

A Again that depends on the purpose. If you are making a repair weld for structural purposes, I would certainly agree. If I were personally doing it or recommending it, I would recommend complete removal.

Q How about if you were doing it for cosmetic purposes --

MR. ELLIS: I don't think he was done.

MR. DYNNER: Oh, I'm sorry.

WITNESS RAU: But again, you have to keep in

AGBagb

mind the purpose. If the purpose is cosmetic, then I suppose the manufacturer could have a different criterion and he may or may not do that.

Q Do you have any basis for believing that the purpose of grinding out the cracks in 101 and 102 was structural but that the purpose for grinding out the cracks in the original 103 block was cosmetic?

A I have no basis other than what TDI has told me for why the repair welds were made on any of the three blocks, 101, 102 or original 103. I was told they were done for cosmetic purposes, now whether that is in fact the case, I don't know, I only know what they told me.

Q Why have you made the assumption that within approximately a month of each other or perhaps a little more, we don't know, why have you made the assumption that TDI ground out all of the cracks on 101 and 102 but did not grind out all of the hot tear cracks on 103?

A Well again it is not an assumption, that's my opinion. And it is my opinion because the casting shrinkage cracks in 101 and 102 were very substantially shallower and the grinding process was in fact able to remove the cracks.

It wasn't so much in my opinion that TDI set out necessarily to do things differently on any one of the three but in point of fact they were not able by their normal gouging procedure to get the cracks out because of their

AGBagb

depth in the original 103 and so they stopped and just covered it over. Whereas in 101 and 102 they were in fact able to get these much shallower indications out by the repair procedures they were utilizing.

Q Now what's your basis for your opinion that TDI was not able to grind out all of the cracks in the original 103 cam gallery area? How do you know that?

A I believe we spent two days talking about that on the cam gallery and I don't know how much the Court would like me to go into it again. We have been through the extensive evidence for why I believe the casting shrinkage cracks were formed during the casting process --

Q That's not my question.

A -- what size they were.

I'm sorry, it's not your question?

Q No. My question is how do you know that TDI was unable to completely grind out the hot tears in the original 103 cam gallery area?

MR. ELLIS: I object to the interruption because I think that was his question he was giving the answer.

JUDGE BRENNER: All right. I think that may turn out to be the case but Mr. Dynner is entitled to try and get the answer one way or the other in the terms in which he asked the question.

I think -- Let me try this, Mr. Dynner, and I

AGBagb

hope I do not interrupt what you were trying to accomplish.

I think what Mr. Dynner means, Dr. Rau, is do you have any direct knowledge that they could not accomplish that or are you basing your opinion only on your views based on the examination of the cracks that you have discussed here extensively already?

WITNESS RAU: Some of both, your Honor. Certainly it is heavily based on my direct physical observations. It is also based upon the representations made to me by TDI representatives who indicated that they were in fact cosmetic in their opinion.

And given that they made that statement there would have been -- if they truly were being done for cosmetic purposes, there would have been no requirement or objective necessarily to remove the entirety of the casting shrinkage crack.

So to the extent that I knew and was told that, for both of those reasons I don't believe that their normal grinding on the surface removed the entirety of the crack.

If Mr. Dynner's question was could they have, surely they could have ground deeper and eventually have gotten the entirety of the indication out. What operational difficulties -- and, quite frankly, replacing the weld without introducing additional weld shrinkage cracks -- would have caused them, given their weld procedures, I

AGBagb

don't know but they made a judgment that they didn't want to go any deeper than they did, I believe.

BY MR. DYNNER:

Q Now Dr. Rau, I would like you to tell me whether -- specifically did someone at Delaval tell you that Delaval made no attempt to completely grind out the cam gallery hot tear cracks in EDG 103's original block?

A (Witness Rau) No direct statement like that was made. There was a direct statement made that they made no repair welds on the original 103 block for structural purposes, that any repair welds that were made were made for cosmetic purposes, that was their representation to me.

JUDGE BRENNER: Dr. Rau, I never understood this "cosmetic" label as applied to this context. And I know you're not the person or a member of the entity that made the statement to you, but can you tell me in your professional endeavors whether this makes sense to you? After all, we're not talking about something that is on display in somebody's living room, it is a cam gallery, I mean who cares cosmetically in the sense of....

WITNESS RAU: Okay. Let me attempt to answer that, your Honor.

In my experience procurers of large castings, like procurers of any piece of machinery, are affected by appearance. And quite frankly a procurer who sees tears,

AGBagb

cracks, anything which doesn't look nice on the surface may in fact tell the manufacturer to put it back on the truck and take it home again.

So quite frankly it is not at all uncommon for a manufacturer to make cosmetic repairs strictly to avoid nuisance, let's say, interactions with the client or the purchaser and he may or may not have sufficient foundation to have made the decision that it is cosmetic versus structural.

But in point of fact they do make decisions I know of where they have evaluated -- I'm not talking about TDI -- but in general manufacturers do make decisions to make certain cosmetic improvements even though they believe they are completely unnecessary.

JUDGE BRENNER: All right. Now that I understand what you mean by "cosmetic," one could use other words to describe that process also. In other words, it's not -- all right, I'll just stop there.

Didn't they -- Now this area was also painted, correct?

WITNESS RAU: Yes, sir.

JUDGE BRENNER: Now am I -- You may not be able to answer this but would the what you believe were the original casting shrinkage cracks have been visible on a painted surface if they had not been ground out?

AGBagb

WITNESS RAU: I can't be 100 percent sure but in my opinion they probably would be.

JUDGE BRENNER: We're talking about the original 103 block.

WITNESS RAU: Original 103, yes, with the deep one.

I believe they probably would be. I don't know how obvious they would be but I think they probably were visible, otherwise there would be no reason to make a cosmetic repair.

BY MR. DYNNER:

Q Dr. Bush, in your judgment would it have been appropriate in making a cosmetic repair to the block for TDI to fail to grind out all of the cracks in the 103 block before the welding was done?

A (Witness Bush) I am not a believer in cosmetic repairs. My personal opinion -- and I can cite several instances and sources are pretty clear about the fact that every effort should be made to completely remove any cracks prior to any welding operation.

I have before me one such source that was established by, I think, a committee with adequate credentials and they clearly indicate it is virtually essentially to do so.

For example, here are the critical words:

AGBagb

"Attempting to weld over a defect instead of removing it completely usually results in poor weld quality."

That's the reason I don't like that possibility.

Q So am I correct, Dr. Bush, that you don't have any direct knowledge as to whether or not TDI completely ground out the cracks in the engine blocks, 101, 102 or 103, before they put in the weld, is that right?

A 101 and 102 I have no direct knowledge. On 103, my opinion is based on the photomicrography that it was not completely removed. And that's based on characteristics there and the depth of the crack. I have no way whatsoever of establishing the case on 101 or 102 as to whether the material was completely removed.

Q Dr. Rau, looking for a moment at Exhibit B-62, I would just like to ask you the same question I did about B-61, and that is:

Am I correct that the labels and words that appear on there are your own characterizations as to what is represented by the sketches?

A (Witness Rau) Yes.

MR. DYNNER: Judge, given those explanations, I will have no objection to Mr. Ellis' motion to introduce B-61 and B-62 into evidence.

JUDGE BRENNER: Staff?

AGBagb

MR. PERLIS: Staff has no objections.

JUDGE BRENNER: All right.

We can do that and we will admit LILCO Exhibit B-61 and B-62 into evidence. I will give you my opinion for what it's worth, and it doesn't matter here although we have had the discussion elsewhere so I will state it again:

I don't think it is going to matter one iota in terms of this record whether these two sketches had remained for identification or in evidence because their only evidentiary value is to permit a finder of fact to better follow the transcript.

I don't want to minimize their helpfulness in that regard, they are very helpful for that purpose but they do not supply any substantive facts independently of what was testified to on the record by Dr. Rau and others. Nevertheless in the absence of objection we will admit them into evidence.

(Whereupon, the documents previously marked for identification as LILCO Exhibits B-61 and B-62 were received in evidence.)

JUDGE BRENNER: Could I ask another question?

MR. DYNNER: Certainly.

JUDGE BRENNER: Dr. Rau, did the TDI personnel who you said supplied you with the information you stated

AGBagb

use the word "cosmetic" in terms of describing their purpose or is that your word?

WITNESS RAU: That's their word.

JUDGE BRENNER: Can you tell me who particularly?

WITNESS RAU: I don't recall which one, I can tell you who was in the room when it was said.

JUDGE BRENNER: Is it going to be a long list?

WITNESS RAU: It may not even be complete but my recollection is that Mr. Matthews was there, Consultant Wallace, I think Mr. Beshouri was there.....

JUDGE BRENNER: What was the last name?

WITNESS RAU: Beshouri, Craig Beshouri, and maybe Mr. Lowery, I'm not sure about Lowery.

JUDGE BRENNER: This was a particular meeting that you recall?

WITNESS RAU: Yes, sir.

JUDGE BRENNER: Do you know when it was roughly, or exactly?

WITNESS RAU: It was at our offices this summer, probably after June, so July-August, something like that.

Wait a second, that can't be right because we didn't know about weld repairs until the end of August so it had to be soon after we discovered the weld repairs at the end of August so it would have been very soon thereafter, probably the last week in August, first week of September.

AGBagb

BY MR. DYNNER:

Q Dr. Bush, in your written testimony, your supplemental testimony, you referred to Section 3 of the ASME code and, while pointing out that it wasn't directly applicable to emergency diesel generators, you mentioned the fact that under that code the crack-like defects would be required to be removed.

A (Witness Bush) That's correct.

Q Given your analogy or reference to the ASME code in that respect, may I ask whether you would recommend that in the EDGs at Shoreham that these cracks in the cam gallery area should first be removed before the EDGs go into operation?

A No, I think my testimony indicates that whereas by and large I do not care for such cracks that if appropriate instrumentation is used in the case of the 101 and 102 cam galleries that this would be considered acceptable.

Q Well what --

A (Witness Rau) Can I add something to that point or are you --

Q Well I would just like to follow up with Dr. Bush a moment, Dr. Rau, and then I would be glad to hear from you.

Dr. Bush, wouldn't it give you a higher level of

AGBagb

confidence and wouldn't it be more conservative in this case to actually remove the cracks, find out what's there and then, if appropriate, weld them shut properly or repair them properly before they go into operation?

A (Witness Bush) Not necessarily. In fact, sometimes repeated weld repair degrades the material more than the presence of a crack.

I did not cite Section 11 because of the nature of it but in fact we have an operating code that explicitly permits the continued existence of flaws, not cracks, in pressure boundary components of nuclear systems provided they have been adequately evaluated and this is accepted by the NRC. So you have to look at each one on a case-by-case basis.

Q Is it your opinion that removal of the weld material in order to establish whether or not there are cracks underneath the welds on 101 and 102 would be injurious to the blocks?

A It conceivably could be, that's correct.

Q Would it necessarily be?

A No.

Q And if it were done properly and you found that there indeed were cracks below then that would give you an opportunity to properly grind out those cracks and properly repair them, wouldn't it?

AGBagb

MR. ELLIS: Objection, form of the question. It assume that -- if I make my objection too explicit, Judge, I may tell the witness --

JUDGE BRENNER: I'm going to overrule it partly for that reason.

WITNESS BUSH: I had thought I had answered this question. Perhaps you had better state it again so I can see if I am answering something different.

MR. DYNNER: Sure. It is a hypothetical.

BY MR. DYNNER:

Q If you remove the weld material in the cracks of 101 and 102 blocks and you found that there were indeed cracks underneath the weld material, that would give you an opportunity to grind out those and properly repair them, wouldn't it?

A (Witness Bush) Obviously the answer is hypothetically yes. If you happen to do an ideal weld preparation or pre-weld preparation and did indeed remove all of the crack and you also did the welding process under an idealized condition, it is possible, if truly idealized that you would have a less degraded situation than you do now.

Q When you say "truly idealized" do you mean --

A I mean "truly idealized." I mean that I would have to adequately control the level of preheat, I would

AGBagb

want -- I would require postheat on it, I would require welder certification, I would want the characteristics of the weld operation, I would want -- I would probably require peening on each bead, things of that nature. There are about six or eight or ten steps that one would have to go through on there and in a limited access area I would not characterize this as being simple.

JUDGE BRENNER: Mr. Dynner, I think you have moved beyond the point where Dr. Rau had wanted to comment.

MR. DYNNER: Yes. I'm sorry, I was about to move on and suggest if Dr. Rau wishes to comment --

JUDGE BRENNER: I want to get Dr. Anderson's view of your questions of Dr. Bush, too, after Dr. Rau.

MR. DYNNER: Yes, sir.

WITNESS RAU: Well the first point I wanted to make I think Dr. Bush commented upon, and that is that ASME Section 3 for those components which is applicable is a design code. When flaws or cracks are detected in service it is in fact Section 11 which requires an evaluation -- and/or the removal, but you don't have to remove it, it allows an evaluation and then continued operation so long as those periodic inspections or other means indicate that the cracks will not extend to unacceptable size. So it's not necessary that the ASME code that would apply to nuclear components requires removal of flaws.

AGBagb

With regard to the latter area you moved into, that is, would it be more conservative to grind out repair welds in 101 and 102, I would agree completely with Dr. Bush that it is not necessarily more conservative to do so. The analyses and measurements are clearly indicative that the indications are not going to extend in that area, they would not extend even if they were as deep as in the original 103, they would not extend even if the material properties were as bad as the original 103 and none of those conservative predicates are met.

But more important than that I also agree with Dr. Bush that if you grind out welds you are going to have a hole which is deeper than the original weld -- or you may have a hole which is deeper than the original weld and then when you fill it back up again if in fact you get any weld shrinkage cracks in the heat-affected zone, which it is entirely possible you might do, you could end up with crack indications that are even larger than those which you have attemped to remove.

In addition to that there are the substantial practical difficulties of considering such a repair given the requirements that would be necessary in an attempt to get a sound repair weld.

Dr. Bush has correctly indicated he would require extensive preheat over an extensive area, and in the

AGBagb

assembled engine this would require basically taking everything apart and it may even require, you know, taking the block away and turning it over on its side; it is a very very -- it is not a trivial operation by any means and there is no guarantees that unless tremendous care is taken that you will end up with a flaw-free repair weld in this area.

BY MR. DYNNER:

Q Just one follow-up, Dr. Rau:

You mentioned that there would be the possibility of winding up with weld shrinkage cracks even larger than you have now, was that what you said?

A (Witness Rau) Yes, sir.

Q Would you be concerned about that?

A No, but I see no point to introduce larger defects than you already have.

MR. DYNNER: I am moving on to another area, Judge.

JUDGE BRENNER: Dr. Anderson, would you recommend that as a remedy the welds in 101 and 102 cam galleries be ground out?

WITNESS ANDERSON: I think that's a possibility. I am not as afraid of welding as my colleagues are. I think that it can be done -- under controlled conditions can be done very, very nicely.

I still think there should be more analysis of

AGBagb

the old 103 before making a decision. For example, the 103 could give us the residual stress data that we require, the fracture surface could be analyzed by X-ray.

I think that if you have done the analysis completely as we have suggested then you would make that determination. And if the determination was to repair it, then it could be done economically.

AGBeb

JUDGE BRENNER: Would grinding out the welds and repairing them in the cam gallery areas be preferable to strain gaging the cam galleries on a continuous basis as recommended by Dr. Bush?

WITNESS ANDERSON: I guess I have problems with that. I don't want to say anything to undermine the recommendation about strain gaging but I think there has to be some preparatory work that are givens, and that is to finish the other things and test it with the strain gage on it, and then keep them on as continual instrumentation.

So I do recommend that, but you have to do some other things first.

BY MR. DYNNER:

Q Let me just follow up on that for a minute with you, Dr. Anderson.

As I recall, yesterday you were asked a question by Mr. Ellis about your view of the strain gaging and how it would affect your concerns. Aside from what you expressed concerning the advantages of monitoring the cam gallery cracks through strain gaging, would you have other concerns before you would want to see these blocks put into service?

MR. ELLIS: I object because it didn't properly characterize the opinion he gave yesterday, and I object. I think it is opening the door to change that, and I object

AGBeb

vigorously.

JUDGE BRENNER: I don't think he properly characterized it either, but I am going to allow the question because I think he is entitled to open the door, as you say. Let's see what he says today, and if it is different, that will play a part in our evaluation of the testimony also.

WITNESS ANDERSON: Okay. As I believe I said yesterday, the strain gaging I believe is valuable. I want ultrasonic profiling or I want appropriate -- TSI would be appropriate -- depth of cracks. But that of course comes after we've done all these other things that I've been elaborating on.

As I've said, I am unconvinced that 101 and 102 metallography has been done properly. I would like to have metallography in the cam gallery regions because there is nothing within several feet that has been examined there. That's non-destructive, because it could be done by transfers as was done on the block top.

I would like to have the residual stresses for old 103 examined in the cam gallery area. I think that is important and that will put to rest a significant concern.

And I would like to have the surface of the crack in the cam galleries of the old 103 examined by x-ray to determine whether it is a growing crack, progressive, or

AGBeb

whether it was an original crack that hasn't moved from the time that the fabrication occurred.

And then I would encourage the use of strain gaging as an operational control.

MR. DYNNER: Unless you have any follow-up, I am going to move on to a related area. I am going to distribute some very--

I'm sorry, Judge.

JUDGE MORRIS: Excuse me, Mr. Dynner.

I thought we had some testimony yesterday on the value of measuring residual stress in 103 as it might be applied to 101 and 102. Do any of the witnesses recall that?

WITNESS BUSH: I believe I made some comments that I would have some reservations because of the different morphology and the different levels of strength, as to whether one could extrapolate from 103 to 101 and 102, because I am presuming--

Well, the first assumption is that we indeed know the actual strength of 103, and by inference we know the strength of 101 and 102. If they are substantially different, I would anticipate that would have a substantial effect on the residual stress.

JUDGE MORRIS: Would the fact that 103 is also the degenerate Widmanstaetten graphite also affect--

AGBeb

WITNESS BUSH: That's basically-- That ties to the degraded mechanical properties. And I don't know how to extrapolate from that condition necessarily to the others on there.

Now if one could prove that similar conditions existed in 101 and 102, then the situation would be different. I don't think that has been proven, but I guess I would have to say it hasn't been unequivocally disproven either.

JUDGE MORRIS: Dr. Rau?

WITNESS RAU: Yes, Judge Morris, I had some comments yesterday on that same matter. And at that time what I said was that the presence of the deep -- much deeper cam gallery casting shrinkage cracks in the original 103 has already resulted in a substantial relaxation in whatever residual stresses, both tensile and compressive, that would have been there prior to the formation, and that any measurements now would be, in my opinion, of limited value because you would be only evaluating those very substantially relaxed residual stresses. And that would not provide any useful information with regard to residual stresses in 101 and 102 that would be there with much shallower cracks or no cracks.

JUDGE MORRIS: Dr. Anderson, do you want to respond?

AGBeb

WITNESS ANDERSON: If we did it, it would be the only information we have with respect to residual stresses, and I think that would be valuable.

JUDGE MORRIS: Thank you.

BY MR. DYNNER:

Q Just to follow up on Judge Morris' questions, Dr. Bush, it is true, isn't it, that in fact the strain gage testing that FaAA performed on the block top was done on the original 103 block which had the Widmanstaetten graphite on it, and that they then transferred the results of that strain gage testing to apply them to 101 and 102's block? Isn't that correct?

A (Witness Bush) Yes, but we're talking about two totally different things.

Q Well, what my confusion is, and perhaps you and Dr. Rau could clear it up, I thought that you expressed that there might be some difficulty in doing the strain gage residual stress analysis on the original 103 block and then using those results on 101 and 102 because 103 had Widmanstaetten graphite.

Was I correct on that?

A Working backward from the Widmanstaetten graphite to the very low mechanical properties on the thing, and let's assume even that it had not relaxed in the area or let's argue that there's a portion of the cam gallery where

AGBeb

there is no cracking but one could infer that there are substantial residual stresses because of changes in cross-sections and things of that nature, and let's put gages in and do either a drilling procedure or a chip-removal procedure to find it, neither of which probably is very accurate with gray irons, -- that's one of the problems -- one might be able to get some information in that respect.

But because of the fact that we have much lower ultimate tensile strengths, I don't think I could use that information to infer what the potential residual stresses would be in the 101 and the 102. That's my difficulty.

Q Dr. Rau,--

JUDGE BRENNER: Wait a minute.

MR. DYNNER: I'm sorry.

JUDGE BRENNER: I don't think-- Well, I'm not sure you asked the question but I think the question that Mr. Dynner meant to ask is why is it not similarly invalid when talking about the block top strain gaging on the old 103 and applying those results to the 101 and 102 blocks?

WITNESS BUSH: I think we're talking-- As I interpret what we're talking about on the top of the block insofar as strain gaging is concerned, we are talking about measuring to establish the initiation of the crack, so we're talking of measuring a load stress that exists either

AGBeb

because of the bolt-up or because of the operation there.

What one can do, we can now take a strain measurement, which is what it really is in this instance, and convert it to a stress at that localized area, and we can infer -- we can deliberately degrade the properties on the basis of that strain measurement because of the loads, and infer something with regard to the initiation of the crack.

That's what I visualize could be done in the one instance, and in fact that's basically what gets used in the Goodman diagram.

I think this other situation is the add-on factor in this particular area, and I don't know how to make the jump, in the case of residual stresses, from a material of grossly degraded properties to another one. That's my difficulty I guess.

JUDGE MORRIS: Well, isn't it true, Dr. Bush, that no measurements of residual stress were made on the block?

WITNESS BUSH: I know of absolutely no measurements of residual stress on any of the blocks.

BY MR. DYNNER:

Q Dr. Rau, I was going to ask you the same question.

MR. ELLIS: He asked-- I beg your pardon.

AGBeb

WITNESS RAU: I'm not sure that came across that clearly.

There are only two reasons why the degraded properties of the original 103 block would affect strain gage measurements, either to record live operational stresses or residual stresses. They are either the presence of a crack which might not be present in a better material, and the crack, obviously being present, would modify or relax any residual stresses and would similarly modify any operational stresses in ways which can be calculated.

The only other way in which there is any impact whatsoever of the differences in materials properties are if in fact there is yielding or plasticity in the metal. In other words, if all the strains or stresses are elastic, that is, loads put on and loads taken off, then the strain gage measurements are completely appropriate no matter where they are taken or whether they're taken in Widmanstaetten -- a degenerate Widmanstaetten structure or conventional gray cast iron.

If, however, the magnitude of the stresses exceeds the yield strength of the cast iron and if in fact the yield strength is significantly different between the degraded properties in 103 and the original or typical Class 40 gray iron properties, then you get different amounts of plasticity in the weaker material than in the other.

AGBeb

Now that would in fact modify the magnitude of residual stresses in a region like the cam gallery where the stresses and strains are very large. In the block top region, where the strains are elastic below the yield level even of the degenerate Widmanstaetten graphite structure, it is not going to have a substantial impact on the measurements one way or the other.

I should also indicate that even in the cam gallery, that fact alone, although it would complicate things, -- and Dr. Bush is quite right, it would make less precise any number you may have measured -- the strain, residual strains would not be markedly affected by the degenerate Widmanstaetten properties which modify the strength, but the corresponding stresses, to the extent they were in excess of the material's yield strength, could be modified by the presence of the degenerate properties.

So to make a long story short, on the block top where the strains are low, it is going to have no impact whatsoever except as the corrections for stress are required by the different elastic constants of typical gray iron, or degenerate, as we have done.

In the cam gallery area, there would be an effect on stresses, residual stresses, due to the differences in yielding if measurements were made on the degenerate Widmanstaetten structure versus a typical one, but the

AGBeb

strains would be close. They wouldn't be exactly the same. They would be close and you could therefore infer what the residual stresses were if in fact you had measured the strains.

JUDGE BRENNER: Dr. Rau, in light of what you just said, tell me again why it would be valid to take strain gage readings of the new 103 cam gallery area and apply those to draw conclusions about the situation with respect to the 101 and the 102 cam gallery regions.

JUDGE BRENNER: Yes, Judge Brenner, it's exactly the same reasons.

The live or the operational stresses measured in the cam gallery of the replacement 103 are elastic; in other words they are relatively low compared to the strains well in excess of yield. And basically I don't expect substantial differences in the strain-- Well, in fact the it's even-- Let me do it in two steps:

What I just said is true. In addition to that, the fact that the stresses are relatively low and elastic in the operational range, the materials properties of replacement 103 and the original 101 and 102 are different in strength but they are not significantly different in elastic modulus or stiffness.

So when you measure strain you have to go through the elastic modulus or stiffness to calculate stress. There

AGBeb

was a significant difference in the stiffness of the original 103 with the degenerate Widmanstaetten structure, but there is not a significant difference in the stiffness of 101 and 102 versus the stiffness of the replacement 103.

Could I-- I'm sorry.

JUDGE BRENNER: I'm sorry. Go ahead.

WITNESS RAU: For that reason, the stresses which are computed from the measured strains on the replacement are appropritae when calculated using the appropriate elastic modulus or stiffness for 101 and 102.

JUDGE BRENNER: One of the other reasons for a potential difference, though, that you discussed, although in the context of the old 103 block, was the difference in the cracks. And how about that in terms of applying information, the operational strain gage readings from the new 103 block?

WITNESS RAU: Yes, Judge Brenner.

JUDGE BRENNER: I know we've asked about that again, but I want to get it right here with your other statement.

WITNESS RAU: Surely.

The measurements in the replacement 103, which basically don't have any substantial depth cracks, those strains and the corresponding stresses are appropriate for an uncracked cam gallery. They would be appropriate for an

AGBeb

uncracked cam gallery whether that cam gallery were 101, 102 or replacement 103.

The presence of the repair weld shrinkage cracks in 101 and 102 will have an effect on the local distribution of stresses that results due to the presence of those weld shrinkage cracks in what would otherwise have been the strain or stress field measured in the replacement 103.

In other words, the measurement is appropriate as if there was no crack. When the crack is introduced you have to, by calculation, infer what the effect of the crack would be in the stresses and the strains which were measured to be there without the crack.

AGBagb

I hope I am making myself clear. It is a standard procedure to calculate the impact of the crack. I would certainly -- Maybe it would be clear this way:

If you put a strain gage on 101 and 102 immediately adjacent to one of the horizontal crack indications on the cam gallery, you would not measure on the surface immediately adjacent to that crack the same strain or stress that you measured in replacement 103 because of the presence of the crack. But you could compute exactly what the strain would be on 101 or 102 with the crack from the knowledge of how deep the crack was and the knowledge of what the stresses and strains were in the replacement 103 as measured without the crack.

So there is a very straightforward scientific relationship between them. So a measurement, if you like, on either one could be used to infer the strain on the other if you know what the crack size it.

JUDGE BRENNER: Now you could follow that same procedure from the original 103 block to the old 101 and 102 block also, couldn't you?

WITNESS RAU: You asked me if we made strain gage measurements on the old 103 while it was operational?

JUDGE BRENNER: No, I switched subjects slightly and assumed you would take care of it in your answer but I wasn't clear enough.

AGBajb

Why couldn't you follow that same process if you destructively measured the residual stress in the original 103 block as suggested by Dr. Anderson?

And I'm asking because the assigned the differences in the cracking as one of the reasons as to why you thought that those measurements would not be applicable. I have not forgotten that you also had other reasons.

WITNESS RAU: Yes, let me try to explain that.

Theoretically if you've got a deep crack in the cam gallery of the original 103 and the residual tensile stresses out by the repair weld and the residual compressive stresses below it have been relaxed somewhat by the cracking process, but not relaxed all the way to zero. Then theoretically you could measure those lower level of residual stresses and reconstruct analytically what the totality of the residual stresses might have been prior to the formation of the crack. Theoretically that's possible.

The difficulty is in the limit where those stresses have been relaxed to zero you are extrapolating an awful long distance and a little bit of error in your measurement of variant small stresses trying to extrapolate up to the very large residual stresses that were there before the crack formed will lead to enormous experimental error in that extrapolation.

AGBagb

So it's not that it is not theoretically possible to do it, it's just, I believe, impractical.

JUDGE BRENNER: Sorry for the long interruption.

MR. DYNNER: No, that's fine. It was an area that I was attempting to explore with less success than you have because my questions weren't as clear.

BY MR. DYNNER:

Q Dr. Rau, it's true, isn't it, that there are some cracks in the cam gallery saddles of the old 103 block that are much less deep than the .8 and .9 inch cracks that were found to exist when some of the saddles were sectioned, isn't that right?

Or Dr. Wachob, if you know?

A (Witness Rau) I don't know what you mean by very much shallower but there certainly are cam gallery indications which are shallower than .9. I remember some down like, you know, .7. There may be some shallower than that, I don't recall them off the top of my head.

Q Do you recall, Dr. Wachob, that there are TSI depth gauge measurements of some of those cracks in some of the cam gallery saddles of the old 103 block around .3 in depth; do you remember that?

A (Witness Wachob) I don't remember the .3 number. The number that sticks in my mind for the lower crack lengths that we measured is about .5.

AGBagb

Q I'm talking about crack depth.

A I understand. Crack depth into the thing. My rememberance is .5. I don't remember .3, sir.

Q I'm about to leave this area but just one last follow-up question and that is:

If you were going to do the kind of residual stress test that Dr. Anderson suggested on one of the old cam saddles from one of the old 103 blocks, it would be better to use a saddle with a shallower crack than one with a deeper crack, is that correct?

A (Witness Rau) That's correct, Mr. Dynner. You have a better chance of inferring something reasonable from those measurements with a half-inch deep crack than you would with one which is .9.

JUDGE BRENNER: I think that we should give Dr. Anderson and then Dr. Bush -- or vice-versa, it doesn't matter to me -- a chance to comment on what Dr. Rau stated, I am thinking particularly in response to my question, his views that the operational strain gage readings from the new 103 block could reasonably readily be made applicable to the 101 and 102 block as contrasted to the problems he discussed in applying the destructive-type strain gage -- the destructive-type residual stress measurements of the original 103 block to other blocks.

I don't know if I said that right but I hope you

AGBagb

understand.

WITNESS ANDERSON: Don't repeat it --

JUDGE BRENNER: I won't. I can't.

WITNESS ANDERSON: -- I get the....

Well I don't think that the new 103 is adequate to represent the 101 and 102 because you have to take into account that there is a weld there, a different metal, and it acts as its own stiffener and changes the surface properties that the strain gages are looking at. I do agree that the elastic modulus is similar in all cases.

WITNESS BUSH: I would have difficulty, as I say, still extrapolating because I think the strains we are talking about --

JUDGE BRENNER: Tell me what you are extrapolating from because we've got a few different situations we've talked about.

WITNESS BUSH: I would have trouble extrapolating from the 103 measurements to the 101 and 102 measurements in the cam gallery with explicit reference to the residual stresses.

I would agree completely --

JUDGE BRENNER: I'm sorry, Dr. Bush, which 103 measurements?

WITNESS BUSH: Pardon, the old 103. I think that is sufficiently explicit now.

AGBagb

I would agree completely that if the strains converted to stresses were on the low side that it would be a precise overlap. Where I am concerned, of course, is the area where we may be measuring a fictitiously low residual stress and I don't know how to handle that situation.

In other words, if I were converting and I were to come up with a residual stress of, say, two to three Ksi, -- which is a value that I wouldn't really be particularly concerned about because of the balance -- I would say yes. If I were -- If I anticipated that the residual stress would be 12 to 15 Ksi, I don't see any way I can get it from the 103 block, that's my problem.

JUDGE BRENNER: All right.

What about Dr. Anderson's view that you cannot -- or I'm not sure of his exact words, but he expressed his view on problems with applying the operational strain gage readings of the new 103 cam gallery area to the 101 and 102 because of the stiffening effect of the welds I guess on the 101 and 102.

WITNESS BUSH: I don't know about the stiffening effect but the welds certainly have a very major effect on the residual stresses before they crack so any relationship between an unwelded area and a welded area is almost impossible to correlate in my experience.

Admittedly in different materials a lot of my

AGBagb

work on residual stresses or examination has been in stainless steels, but if I infer from those then I would have a great deal of difficulty.

JUDGE BRENNER: Maybe we are mixing terms and I've lost it. I am talking about the strain gage readings that were taken on the new 103 cam gallery area. Are those -- I thought those were not direct measurements of residual stress.

WITNESS BUSH: They are not.

JUDGE BRENNER: All right.

Take those readings. Can those be made applicable without problems to the 101 and 102 cam gallery regions so that we could decide whether or not the stresses were compressive?

WITNESS BUSH: That is a superposition on an existing condition where we have a residual stress that has an X value in there, we can infer something about its presence but I don't know how to go from there to a welded structure and indicate what -- the X plus some value goes in there, that's my difficulty.

I offhand can't think of doing it in a totally non-destructive method unless I can either heat treat the object and change it that way or destructively test it or maybe go to an X-ray defraction technique and do it. Those are the only three techniques, and I wouldn't trust the

AGBagb

X-ray defraction.

JUDGE BRENNER: So Dr. Bush, then what was the Staff's purpose in recommending that LILCO perform the strain gaging -- strain gage testing of the new 103 cam gallery area?

WITNESS BUSH: Not in the context of residual stresses, that was to get an appreciation of the, what I would call the compressive stresses. It started with the assumption there were no cracks there and what we were attempting to do was to get a feel for the loads as contrasted to the -- loads measured experimentally as contrasted to those that had been predicted analytically for a given operating condition, that was the basic reason.

JUDGE BRENNER: And why would those readings be applicable to the 101 and 102 cam gallery?

I thought Dr. Anderson said they would not be because of the presence of the weld material.

WITNESS BUSH: Well I guess I wouldn't depend that much on it, that's one reason that I have said I would like to have crack opening displacement gauges or wire gauges because I would like to see if there is a movement in that case, quite frankly.

In other words, I think we have a complex situation here with the weldment with cracks in it in a complex geometry and with unknown bending moments and I

AGBagb

would like to have something that would indicate whether the crack is essentially static under loading conditions or whether it appears to be moving, and that's the whole reason for it. I don't trust the analysis that much, that's the situation.

JUDGE BRENNER: Well why did you recommend the 103 block then instead of doing the test on the 101 block, for example?

WITNESS BUSH: Because if I did it on the 101 and 102 block with the existence of cracks, I introduce a major unknown from a predictive point of view. What I am trying to do here is establish the loading conditions there because as soon as I get a gauge that is anywhere near a crack I will tend to perturb the values substantially. And if the crack moves it makes it worse. So that was the basic reason we picked 103.

JUDGE BRENNER: But wouldn't such a test on 101, for example, at least tell you whether the stresses would remain compressive for the 101 block?

WITNESS BUSH: I would have difficulty --

JUDGE BRENNER: I'm talking about the cam gallery of the 101 --

WITNESS BUSH: I am assuming you were talking about the cam gallery.

I guess the problem I have there is where to

AGBagb

put the gauges that would give me what I would consider to be representative readings in the presence of the cracks as such, that's my difficulty.

In other words, it gets to be a complex problem. Now Dr. Rau may be able to expand on it, but I guess if I saw the values and I have seen them near cracks I would have to ask myself are they valid numbers or not, that's my difficulty.

WITNESS RAU: I think there is some confusion over the residual or live stresses. The measurements of live or operational stresses on the replacement 103 are directly applicable and with no reservations in my opinion whatsoever to 101, 102. However that is a completely separate issue from the residual stresses introduced --

JUDGE BRENNER: Let me stop you there, if I might. Hold your thought.

Dr. Bush, do you agree or disagree with that statement?

WITNESS BUSH: If I have the values on a surface such as the 103 where I have considerable confidence in the values, the answer is yes, I believe I can apply it to a cracked region in 101 and 102.

JUDGE BRENNER: And I think Dr. Rau was right, we did have a lot of confusion in our exchange. I'm sure it's my fault.

AGBagb

Dr. Anderson, do you agree or disagree with just that one statement that we have stopped Dr. Rau at so far?

WITNESS ANDERSON: Well I'm not sure we can apply it, because we have a weld, we have a crack and I'm not sure that you can transfer it directly, I would have reservations.

JUDGE BRENNER: Dr. Rau, forgive me if I caused -- Could you hold your thought if I go back to Dr. Bush?

WITNESS RAU: I don't promise that but please go ahead.

JUDGE BRENNER: Why don't you have the same reservations Dr. Anderson has?

WITNESS BUSH: Once I have established it in an uncracked surface and I have measured it from the unloaded condition, from boltup-to-boltup, and then through the operating condition and I have a series of values, I can then work from these values -- obviously I have to do some modeling, I can make some assumptions.

I would tend to agree with Dr. Anderson if I had a totally uncracked weld there where the possibility exists of a crack occurring, that gets to be very complex. If I have cracked it, I have tended to relieve the residual stresses due to the welding operation and I believe that I can now model it at least to a degree.

JUDGE BRENNER: Did you mean that if you had a

AGBagb

totally uncracked weld on the 101 and 102 cam gallery to which you were going to apply the data, is that what you meant?

WITNESS BUSH: That would cause me difficulty, yes.

JUDGE BRENNER: All right.

Let me go to you, Dr. Rau, forgive me for the two interruptions now.

WITNESS RAU: Okay. Clearly we must separate operational from residual stresses. On the operational basis, in my opinion, you can directly apply them.

I agree -- again from a first principles point of view the presence of a repair weld with a slightly different elastic stiffness, elastic modulus or stiffness, will modify the stresses slightly in the weld bead itself, but as Dr. Bush has pointed out, since we have weld shrinkage cracks adjacent to that, with regard to the live stresses at the point of concern, that is, down towards the crack tip, that is of less import.

In any case, the effect of that stiffness change is very modest with regard to the operational stresses, those due to the throughbolt clamp-up and those due to the operational stresses that come from the repeated lifting of the head by the firing of each cylinder.

With regard to the residual stresses, there's no

AGBagb

question you can't infer anything directly from the strain gauge measurements on the replacement 103 block in the cam gallery, those are measurements only of the operationally-induced stresses. They say nothing about where there was no residual stress or where there was positive residual stresses or where there was compressive residual stresses in that block or any other block.

But the operational stresses are directly appropriate with these minor effects due to the weld to any other cam gallery. The residual stresses are treated on a completely different bases and we have been through that I think to some extent. I have made calculations and indicated that we would expect to have large compressive stresses in the weld, but in fact we expect to have balancing compressive stresses beneath the weld.

And the precise knowledge of the residual stresses is basically unimportant or irrelevant with regard to whether or not a cam gallery crack can extend beneath the repair weld bead, because once it gets down into there there is either no residual stress or there is a compressive residual stress and that's just going to make it even less likely that the measured operational stresses which have been shown to be fully compressive, perpendicular to the crack indications, they will just become even more negative. So a precise knowledge of their magnitude

AGBagb

becomes unimportant with regard to whether or not a cam gallery crack indication can extend all the way through the wall and get to the water jacket.

(The Board conferring.)

MR. DYNNER: I thought that, if I may, before we break I could get Dr. Anderson's comment and then if Dr. Bush wants to add anything, and then I was going to suggest that perhaps we could take a little bit shorter lunch break today if everybody agrees.

No, you don't agree?

JUDGE BRENNER: No, I don't, and I'll tell you why in a minute.

MR. DYNNER: Okay.

BY MR. DYNNER:

Q Dr. Anderson, would you have any comments on Dr. Rau's statement?

JUDGE BRENNER: I'll tell you what the situation is and maybe we would be able to. Let's see.

WITNESS ANDERSON: While I continue to disagree that a welded surface -- the strain gaging of an unwelded surface is equivalent to the strain gaging of a welded surface, one would have to be very careful if you did strain gage the welded surface where you put it. I just don't see that it can transfer. I am worried about modeling it, I am worried about any reasonableness in the values and certainly

AGBagb

one has no way of empirically checking them unless one does the strain gaging. So they are just different -- a different situation and should be strain gaged for its own kind. I do agree that you only have to strain gage 101 and 102, that they are similar, but 103 is not similar.

BY MR. DYNNER:

Q Dr. Bush, do you have a comment?

A (Witness Bush) No.

Q I would have just one last question --

A (Witness Rau) Before you move off that?

Q Sure.

A I think Dr. Anderson has mischaracterized what I said, at least if I said it I didn't mean to say it. I didn't say that you would get precisely the same strain gage readings if you put a strain gage on the repair weld that you would get on -- and did get on the replacement 103.

What I did say is the strains would not be substantially different and in fact if I knew the depth of the weld repair and the measurements made on replacement 103, I could compute, calculate quite accurately what the stresses would be even in the middle of the repair weld.

I didn't mean to imply you would get exactly the same measurement, I just think it is unimportant.

Q Do any of you know whether there are any uncracked welds in the cam galleries of 101 and 102?

AGBagb

A (Witness Bush) I asked a similar question -- and I guess this has to be hearsay, and I was informed that there were repairs at all locations in the cam gallery, that was my interpretation of the thing. I didn't know of any. Because we did ask the question because we were interested initially in considering other possibilities and that was the answer I got. I can only cite it as hearsay though.

Q I want to make sure you understood my question, Dr. Bush:

I didn't ask whether there were any uncracked areas in the cam gallery --

A I understood --

Q -- but any weld material that was not cracked.

A I guess I can't answer that question. I can answer that there are welds in every case, as least that is what I had understood, and I had thought from everything I saw that there were cracks but I guess I can't answer that question.

A (Witness Rau) I want to make sure I understand the question. You are asking me whether there is any portion of any weld that doesn't have a crack in it or just whether there is any cam gallery saddle which doesn't have a crack somewhere in the weld on a given cam gallery saddle?

Q All right. Let me explain.

It goes back to a comment that I think Dr. Bush

AGBagb

made concerning the fact that you might be concerned if there were repair welds -- as far as this strain gage testing is concerned -- that you might be concerned if there were repair welds on 101 and 102 cam galleries that had not developed cracks on the surface; in other words, successful cosmetic or otherwise welds of existing cracks, but where there were no what have sometimes been termed weld shrinkage cracks associated with the weld material.

And my question is do you know whether there are any such weld repairs on 101 and 102 that do not have any weld shrinkage cracks associated with them?

A (Witness Bush) I can't answer.

A (Witness Rau) Well Mr. Dynner, I don't have all the inspection reports with me. My recollection is that all of the cam gallery saddles on 101 have repair welds and each of those have crack indications in them. On 102 -- I also believe that to be the case but I don't have as clear a recollection that each and every one of them -- I mean certainly the vast majority of them had indications and my recollection is that all of them did. But I would have to look at the specific inspection reports to conclude that with 100 percent confidence.

Q I'm correct, aren't I, that if you had a successful weld repair where there was an unbroken surface that you wouldn't be able to detect that by liquid penetrant

AGBagb

or mag particle or the other NDE devices that are used for detecting surface cracks, isn't that right?

A Again let me make sure I understand:

You asked if there was no weld shrinkage cracks, in other words no crack on the surface that I could not detect a casting shrinkage crack below it, is that what you're asking me?

JUDGE BRENNER: No, that you could not detect that it was in fact welded.

WITNESS RAU: No, that's not true.

BY MR. DYNNER:

Q Okay.

Which of those NDE methods would detect a successful weld where there was no crack -- broken surface associated with it?

A (Witness Rau) Well if -- when you grind off the paint, you will simply see from the edge of the weld -- it is not a crack indication, but you will see porosity and differences in the materials' luster. You know, without the paint there you can tell there is a weld even if there is no a crack. In the areas where there were cracks but they weren't continuous you could see the termination of the weld.

There is also what is called a materials gauge which LILCO has used. It measures --

AGBagb

A (Witness Bush) -- permeability, I think.

A (Witness Rau) -- it measures some sort of magnetic or electrical permeability and from which you can ascertain whether or not it is the same material, and that was used to distinguish between cast iron and the iron nickel weld material and to identify that in fact there were repair welds in each of those locations.

Q Has the --

JUDGE BRENNER: Doctor --

MR. DYNNER: I have two more followups but if you --

JUDGE BRENNER: Go ahead.

MR. DYNNER: I defer to you.

JUDGE BRENNER: Well I think he is correct and your question surprised me but I can't testify so I want to ask Dr. Anderson:

Isn't it correct that assuming things aren't painted over you can just look at a surface and see a weld, the difference between the fact that something has been welded and cast iron?

WITNESS ANDERSON: Not necessarily. I can smooth out a weld and polish it down so that I don't think you would be able to detect it even though it is not painted over.

Generally -- now that I have given you the

AGBagb

boundary -- generally it is easy to spot a weld because they are never polished to that extent and they are just so different that it is easy to get. And if you have any question you would give it an acid etch and quickly determine it.

BY MR. DYNNER:

Q My two follow-up questions are, number one, do you know whether in fact the paint has been removed from every one of the cam gallery saddle areas of the 101 and 102 blocks in order to-- Do you know that, Dr. Rau?

A (Witness Rau) I don't know again with 100 percent confidence that the paint was removed from all of them. I know that it was removed from a representative sample for sure, because I have seen them.

I have seen inspection reports I think for all of them but some of those inspection reports may have been fluorescent magnetic particle inspections which were done with the paint on. Some certainly were done with the paint on. So again I can't state.

It may be in the record from Mr. Schuster or Mr. Johnson; I can't recall.

Q And do you know whether or not every one of the cam gallery areas of 101 and 102 were inspected with this device that would detect permeability?

A Any area where the repair weld was not obvious to

AGBeb

the eye would have been inspected. I wasn't there when they did it so I can't recall that they used that device on every one. They did on the representative sample but you could see it very clearly I don't know whether they continued to actually do it on each and every one.

MR. DYNNER: I am ready for a break if you are, Judge.

JUDGE BRENNER: All right. Two things.

First of all, you wanted a shorter lunch break, which I take it is to assist the witnesses in being completed earlier than they might otherwise be.

MR. DYNNER: Yes, sir. I was hoping we could all get out of here at a reasonable hour, and that might help things along if we took 15 minutes off of the lunch break.

JUDGE BRENNER: We are willing to take a one-hour lunch break, but let me tell you what my hesitation was before, and how I will accommodate it.

We need some time to go over a few more things regarding the pleadings we have received on the motion to reopen and supplement the records and the answers thereto. We will take the shorter lunch break and if I haven't accomplished everything that I think I need to accomplish during that shorter lunch break, what we'll do is take another, longer than the normal break between the completion of the witnesses and the time we have discussion of that

AGBeb

matter.

So when we do break, which will be in a moment, we will break for one hour.

Another miscellaneous point:

Since it now appears that I'll be in beautiful downtown Bethesda tomorrow instead of beautiful downtown Hauppaugh, the County's crankshaft findings which were due to be received today can be delivered there instead of your having to bring them up here, if that makes a difference on your logistics. Either way is acceptable.

MR. DYNNER: I frankly haven't checked on that, and they may be in transit, but I will call the office right away and see whether we can get them sent to Bethesda.

JUDGE BRENNER: Whatever is easier for them would be perfectly fine with us.

MR. ELLIS: Judge Brenner, I speak as one who does not have a hotel reservation tonight. Can I take heart that it appears that the Board doesn't envision a lengthy argument period on the motion?

JUDGE BRENNER: That's right, but my vision has been cloudy before. That's right, we don't. I don't know what time we are going to finish with the witnesses, though. That's the only problem.

And there is, you know, a divergence of opinion on those motions and to the extent that still reflects reality --

AGBeb

that is, the present situation -- then that may cause the argument to be longer.

You made a cryptic comment last week, maybe two weeks ago, Mr. Ellis. I guess it must have been last week, from which I inferred that some of what you said in your written pleading was not hard and fast as to certain things, and of course none of that got reflected in the answers of the other parties. I was hoping there would be some mechanism to do that if the discussions among the parties had changed things.

So you will have to inform us of that when we have the discussion of the whole matter, and when we do take a break before we have that discussion, it may be that while I'm using my time, the parties can valuably use their time to make sure they are on the same wavelength, at least as to what the positions are, even if they don't agree with them.

MR. ELLIS: Yes, sir. I'm not revealing anything surprising when I say that it was in the order of what the Staff wanted to put in that we were willing to agree with, rather than with what the County was suggesting.

JUDGE BRENNER: Well, I obviously need some more preparation time for myself, so this comment that I am going to make may be inaccurate, but I didn't see any material divergence between the County and the Staff on that point, that is, on what would be pertinent in a further proceeding

AGBeb

if we permitted one.

MR. ELLIS: All right, sir. We will explore that at lunch time.

JUDGE BRENNER: And I will look at that myself, also.

Let's break until 1:30.

(Whereupon, at 12:25 p.m., the hearing in the above-entitled matter was recessed to reconvene at 1:30 p.m. the same day.)

WRBbrb

A F T E R N O O N  S E S S I O N

(1:30 p.m.)

JUDGE BRENNER: On the record.

Whereupon,

HARRY FRANK WACHOB,

CHARLES A. RAU,

ROBERT N. ANDERSON,

and

SPENCER H. BUSH

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

JUDGE BRENNER: We're ready whenever you are, Mr. Dynner. The witnesses are all back.

EXAMINATION

BY MR. DYNNER:

Q Dr. Bush, I think that this morning you expressed the opinion that you thought that the calcium that was found on the surface of the crack from cam gallery number seven more likely came from the welding process than it came from lubricating oil after operation began.

Is that correct?

A (Witness Bush) That's correct.

Q Where do you think the sulfur that was also present on the oxide layer on the crack came from?

A I don't really know. I have heard various

WRBbrb

postulates as to where it might come from, in the context of the fact that you have a finite level of sulfur, albeit not this high, in the cast iron, et cetera. But I have no basis for establishing where the sulfur would come from.

I take it you're discussing the microprobe data that indicate the presence of calcium, silicon, sulphur on that. That is the only piece of evidence that I am aware of.

Q Actually, the EDX analysis, right?

A EDX, yes.

Q Could the sulfur have come from the welding process, do you think?

A If it did, I'm not aware of where it would have come from, to tell the truth.

I don't really know the coatings. I know that one of the more common ingredients in such coatings is calcium. A lot of these tend to be proprietary coatings. They certainly would not use them for high nickel alloys if they had any sulfur in them. That would be a forbidden thing, which would lead me to believe that, since this is an iron-nickel electrode, that they wouldn't have sulfur in them. But that's inference, because I don't know.

Q Would any other member of the panel like to comment on this issue?

A (Witness Rau) Mr. Dynner, the only thing that I

WRBbrb

might add is that the quality of these repair welds is a little less than optimum and grease or, you know, just lack of cleanliness of the surface can lead to sulfur contamination. That's one possible source. If they don't get any cutting oils or greases they may have used in the grinding process completely out before they lay the bead down, you can get sulfur contamination that way.

Q Dr. Rau, did the calcium that you noted appear in all areas of the surface of the crack that was covered with the thick dark oxide?

A My recollection is it was all areas which we interrogated with the EDX; but Dr. Wachob did it. Perhaps he should comment upon it.

A (Witness Wachob) All areas of the broken-open crack, being the weld interface in what we are referring to as the shrinkage crack, all had indications of sulfur.

Q And those were all areas that were covered with the thick dark oxide as well?

A The thick dark oxide that we have been referring to is on the shrinkage crack. It is not on the weld boundary crack, the interface crack that runs along parallel to the fusion metal and in the cast iron.

Q Did you test all areas of the crack, from the tip of the crack all the way up to the surface with the EDX analysis in looking for calcium?

WRBbrb

A We chose a variety of spots that included from the surface as one proceeds inward. We took a variety of spots which went from, basically, the very outer surface to the inner surface.

Q And this outer surface you're referring to: was that the area where the weld was located?

A When I referred to "outer", I meant what would have been the cam gallery surface as one views it from that weld, along the weld crack, weld shrinkage interface, and then eventually into the shrinkage crack from the casting process.

Q And were there any other areas where there was no thick dark oxide where you found calcium -- areas of the crack surface, I'm talking about, that you did the EDX examination on?

A Where the weld shrinkage crack is we found calcium, and that doesn't have the thick dark oxide.

Q Did you find the calcium in the area of the -- I guess what I will term the "clean fracture"; that is, the area that was broken apart?

A I do not remember seeing calcium in that region, no.

MR. DYNNER: I'm going to ask that there be distributed -- and I apologize for the fact that, like Mr. Ellis, I don't have originals of the photographs; I'm going

WRBbrb

to distribute some xerox copies, and what I propose to do is to give my copy of the original photographs to the Board so that they can follow along during the questioning, the short questioning that I have on these.

BY MR. DYNNER:

Q I would ask, Dr. Rau, since I see a copy of the photographic album, that you share that with your colleagues on the panel.

JUDGE BRENNER: Off the record.

(Discussion off the record.)

JUDGE BRENNER: On the record.

BY MR. DYNNER:

Q I ask you to take a look, please, at the photograph -- and as you can see, there were four photographs on the xerox page -- the photograph in the upper right hand corner which bears the notation "HFW-4" and the date "9/3/84" on it.

MR. ELLIS: Mr. Dynner, is that notation on the originals as well?

MR. DYNNER: Yes, Mr. Ellis. That notation is the notation that appears on the back of the original photograph.

BY MR. DYNNER:

Q In the album, gentlemen, there is a label on the plastic over that particular photograph that says "DG-103,

WRBbrb

Cam No. 7, I-612".

Dr. Wachob, I would like you to identify the subject matter of this photograph.

A (Witness Wachob) This is a segment of the cam saddle number seven position that was removed from the original 103. And we have cut the section that we have removed, and we are now looking at it in cross-section.

Q Is this an FaAA photograph?

A This is an FaAA photograph and mount.

Q And just below that photograph, there's another one. On the book, the plastic covering, it bears the nameplate "DG-103, I-612", and on the reverse of that photograph, and as noted in the exhibit which I'm going to ask be marked for identification, it says "CB-1", and underneath that the date "9/11/84".

Can you identify that photograph, please, Dr. Wachob?

A That photograph is an enlargement of the one above, just taken at a different time, that's all.

Q And is that an FaAA photograph, also?

A That is an FaAA photograph.

MR. DYNNER: Judge, I would like these two photographs, which will be on a single page, to be marked for identification as the County's Exhibit -- I believe it's 81, Judge Morris, unless I've lost count. So that would be

WRBbrb

Suffolk County Diesel Exhibit 81.

JUDGE BRENNER: All right, for identification.

(The photographs labelled "HFW-4, 9/3/84" and "CB-1, 9/11/84, were marked as Suffolk County Exhibit 81, for identification.)

BY MR. DYNNER:

Q Dr. Rau, I would like you to look for a minute, now, at LILCO's Diesel Exhibit B-61; and I believe you earlier had testified with respect to the photo marked "HFW-4", that it in fact was a photograph of what you were sketching in B-61.

Could you tell us how that photograph fits in with your drawing?

A (Witness Rau) Mr. Dynner, I don't think I said that it was -- that my Exhibit 61 was a representation of any particular photograph. But certainly, the sketches which I introduced -- made and introduced as B-61 are intended to schematically represent the cracking in the cam gallery area, of which your County 81 is an example.

As far as orientations go, I can reference the orientation of the photograph, if you like, to LILCO B-61, if that's what you had in mind.

Q Would you please do that? I'm sorry if my question implied that this was a particular sketch. I did

WRBbrb

not mean to imply that.

A Okay.

If you take County Exhibit 81 and you rotate County 81 ninety degrees counterclockwise such that the most pointed portion of the photograph in 81 is pointing to the lower right, the orientation will be comparable to that which I have sketched in LILCO B-61.

Q And I'm correct, aren't I, that the material in the photograph that appears in the real photograph to be shinier, and is located where your sketch shows weld material, is in fact the photograph of the weld material in the County's Exhibit 81.

Is that correct?

A Yes, Mr. Dynner, that is correct. The shining area is, in fact, the repair weld, as contrasted to the grayer and the dark lines, which appear different after the etching procedure.

Q Now, could you look for a minute at the County's Diesel Exhibit S-4, which as you'll recall are the micro-photographs of cam saddle number seven? It's in the bound- in volume with the County's supplemental testimony, Dr. Rau.

A Just one minute. Our original has disappeared from our book.

(Pause.)

WRBbrb

Q You have that now, don't you, Dr. Rau?

A Yes, I do.

Q Could you please orient us with respect to the photographs in the County's Exhibit S-4, as to what portion they would be of the photographs in the County's Diesel Exhibit 81?

And you might, if it's convenient for you, Dr. Rau, use the photo labelled "CB-1", because that's a slightly larger magnification and it might be easier for us to see.

JUDGE BRENNER: That gets to a point I was going to ask about. If you can, in the course of this, let us know what the magnifications are in the two photos that comprise Suffolk County Exhibit 81, that might be helpful information, also.

WITNESS RAU: I can give you those -- I'm sorry, 81.

Judge Brenner, the full width of the cam gallery section, starting from the weld, on County 81, and progressing from right to left to the water jacket side is an inch and a quarter. So the uppermost photograph will be a mild magnification, perhaps one and a half times, and the lower one might be of the order of about two times magnification.

What I'm trying to ascertain here, Mr. Dynner,

WRBbrb

is whether or not County S-4 exhibits are from the same cross-section which is shown by County 81. It certainly is of a comparable one, very nearby, but it may not be the same surface. So if you'll give me a moment, I'll try to ascertain that.

(Pause.)

BY MR. DYNNER:

Q Dr. Rau, if they are similar, and if you can tell me it really doesn't matter in terms of orientating us to the section that was fractured --

A (Witness Rau) Well, okay. In that case, it really doesn't matter.

Let me attempt just to orient us relative to your Exhibit 89. If you take County Exhibit S-4 and rotate it ninety degrees clockwise so that the shiny or the white constant area with little speckles in it is on the upper right, and the labels are on the left hand side, you will then have a black region on the far right.

The black region on the far right and upper top is basically the surface of the cam gallery area. We're then looking at the bottom or lowermost portion of the repair weld, as revealed by County 81 when it is turned ninety degrees counterclockwise.

So the crack between the repair weld, or in the heat-affected zone adjacent to the repair weld in the cast

WRBbrb

iron is the same orientation as the interface shown in County Exhibit 81, which runs from the lower right portion of the repair weld up generally along the boundary.

Is that sufficient detail?

Q Yes, it is.

As I look at those two photographs -- one, of course, which is the S-4 photographs, which are 50-power and 100-power, of course -- and orient them the way you've suggested, it would appear -- and it's true, isn't it -- that the S-4 photographs would be in the area below the area where the crack extends from the cam gallery surface into the body of the material, which is about half way up in the photograph.

Is that right?

A I'm not sure I understand what you're asking.

The cracks illustrated in S-4 are below the horizontal -- what I call the casting shrinkage crack, which runs horizontally once 81 is rotated ninety degrees clockwise, yes.

Q Thank you. That's what I was trying to ascertain.

WRBeb

Now am I correct that the sample which is shown in the photo marked CB-1 in County Exhibit 81 was fractured by FaAA in order to take a look at the surface of the crack?

A As I mentioned yesterday, Mr. Dynner, it is my belief that the crack revealed in S-4, that section, if it in fact is the same one shown in your Exhibit 81, was not the one that was broken open for examination of the fracture surface. The one that was broken open was the next slice immediately behind this region, located perhaps a quarter of an inch, at least in the center of the slice, from this location.

Q And there aren't any comparable photographs in the album of that particular slice. Isn't that right? That is, comparable to the County's Exhibit 81?

A Mr. Dynner, if you move several pages rearward in the original book to two macrophotographs labeled "Cam Saddle Number 7, D-1," -- they look like this (exhibiting document) -- you will see that this is in fact a comparable view and a comparable magnification of the sample which was in fact broken apart so that it could be examined directly on the fracture surface.

These particular photographs obviously have not been mounted in plastic nor have they been metallographically polished as the one shown in your Exhibit 81.

WRBeb

Q Yes. I just wanted to establish that the photographs of the slice, if you will, or the sample shown in County's Exhibit 81, while, as I think you said, wasn't exactly the one that was split open, basically looks the same, because we don't have a similar photograph of the one that actually was split open. Is that right?

A Well, there is no similar one in the sense that it was put in plastic, mounted, polished, and then taken out of the plastic and then broken open. That's correct.

Q I'm saying there is no--

JUDGE BRENNER: Mr. Dynner, this seems to be taking longer than it's worth. I don't know where you are heading but I'm sure you're heading to something that you think is useful, and I accept that. But can you get there a little more expeditiously?

MR. DYNNER: I'm going to try. I wanted to first get confirmation that County's Exhibit 81, photographs of the slice that we have been talking about, would look approximately the same as the sample which was in fact split open, if you had taken photos of that from the same angle and magnification.

BY MR. DYNNER:

Q Isn't that right?

A (Witness Rau) I'm sorry, I didn't hear all of that. Will you ask it again?

WRBeb

Q Yes. The question is:

You testified that the photographs shown in County's Exhibit 81 are not the exact sample that was split in half for your fractographic analysis. And my question is if you had taken photographs of the sample slice that you did split in two for the fractograph, it would look about the same as these photos, wouldn't it?

A Yes, in a general sense. I mean it wouldn't have exactly the cracks in exactly the same places and the amount of porosity in exactly the same places, but generally it would show the casting shrinkage crack extending from the base of the repair weld. It would show the weld shrinkage crack extending along the heat-affected zone between the repair weld and the cast iron. And it would show some porosity in the weld. It would be generally similar, yes.

Q Is there any reason why you didn't take a picture -- take photographs of the slice or sample slice that was actually fractured before it was fractured?

A Yes. It's just a matter of practicality, Mr. Dynner. In order to do that what we would have had to do is to mount that particular slice in plastic, as we had done in 81, and then we would have to have done the metallography, if you like, and then we would have to take the piece out of the plastic and then we would have to break it open.

WRBeb

Since we have the adjacent slice, there seemed no reason to repeat that particular observation on that particular slice.

Q Okay. Thank you.

MR. DYNNER: Now I am going to ask that there be distributed and marked for identification some of the photographs, Dr. Rau, that you alluded to in your explanation.

(Documents distributed.)

MR. DYNNER: I will ask that this be marked for identification as Suffolk County Diesel Exhibit 82. It consists of a sheet. I am going to refer only to three of the four photographs that are reproduced on the sheet. In the upper left-hand corner on the rear of that photograph there is the notation, DP-1. It bears the date 9/12/84. And in the label on the plastic covering it says "Cam Saddle Number 7, D-1."

The photograph in the upper right on the rear of the photograph bears the notation DP-2 and the date 9/12/84. And it has a label on the plastic cover that says "Cam Saddle Number 7, D-2."

Finally, in the lower left-hand quadrant is a photograph. On the rear it bears the notation DP-3, and the date 9/12/84, and has the label "Cam Saddle Number 7, D-1."

BY MR. DYNNER:

WRBeb

Q Dr. Wachob, would you kindly identify the fact that these are FaAA photos?

A (Witness Wachob) These are several photos taken by FaAA.

There is one typographical error that I did not catch before you received the book. In the upper right-hand corner, instead of being DP-2, 9/12/84, that one should have been typed D-1, not D-2.

Q DP-1?

A No, on the front label it says "Cam Saddle, D-2." It should be D-1.

Q I see. Thank you.

JUDGE BRENNER: You want it marked? Is that it?

MR. DYNNER: I would like that marked for identification, if I may, as Suffolk County Diesel Exhibit 82.

JUDGE BRENNER: All right, fine.

When you follow the catch-up procedure with the photographs, make sure they are in the same position on the sheet.

MR. DYNNER: Yes, sir.

(Whereupon, FaAA photos DP-1 - DP-3, 9/12/84 were marked as Suffolk County Exhibit 82 for identification.)

WRBeb

MR. DYNNER: Judge, I just wanted to point out that when we furnish the actual ones, we are only going to have the ones that we are referring to. So the record talks about a quadrant, or four, and there are really only going to be three on this particular exhibit.

BY MR. DYNNER:

Q Now am I correct, Dr. Wachob or Dr. Rau, that the top two photographs show the crack on cam gallery Number 7 that was split in two or fractured in order to do a fractographic examination?

A (Witness Wachob) The top two photographs there are the same piece. They are not mating fracture surfaces. The photographs there are showing one side of it, then it is turn over and then a photograph on the other side.

Q Would you be good enough to orientate us with respect to the photograph bearing the location DP-1, orientate us as to where that would appear with respect to the photograph of the whole area marked CB-1? I understand it is a slightly different slice, but I want to get an idea of where it would come from from the actual slice that was fractured.

And if it is more convenient, use photograph DP-2, whichever you feel would be the more appropriate orientation.

A If you look at the upper left-hand corner one,

WRBeb

the DP-1, that orientation is identically the same as the orientation. You take the page of County Exhibit 81, leave it as it is in the vertical sheet so therefore we are looking at DP-1 on the lower right-hand corner. And if you take that piece from County 82 and place it on top of that, what you see is the weld shrinkage crack and then the vertical casting shrinkage crack. That forms the left-hand boundary of the photograph DP-1.

If you start at the bottom and move up along the outside boundary-- If you take DP-1 and orient it the way you have it there, if you just laid it down on CB-1, that is the orientation of that piece. You can see the shrinkage crack, the vertical shrinkage crack and then the welding shrinkage crack on the left in CB-1.

If you now take this piece that is shown and depicted in DP-1 and you translate it over, it will just sit on top of that match.

So the left-hand boundary of DP-1, if you start at the bottom and go up along the boundary, the first portion of it there is the weld shrinkage crack. When you get up to about what would be a twelve o'clock position and start to go vertical, at that position is where the shrinkage crack from the casting process occurs.

Q Okay.

You have CB-1 now orientated--

WRBeb

A The long way.

Q The long way.

A Correct.

Q The way it was originally shown.

MR. DYNNER: I think I understand. If the Board has any questions about that, we've got both the photographs marked CB-1 and DP-1 in exactly the same orientation that they appear on the exhibit pages.

JUDGE BRENNER: I'm not sure I can see the weld material on DP-1.

WITNESS WACHOB: The weld material on DP-1, since it is a rough cast one, you cannot see it directly, no. You get a hint of it. If you look at the bottom of the photograph, you can see a slightly lighter gray on the bottom, and a slightly darker gray on the top, but it is difficult to pick out the weld in that photograph.

Another way to look at it to see the orientation here is that if you were to take the photograph CB-1, County Exhibit 81, and break it forcing that crack, the piece that is in your right hand when you break it is the one that would match with the photograph in County 82, DP-1.

BY MR. DYNNER:

Q And I am correct, aren't I, that the bottom perimeter, if you will, or the bottom part of the photograph which is DP-1 is the surface of the cam gallery? Is that

WRBeb

right?

A (Witness Wachob) Yes.

Q And the top of that piece is the tip of the crack?

A The top horizontal portion to that piece in that photograph is the back wall of the cam gallery area.

Q Okay.

So the tip of the crack would be--

A The tip of the crack is somewhere below that.

Q Thank you.

Now presumably--

A (Witness Rau) That's the surface you have been calling the water jacket side, for clarity.

Q I understand the top part would be the water jacket side. The bottom of this photograph is the cam gallery surface.

A (Witness Wachob) Correct.

Q Thank you.

Now can you tell me-- Looking at DP-3, can you orient me from DP-1 to DP-3, if that is the photograph on the County's Exhibit 82 that appears immediately below DP-1?

A Correct. DP-3 can be obtained by doing the following:

If you take DP-1 that we were just talking about and the piece is set in there flat, if you now rotate it

WRBeb

from left to right, bringing what is the sharp tip of the weld on the left-hand side, bring that into a vertical position, you would be now looking at, in the bottom photograph, basically the fractured surface that appears on the left-hand side of DP-1.

This is a slab that is about a quarter of an inch thick, so that when you take that piece in that orientation and just turn it up, what you're looking at is the fracture surface that is shown in profile in DP-1.

JUDGE BRENNER: Is it part of the horizontal or part of the vertical as DP-1 is presently oriented?

WITNESS WACHOB: It is a little bit of both in that the shrinkage crack is the vertical portion and the weld shrinkage crack along the bottom has some horizontal component to it.

BY MR. DYNNER:

Q So what we're looking at is in fact in DP-3 the surface of the crack which is shown in profile in DP-1. Is that right?

A (Witness Wachob) Correct.

MR. DYNNER: Is that clear to the Board?

JUDGE BRENNER: Well, I don't know if I need to know because I don't know where you're going, so I will let you proceed. I don't know exactly which portion of that boot-type shaped profile it is from. I understand roughly

WRBeb

the different view, but I assume it is not the whole length of it.

WITNESS RAU: Let me try to describe it, if I can take a different stab at it.

If you look at DP-1, just lay that piece flat on the table. Okay? Then grab it with your right hand so your thumb is on the left-hand side and just put your thumb straight up in the air now and pick that point up. The point is on your thumb tip.

Now as you look down at the point of your thumb you're looking at a broken surface, the fracture surface, the cracked surface of the cam gallery. You're viewing all of the cracked surface. That is, you are viewing the weld shrinkage crack, which is at the bottom of DP-3. That's not a flat surface, not perpendicular to your view. It comes down at an angle, at a curved angle.

Then you're viewing the casting shrinkage crack which then extends from perhaps a quarter of the distance from the bottom up to about two-thirds of the way up.

And then you're looking at a light area, and that's the area which was originally intact that has been broken open in liquid nitrogen in order to reveal the entirety of the surface for examination.

BY MR. DYNNER:

Q Now, Dr. Wachob, would I be correct that there

WRBeb would also be a mate to DP-1 and DP-3 which would be represented by the other side of the crack that was fractured in two?

WRBbrb

A (Witness Wachob) Yes. There would be a mate to it.

Q And there aren't any photographs in the album that has been furnished to us -- the mated side that would be equivalent to DP-1.

Isn't that correct?

A No. That is not correct.

Q Okay. Could you identify that for me?

A If you'll move about two pages later, you will see a picture which has weld -- that page, the lower right hand photograph which is dark, unfortunately, in the printing, is the mate to that fracture surface.

Q Okay. The one that is marked on the cover -- it looks like DP-3, except that it is marked "Cam Saddle No. D-2".

A The D-2 is the mating fracture to the D-1.

Q Yes. And there, in fact, is no photograph similar to DP-1.

A There is no photograph similar showing the profile of D-2.

The other thing to note is that that really is Cam Saddle 7 and not Cam Saddle 2.

MR. DYNNER: I don't propose to put this other photograph in for identification. I'm going to hold it up so that the board can see that it is -- that it looks just

WRBbrb

like DP-3, except it appears in my photograph, at least -- and I don't know whether it is an exposure or not -- to be quite a bit darker.

BY MR. DYNNER:

Q Is that quite a bit darker coloration on the mating side labelled D-2 for any reason, Dr. Wachob?

A (Witness Wachob) When they printed the sheets of photographs for you, that had a different exposure. The colors were all the same. It's just improper photographic exposure.

JUDGE BRENNER: Just so I don't mislead you: I can't see it from here. I'm not saying I have to. You certainly have my attention. I'm sitting here with anticipation, waiting to see where you're going to go with all this.

(Counsel exhibiting document to the Board.)

JUDGE BRENNER: All right. I have seen it now that you have brought it closer.

You probably don't realize it, but you started with the photographic exhibits about a half hour ago.

MR. DYNNER: Yes. I think this is going to be of some usefulness.

JUDGE BRENNER: I granted you that assumption. I just wanted to get there.

BY MR. DYNNER:

WRBbrb

Q Now, I think you testified, Dr. Wachob and Dr. Rau, that when this crack sample was fractured, when it was split open, that one side came away with most, if not all, of the weld material adhering to it and the other side didn't.

Is that correct?

A (Witness Wachob) That is correct.

A (Witness Rau) It came away with basically all of the weld material.

I think if you look at DP-1, you'll see that that particular half of the two broken apart has the entirety of the repair weld bead. The left portion, which is the one shown and labelled D-2, the one that has not be marked as an exhibit, that would be the mating fracture, and that one has got basically none of the original repair weld. It just has the cast iron.

Q Thank you. I was about to ask you that question, and I appreciate your anticipating my question.

Now, Dr. Rau, it's true, isn't it -- and Dr. Wachob -- that in your supplemental testimony, on page 5, you say that the fractography of the crack -- and I'm quoting, now, "revealed that the entire surface of the crack was covered with a thick oxide;" and that's repeated twice on page 5: "the entire surface of the crack".

You didn't differentiate there between the -- if

WRBbrb

we look for a minute at photograph DP-3, in your statement in your supplementary testimony you say "the entire surface of the crack was covered with a thick oxide," and you didn't make any differentiation between the portion of the crack surface that once had the weld on it and the other portion of the surface, did you?

(Pause.)

Can you answer that question, gentlemen?

A (Witness Rau) Yes, Mr. Dynner, the words are obviously as you read them.

The question is, perhaps, a little ambiguous. We were obviously referring to the casting shrinkage crack and not referring to the weld shrinkage crack.

Q Well, is it your testimony now, looking at photograph DP-3, that only a portion of the surface of the crack was covered by the dark oxide?

MR. ELLIS: Judge Brenner, I object. We've had endless amounts of testimony about what portions are the thick layer and what portions are the thin layer.

JUDGE BRENNER: I think so, too. But I'm going to let him follow up.

Mr. Dynner, you finish and then I'm going to tell you what I'm going to say.

MR. DYNNER: We're going to find out, I hope, what I regard -- at least so far -- to be a confusing bit of

WRBbrb

testimony.

JUDGE BRENNER: Not to me. But go ahead.

MR. DYNNER: All right -- but it is to me, sir.

BY MR. DYNNER:

Q In your supplementary testimony you say "The entire surface of the crack was covered with a thick oxide," and I'm asking you now whether that is still your testimony or whether, looking at the crack surface that you have defined in DP-3, only a portion of the surface is covered with a thick oxide.

A (Witness Rau) Mr. Dynner, all along our testimony has been that the thick dark oxide covers uniformly the casting shrinkage crack. That is the one that extends from the base of the repair weld down to the full extent of the pre-existing crack.

On DP-3, the light area of fracture at the top didn't even exist until we broke it open, and that has no substantial oxide of any type on it. The weld shrinkage crack, as we've discussed extensively, has a light, almost negligible thickness oxide which, in profile, is clearly revealed to be very, very thin and markedly different from the thick dark oxide which is on the casting shrinkage crack.

Q So you meant to differentiate the portion of the surface shown in DP-3 that was opposite the weld material

WRBbrb

from the portion that was below the weld bead.

Is that your testimony?

A Yes, sir. That has been our testimony.

Q And on page 6 -- if you will bear with me for a few minutes here, Dr. Wachob, to help out my confusion; on page 6 of your supplementary testimony, in the last paragraph of Answer 9, you're talking there, aren't you, about shrinkage cracks in the cam gallery. And you say, "Since the oxide was present over the entire surface of the cam gallery cracks examined in the original EDG-103 block:" did you mean to make any limitation to that statement? I'm asking you, Dr. Rau.

A What we were commenting about there was that there was no portion of the crack -- I'm talking about the original casting crack, down at the deepest extent -- which had anything other than the same uniform thick dark oxide. So at the deepest portion of the crack -- which would have been the one which was extending it, if in fact there was any extension during operation -- there was no evidence whatsoever of anything different in the characteristics, thickness or anything else with regard to the oxide coating on that portion of the crack -- that is, the deepest portion of the crack -- and therefore no basis to distinguish any evidence of crack extension during operation.

Q So by that statement you meant to refer to what

WRBbrb

you call the shrinkage crack rather than the cam gallery crack in its entirety; is that what you mean?

A To the extent that you lump the weld shrinkage crack and the casting shrinkage crack together and call that the total cam gallery crack, yes, there's definitely a distinction between those two.

Q Well, is that what you called the total -- the cam gallery crack?

A In what context?

Q Well, what do you mean by the cam gallery crack, Dr. Rau?

A In what context?

Q In the context of your testimony. How do you define a cam gallery crack?

A It's been defined over and over. It consists of the casting shrinkage crack, which runs roughly horizontally, extending from the surface of the cam gallery saddle region in towards the water jacket. After that casting shrinkage crack was formed -- was gouged out, in my opinion -- there was a repair weld made. The shrinkage associated with the repair weld led to the formation of weld shrinkage cracks.

And the totality of those two together led to the surface indications revealed by LP and flourescent mag particle. And the totality of those two cracks together led

WRBbrb

to the depth measurements as recorded by the TSI depth gage and as observed in the destructive examination.

Q And is the totality what you've been calling the cam gallery crack, or something else?

MR. ELLIS: Objection. Asked and answered.

JUDGE BRENNER: I'll overrule it. But this isn't the big point you though it was, Mr. Dynner. But go ahead.

MR. DYNNER: We'll get there.

JUDGE BRENNER: Well, I think you're past it already. But go ahead.

WITNESS RAU: I'm not aware that I've been using the term "total cam gallery cracks". We've been talking about those two aspects of the cam gallery cracking and the differentiation, the differences in the oxide between them, the reasons we believe that the conditions under which they formed are clearly defined by the physical evidence --

BY MR. DYNNER:

Q Let me try again.

All I'm talking about is something very simple. If you look on page 6 of your testimony, in the last sentence of Answer 9, you say, "Since the oxide was present over the entire surface of the cam gallery cracks...;" when you used the term "cam gallery cracks", were you referring only to what you now call the shrinkage crack, or were you referring to the shrinkage crack and the weld shrinkage

WRBbrb

portion of that crack?

A We were referring to the casting shrinkage crack.

Q Only?

A Yes.

Q All right.

And the difference would be that the -- that what you call the weld shrinkage crack extends all the way down to the cam gallery surface, as opposed to what you call the shrinkage crack, which stops somewhere before it becomes the weld shrinkage crack.

Is that right?

A No, Mr. Dynner, that's not right.

We've been through this many times. I ve got an exhibit which we've discussed extensively, B-61, which shows you exactly what I thought the condition of the casting shrinkage cracks were after the casting. I've indicated why I believe they were gouged out, ground out, and why during the repair weld process we formed additional weld shrinkage cracks.

And, clearly, in my opinion, they originally extended all the way to the cam gallery surface; and in 103 they, through connection with the weld shrinkage cracks, they also extended fully to the cam gallery surface. That was clearly indicated by the TSI depth gage readings, which recorded the entirety of the crack depth.

WRBbrb

Q Look, I'm just talking for a minute, if you will bear with me, to photograph D-3; and I'm asking you now to look at that. And you've described it once.

The bottom of that photograph, that shows the cam gallery surface, right?

A Well, it doesn't show it, but the cam gallery surface is along the bottom of that photograph, yes.

Q All right.

Now, working your way upwards: the first portion of that photograph shows what crack?

A The first -- approximately -- quarter of that photograph shows the weld shrinkage crack surface, fracture surface, after it's been broken open and separated from the main half, which is labelled D-2.

Q All right.

And then going up from that, the next portion up to the sort of whitish area is what you're calling the shrinkage crack; is that right?

A That's correct, Mr. Dynner, with one exception: there's a light region within the generally dark thick oxide. That portion is a portion which broke during the final break-open with liquid nitrogen, and so that's not part of the original shrinkage crack surface.

Q Now, Dr. Rau, I want to explain to you my confusion, because in your deposition on October 11, at page

WRBbrb

111, you testified, and I quote -- and this is in line 13, Dr. Rau:

"The oxide which we observed on the shrinkage cracks is thick and is uniform, relatively uniform in thickness all the way from the outer surface right on down to the tip."

What was the outer surface you were referring to there?

A That would have been the outer surface of the cam gallery after the grinding had taken place; it would be the middle sketch on LILCO B-61.

And what I was saying was that the oxide is uniform in thickness over the entirety of the cam gallery crack from the surface -- which, again, is at the bottom of the gouged-out region -- all the way down to the tip of the casting shrinkage crack.

And the point we were discussing there had to do with if, in fact, the oxidation had been introduced by the weld repair process itself I would have expected, because of the lack of preheat, that we would have much more heat right at the surface where the gouged-out region touched that remaining portion of the casting shrinkage crack than we would have down at the deepest extent of the casting shrinkage crack.

And because the oxide characateristics and

WRBbrb

thicknesses were uniform over the entirety from that outer surface -- the bottom of the gouge, if you like -- all the way down to the tip, it was my opinion that the oxide had formed during the casting process, not primarily during the repair weld process.

Q So, looking for a minute again at the photograph DP-3, in your testimony on page 11 when you refer to the "outer surface": is it your testimony now that you did not mean the outer surface of the cam gallery, which is the bottom of that photograph of the sample in DP-3?

A That's correct, Mr. Dynner.

WRBwrb

Q And the calcium that you referred to, was a sample of that taken from the portion of the -- what you call the weld shrinkage portion of that crack?

A Yes, Mr. Dynner, the calcium was noted both on the weld shrinkage portion of the crack and also on the casting shrinkage portion of the crack.

JUDGE BRENNER: That's a repeat of one of the first questions you asked after the lunch break, Mr. Dynner.

BY MR. DYNNER:

Q Now, turn for a minute, if you would-- This is a final point to try to clear up my confusion. --to transcript page 25,403 of October 31st, the transcript of October 31st.

MR. ELLIS: We're going to run to get that, Judge Brenner.

JUDGE BRENNER: Just proceed. I don't have it, either.

BY MR. DYNNER:

Q Let me explain to you my continuing confusion, Dr. Rau, because, starting at line 20 you testified on October 31st, and I quote. I asked you a question, I said,

"You didn't do a depth profile analysis to determine the thickness of the oxide layer along its length in entirety, did you?

And, Dr. Rau, you answered in line 20:

WRBwrb

"Yes, I did, Mr. Dynner. I did not report specific numbers as we went down the depth, but I very definitely did examine the thickness of the oxide as a function of depth from the surface of the cam gallery down toward the crack tip, and that is the basis for the testimony we have given and the thicknesses we have been talking about."

If you turn back for a minute to transcript page 25,400, there is reference to the thickness we've been talking about; isn't that right, Dr. Rau; the relatively uniform thickness which you said was from .2 to .5 mills?

A (Witness Rau) Yes, Mr. Dynner, there is mention of that thickness of oxide. It was clearly testified on many occasions-- I haven't read the entirety fore and after this reference. --that that deals with the thickness of the oxide on the casting shrinkage crack. It does not deal with the thickness of the oxide on the weld shrinkage crack.

I have testified on various occasions that that's very, very thin. It is dark, but it's very, very thin, and completely unlike the thickness and characteristics of the oxide on the casting shrinkage crack.

Q So how do you account for the fact that on transcript page 25,403 you specifically testify about the thickness of the oxide from the surface of the cam gallery down towards the crack tip? The surface of the cam gallery

WRBwrb

you've already said was part of the -- of what you call the weld shrinkage crack.

A That's exactly what I just said, Mr. Dynner. I examined the thickness of the oxide through the metallographic cross-sections all the way from the surface down along the weld shrinkage crack, all the way along the casting shrinkage crack down to the tip. I've testified over and over again that that oxide was very thin, almost negligible, on the weld shrinkage crack, it was thick, between .2 and .5 of a mill, and uniform, and dark all along the casting shrinkage crack from the bottom of that repair weld all the way down to the tip. And that's exactly what I said here.

Q Dr. Anderson, you looked at these samples, didn't you?

A (Witness Anderson) Yes.

Q Did you observe any-- Could you observe any difference in the thickness of the, what I'm calling the oxide layer for convenience sake; did you observe any difference in the thickness of the oxide layer from the surface of the cam gallery down to the tip, or did it look relatively uniform to you?

A In the manner of looking at it flat on, as I did, it looked fairly uniform. I discerned no differences.

Q Did you look at it in a cross-section view similar

WRBwrb

to the photograph that we've marked as DP-1?

A Yes. That's a separate specimen. I did look at that.

Q And in looking at it that way, did you discern any difference in the thickness of the oxide layer from the surface of the cam gallery down toward the crack tip?

A At the magnifications I was using, no.

Q What were those magnifications?

A I believe they would be 50 and 100.

Q Dr. Bush, am I correct that you did not examine these specimens with any care?

A (Witness Bush) The specimens I did not; the photomicrographs I did.

MR. DYNNER: Well, I'm going to move on to a different area, unless the Board has some questions.

JUDGE MORRIS: I'd like just to follow up with Dr. Bush.

What were your observations?

WITNESS BUSH: My observations were, at the higher magnifications that there was a distinct difference, and the area underneath the weld, so far as the thickness of what we will call oxide for convenience, it was either non-existent or very thin when one was in the area adjacent to the weld.

JUDGE MORRIS: So do you concur in the conclusions of Dr. Rau?

WRBwrb

WITNESS BUSH: I do.

JUDGE MORRIS: Thank you.

BY MR. DYNNER:

Q Well, I'm correct, aren't I, Dr. Bush, that there was no magnification above 100 power of the area before the crack was fractured between the weld and the cast iron surface; isn't that right? There were no photomicrographs above 100 power?

A (Witness Bush) The was 50 and 100X, and then as you go further down there are 100 and 500X, yes.

Q When you say "further down," you mean further down the surface of the crack; is that right?

A That's right.

Q And I'm talking now only about the area showing the interface between the weld material and the cast iron. There's nothing more than 100 power on that one, is there?

A That's correct.

Q And is it your testimony that, looking at the 100 power photomicrograph, you can tell whether or not there is oxide and how much oxide there is there?

A I can tell the absence of oxide, or I can tell from the color the presence of the oxide and, as a first approximation, the thickness.

Q The photographs we're talking about are in black and white, aren't they?

WRBagb

A That's correct.

Q So when you say you can tell by the color, what are you referring to?

A Black and white and gradations of color through gray. And the gray is the important thing that you are looking for here.

A (Witness Rau) Can I simply add for the record that the photographs you are referring to are County S-4, which on the right-hand side shows the absence of any discernible oxide at 100 times magnification on the weld shrinkage crack and the comparable picture on the casting shrinkage crack at 100 times magnification is LILCO Exhibit B-63.

And at 100 times magnification it is very clear and very obvious that there is a thick oxide on the casting shrinkage crack and it is very obvious that there's no such oxide on the weld shrinkage crack.

Q Are these photographs that you are referring to photographs of the side that the sample D-1 portion of the crack was taken or are they of D-2 portion of the crack once it was split open, or don't you know?

A As I said, Mr. Dynner, it is not exactly the same amount but basically the photographs we are referring to in S-4 and B-63 include both halves. I mean it is in fact the crack before it is broken open and one half would be

WRBagb

analogous to D-1, that is the left side, and the right side would be analogous to D-2. So they are both there.

Q How can you tell that? How do you know that?

A Well Mr. Dynner, if you look at County 81 for a minute you have here the mounted section, at least one of those on which the metallography, that is, the profile examinations of the cam gallery region were made. Clearly the cam gallery crack location has not yet been broken open in County 81 and it has, if you like, both the left and the right-hand sides of the cam gallery in this picture. I mean it is actually top and bottom in the actual block, both halves are still intact. And this view is the one which the higher magnifications at 100X are shown on S-4, that is County S-4, and LILCO S-63. So both the left and the right side are top and bottom, both sides of the crack are shown in those exhibits. Once you break it open, you then have two pieces and that's the D-1 and the D-2 which were examined in the scanning electron microscope and optically directly at the fracture surface.

Q My question was a little bit simpler than that. You have orientated us already to the location of the photographs in County's Exhibit S-4 with respect to the photograph CB-1, which is part of County's Exhibit 81.

Now you were referring to LILCO's Exhibit B -- was it 64, you said?

WRBagb

JUDGE BRENNER: 63.

MR. DYNNER: 63.

BY MR. DYNNER:

Q Now those don't show the area adjacent to the -- that is, those don't show the boundary of the weld material to the cast iron, do they?

A (Witness Rau) No, Mr. Dynner. As I have indicated previously, B-63 is a higher magnification view at the deepest point of the casting shrinkage crack. If you like on your CB-1 it would be at the uppermost portion of the casting shrinkage crack, that point closest to the water jacket side at the top, or on LILCO B-61, the sketch I have indicated and talked about before, it would be at the far left or deepest portion of the casting shrinkage crack.

Q Yes. And what I'm getting at is with respect to the photomicrographs that Dr. Bush saw he only saw the areas which you have so far identified as coming from the section of the crack that was split in two shown in the photograph on Exhibit 82 as DP-1.

You don't have any similar photographs showing the boundary between the weld material and the cast iron for the portion of the crack which was later denominated D-2, isn't that right?

MR. ELLIS: Objection to the form of the question. There was a sentence or....

WRBagb

JUDGE BRENNER: I am going to sustain the objection. You can ask it again if you want to. I think it got a little confusing, at least to me.

MR. DYNNER: All right. I'll try it again, sir.

JUDGE BRENNER: But you may want to ask Dr. Bush what he saw again also.

MR. DYNNER: I'll do it that way.

JUDGE BRENNER: If it is important to you. It's not important to me.

MR. DYNNER: Is it important to you, Judge Morris? Let's take a vote. If nobody cares I won't pursue it.

JUDGE MORRIS: I think you have covered it.

MR. DYNNER: All right. I'll drop it.

JUDGE BRENNER: I do have a question in the area.

Dr. Anderson, when you looked at the sample you looked at of the area that was broken apart, did you look at a view identical to or -- well, did you look at the sample that we see in DP-3 on Suffolk County Exhibit 82 from that view?

WITNESS ANDERSON: Yes, I did.

JUDGE BRENNER: The same sample?

WITNESS ANDERSON: Yes, I believe it was the same sample.

WRBagt

JUDGE BRENNER: All right.

In any event you at least looked at one that would have that same view.

WITNESS ANDERSON: Yes.

JUDGE BRENNER: Did you see a difference in color of the layer?

WITNESS ANDERSON: The darkness appeared to be covering from the original surface down to the base. It probably was a little lighter toward the top for some reason. But the distinction is one that I could only estimate. But the color was uniform, principally uniform throughout the entire length.

JUDGE BRENNER: One last time and that's it.

Dr. Rau, do you want to describe what you saw in terms of color or shade?

WITNESS RAU: Yes. I want to indicate that there is not necessarily -- in fact there is not a difference in color or shade of the oxide on the weld shrinkage crack compared to the casting shrinkage crack, they are both black or dark.

However there is a substantial difference in thickness and you can't really examine the thickness very definitively looking at the fracture surface, you have to cut it in profile and mount it and then examine it with a microscope. That's what I did. And we did extensive

WRBagb

examinations. County Exhibit S-4 is a representative sample of the lack of any thick oxide on the weld shrinkage crack. And LILCO Exhibit B-63 is a representative sample of the thick oxide on the casting shrinkage crack.

And I observed that consistently over the entirety of the casting shrinkage crack and over the entirety of the weld shrinkage crack. It is not a matter of black, they are all black, there is no red rust on any of them. But there is a substantial difference in thickness revealed by those exhibits and much more extensive examinations that we did.

JUDGE BRENNER: Dr. Anderson, remind me: Did you look at it polished and mounted in a microscope when you said you looked at the 100 power?

WITNESS ANDERSON: Yes. We would be talking about the -- What is it? -- Suffolk County Exhibit 81, the side views. Yes, those were polished and mounted, yes, and etched.

JUDGE BRENNER: Yes, but those aren't at 100 power.

WITNESS ANDERSON: I don't recall.

JUDGE BRENNER: Didn't you tell me you looked at it at the 100 power?

WITNESS ANDERSON: Yes, but not above that.

JUDGE BRENNER: How much more do you have,

WRBagb

Mr. Dynner?

MR. DYNNER: I'm in the process of trying to cut it down.

JUDGE BRENNER: You didn't make use of the panel the way I envisaged. I'm not going to belabor it, I'll just make that statement.

JUDGE MORRIS: Dr. Anderson, you just referred to Suffolk County Exhibit 81 with respect to your observation of the oxide layers. Those photographs are at most at 2 times, aren't they?

WITNESS ANDERSON: I'm sorry, they are macrophotographs of the specimens that I had access to the Failure Analysis microscope to look at, so they just represent the samples. It's not the photographs themselves that are of value to me.

JUDGE MORRIS: I see. So you actually looked through the microscope with as much as 100 times magnification of these samples?

WITNESS ANDERSON: Yes.

JUDGE MORRIS: Thank you.

BY MR. DYNNER:

Q Dr. Anderson, you also looked at the -- or did you also look at the samples which are shown in photographs -- in the three photographs I refer to on Suffolk County Exhibit 82?

WRBagb

A (Witness Anderson) Yes, I did.

Q Thank you.

JUDGE BRENNER: Let me try one more:

Dr. Anderson, don't you see the differences between LILCO Exhibit B-63, the upper photograph magnified 100 times, and Suffolk County Exhibit S-4, the right photograph magnified 100 times?

MR. DYNNER: Dr. Rau can share the original photographs with his colleagues.

JUDGE BRENNER: It is two 100 times magnification photographs. One of them is one of the photographs in LILCO Exhibit B-63, the other is the one you should have, Dr. Anderson, it is your own Exhibit S-4.

WITNESS ANDERSON: I have a copy he can look at.

JUDGE BRENNER: We have been talking about it for two days and I assumed they had them.

Don't you see the difference in the --

WITNESS ANDERSON: Oh well with the 500, yes.

JUDGE BRENNER: No, just the two 100's.

Use your magnifying glass, if you want to.

WITNESS ANDERSON: No. There is a fuzziness around the fracture.

JUDGE BRENNER: I want to be very candid with you, I mean even I see the difference and I have trouble with a lot of these things.

WRBagb

WITNESS ANDERSON: Is there another one of these?

(Document handed to Witness Anderson.)

JUDGE BRENNER: I should say I saw the difference when I had the two originals in front of me.

WITNESS ANDERSON: There is a sharpness in one case and a fuzziness in the other case. The upper fracture has a sharpness and a delineation of a black -- a dark black and a light gray in the fracture portion. The bottom of the crack is fairly fuzzy in all areas. But you'll notice that there are areas which are not associated with the fracture that are just where the graphite is and it has the same fuzziness. So I used that as sort of my control condition.

WRBeb

You will notice the photograph at the top where the weld is, that the graphite in that location is fairly sharp, so there is a fuzziness to one photograph and sharpness that runs through the other.

JUDGE BRENNER: Dr. Rau, what about that? If you look at the two photos in LILCO Exhibit B-63, taken at 500 X magnification, do you see it? Are those graphite flakes? Let's take the one at the very top that you see only part of.

WITNESS RAU: I'm sorry, take the 100 or the 500?

JUDGE BRENNER: The 500.

WITNESS RAU: And what is your question?

JUDGE BRENNER: At the top, what is that at the top?

WITNESS RAU: That's another graphite flake that has been oxidized, or around which the perlite has been oxidized. That's a portion of the casting shrinkage crack which is connected to the major portion of the crack out in the plane of the polish. In other words, it is linked up just below or just above where the plane was.

And the thick oxide is clear and uniform on both those portions of the crack as well as the regions in between where the graphite flakes were, as shown in the middle of the 500 X magnification photograph of B-63.

JUDGE BRENNER: What is that a valid control,

WR3eb

Dr. Anderson, if it is part of the same crack network?

WITNESS ANDERSON: I wasn't referring to the 500 X. I believe the 500 X clearly shows in itself. What is missing is a 500 X up in the weld area which we could compare on itself.

It's the 100 X where if you go off-crack and look at the artifacts then that's what one would look for.

JUDGE BRENNER: Mr. Dynner.

BY MR. DYNNER:

Q Dr. Bush, are you all right?

A (Witness Bush) Yes, I'm all right. Sure. I'm just listening.

Q Well, I'll give you a question you can answer.

A Okay, that will wake me up.

Q Can you tell us at approximately what temperature range you would expect to find wustite oxide form in the block?

A I'm not really an expert in that area but I would expect this to be the higher temperature regime. I guess a semi-educated guess would tend to be up in the neighborhood of 12 to 15 hundred degrees, something of that nature, but that is just a guess.

Q All right.

These questions can be for any of the experts on the panel. I just wanted to get the temperature range.

WRBeb

Please tell me whetner you are talking Fahrenheit or Centigrade, because I get confused.

A I would consider it as forming in the upper part of the solid range. I'm not concerned too much about that, so that would put it I would consider in what I call the austenitic range, so I would put it up in that temperature ranging possibly at 17 to 18 hundred but I imagine it is fairly continuous, but I don't know the lower breakpoint on the thing where you might get the transition.

Q Anyone else on the panel?

A (Witness Rau) Yes, it's as Dr. Bush has-- He has guessed correctly. It's about 1200 degrees Fahrenheit for the lower bound. It will form above that temperature.

Dr. Wachob may know more specifically.

Q So 1200 degrees Fahrenheit upward to 18 or higher?

A (Witness Bush) It could probably go higher but it becomes academic when we have molten iron, so I'm considering it only in the context of the solid material.

Q You will notice you're talking to somebody who doesn't know the temperature of molten iron.

How about the temperature range for the formation of hematite oxides? Anyone?

A It's a low temperature. Let's see. I am trying to think of the hydrated oxides that would form there, too.

WRBeb

I think these are-- I have to get myself separated into the magnatite and the hematites.

Now I would say these would be the low-temperature regime, probably 400 degrees or so, and down. Perhaps 400 may even be on the high side; I'm not sure.

Q Dr. Wachob?

A I'm talking Fahrenheit in this instance. I won't change gears with regard to Centigrade and Fahrenheit.

Q Thank you.

Does anyone disagree with that?

A (Witness Rau) Yes. I think Dr. Bush is a little bit on the high end.

Certainly the conditions under which the transition from the FE203, which is the hematite, to the magnatite, the FE304 kind of oxide, can depend on a lot of different factors, but generally speaking, the FE304 will extend -- will form from temperatures like 1200 down to -- I'm not sure what the lower cutoff is, but I believe it to be lower than 400 in general.

And then the FE203, the hematite, is the low temperature -- lower temperature oxide.

And again, Dr. Wachob may want to add to that, too.

Q Do you want to add anything, Dr. Wachob?

WRBeb

A (Witness Wachob) No.

Q All right.

Dr. Anderson, do you generally agree with these numbers, or do you have any disagreement with them?

A (Witness Anderson) I think it is a real pleasure to be able to agree with my colleagues for once. I think I'll stop at that.

MR. DYNNER: I'm not going to spend a lot of time because this ground has been gone over somewhat, but I just have a couple of questions to put to them, Judge.

JUDGE BRENNER: Well, that's fine. And I know you keep putting things in the form of questions to the witnesses when you are talking to me, and that's fine also. But don't expect to finish this panel -- your questions of this panel at one minute before the time you expect this panel to be dismissed, because that is not going to happen.

MR. DYNNER: I understand that. I understand, sir.

JUDGE BRENNER: Okay.

MR. DYNNER: I really am trying to cut down on a lot of this, albeit it's difficult.

BY MR. DYNNER:

Q Dr. Rau, let me give you a hypothetical.

If you were to find that the celebrated oxide

WRBeb

layer was comprised of hematite, it is true, isn't it, that that would indicate that your theory of the formation of the oxide layer would not be correct? Isn't that right?

A (Witness Rau) Your hypothetical is not complete enough for me to answer. You mean I am to assume that it is hypothetically only hematite, there is no hydrated oxides,--

Q Let's start--

A -- there is no -- nothing else?

Q Let's start with hematite, 100 percent.

A If that is all there is and if the interrogation was sufficient to insure that that's all there was in all layers from the top of the oxide all the way down, then I would agree that my perception of the formation of the crack during the casting process would not be what it was.

Q And let me put the shoe on the other foot, Dr. Anderson.

If we did this test that you have been advocating, what would convince you that your theories about the formation of the oxide layer were incorrect?

A (Witness Anderson) Certainly if the higher temperature oxides, wustite for sure, but a spinel-like magnatite being present, I think that would be sufficient and adequate to indicate that it truly had been characterized properly by the Failure Analysis people.

Q Are you saying that if any presence of wustite

WRBeb

was found in the oxide layer, that would disprove your thesis?

A Assuming that there has been no partial deoxidation of the oxide layer, in other words, nothing has happened since, I would accept as definitive the presence of a wustite.

Q How about the magnatite?

A I think that gets into the middle ground. If I saw wustite I would expect magnatite. If I saw hematite I would expect maybe some magnatite. So a wustite-magnatite I still would say was properly characterized.

I think the magnatite is non-definitive.

Q Well, consistent with your theory, would you be willing to surrender your thesis if you found let's say more than -- if you found that there was more than 25 percent of the oxide was a magnatite?

MR. ELLIS: Judge Brenner, I object to all of these hypothetical questions. They are based on a test that has not been done, and as far as LILCO is concerned, will not be done, is not necessary. And there has been a great deal of testimony relating to that. And I therefore object to the question.

JUDGE BRENNER: The test is not going to be done, never. Is that what you're saying?

MR. ELLIS: It is not LILCO's current intention

WRBeb

to conduct that test.

JUDGE BRENNER: Well, LILCO has changed its intentions from time to time in this very proceeding. Correct?

MR. ELLIS: Yes, that's correct.

JUDGE BRENNER: Well, let's let him ask a few more questions along these lines.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: Some of them are repetitious of questions I attempted to ask, but perhaps not as well. So I'm not certain the exact information is there, but I think similar information is already in the record, Mr. Dynner.

MR. DYNNER: Yes, sir.

WITNESS ANDERSON: I think I would always be willing to change my opinion if new information comes in that buttresses my concerns. This would qualify as new information. It would be irrefutable and it would certainly give an unambiguous answer to the surface.

And I might point out what it really does is not just -- it doesn't just identify the surface layer, it identifies the whole etiology of the crack.

BY MR. DYNNER:

Q Go ahead, Dr. Rau.

A (Witness Rau) That was a different question. The hypothetical I answered. I have a comment to add to

WRBeb

what Dr. Anderson has just said.

He indicated that the presence of magnatite would not be conclusive in his opinion. We have already testified that, based on our calculations and analyses, that it is our belief that that oxide, the thick dark oxide is magnatite. It is not our belief that it is wustite.

In the absence of wustite and the presence of magnatite or the presence of some low-temperature oxides like hematite along with the magnatite would not be definitive. It wouldn't be conclusive with regard to the formation conditions of the shrinkage -- the casting shrinkage crack.

For that reason Dr. Anderson has just indicated that the test which he has been suggesting need not be conclusive because he just indicated that the presence of magnatite and hematite together wouldn't tell him whether or not it was a shrinkage crack or a low-temperature crack. And as I have already indicated, it is very difficult to do that kind of test properly.

I believe it is completely unnecessary given the thickness measurements and given the marked and clear difference between the thickness of the oxide on the casting shrinkage crack and the thickness of the oxide on the weld shrinkage crack.

I have already indicated there is no way to

WRBeb

explain the differences or lack of oxide on the weld shrinkage crack and still explain the thick oxide on the casting shrinkage crack by any sort of an operational mechanism. For that reason, it is completely unnecessary and would be inconclusive to do any additional testing of this type.

JUDGE BRENNER: Dr. Rau, I did hear what Dr. Anderson's view on what he thought the presence of magnatite would show. I'm not sure you fully characterized what he said. But I thought it would be consistent with your opinion that the presence of magnatite would be inconsistent with Dr. Anderson's theory that the cracks occurred during operation.

WITNESS RAU: I agree with that, your Honor, but what Dr. Anderson said was the presence of magnatite would not be inconsistent with his.... I agree, your Honor. Yes, I believe it to be magnatite. It's dark, as magnatite is. It is not rusty colored like dehydrated low-temperature oxides are. And there is no question in my mind that it's magnitite.

And for the reason I indicated, I expect to see some of the low-temperature oxides just because--

JUDGE BRENNER: I understand.

You would expect that there would be magnatite present in greater than just say trace quantities?

WRBeb

WITNESS RAU: I think it is almost all magnatite, greater than 90 percent. But you know, I wouldn't be surprised to have a few percent of low-temperature oxides in there. I might not even be surprised to find a few percent of the wustite.

I don't think the majority of it can be wustite because it is were it would be a lot thicker even than it is.

JUDGE BRENNER: And Dr. Anderson, I thought you did go so far as to say, in answer to a question from your Counsel, that if magnatite was present in greater than 25 percent that that would be inconsistent with your theory.

WITNESS ANDERSON: If there is magnatite in that quantity it certainly would be, but perhaps from a reason that is not clear. Magnatite is a very unusual oxide. It can readily be reduced. If you breathe on it you can reduce it. It is not the most common form of iron oxide.

Therefore I believe that there also is present some carbon that hasn't been characterized. So if there was magnatite, I would say that that would rule out the presence of carbon being on the surface, too. The magnatite and the carbon being there at the temperatures of this operation are counterindicated.

And so seeing the magnatite, characterizing the magnatite would certainly, in my mind, be definitive and I

WRBeb

could make a very strong argument for the fact that at the bottom line, the cracks are not operational but are--

JUDGE BRENNER: Would that be true if magnatite was present in any appreciable quantity? I don't know if 25 percent was a studied number between you and your Counsel, or just something he picked out of a hat.

WITNESS ANDERSON: I don't know where he got that number.

JUDGE BRENNER: All right. That answers my question right there.

What would your lowest definitive number for the presence of magnatite be?

WITNESS ANDERSON: Well, assuming there's no surprises and that there is not something else that they find in there besides calcium and sulfur, there's not something that would bear on it, just what we know, and we are just characterizing the surface, if the magnatite was on the order of 10 to 15 percent, then I would say that that rules out the presence of carbon, free carbon, and then rules out the possibility of fretting or graphitization. It rules out the possibility of a working crack.

So if I saw 10 or 15 percent unequivocally-- Of course wustite, then I would only have to worry about externalities, finding something unusual on the surface.

JUDGE BRENNER: But you were talking about

WRBeb

magnatite up until your last phrase?

WITNESS ANDERSON: Yes. Yes, we were focuing on magnatite.

MR. DYNNER: I just want to make a quick comment, Judge Brenner, and that is that Mr. Ellis had the advantage of knowing that. Last night I telephoned him and requested that LILCO voluntarily perform this test and--

JUDGE BRENNER: I'm certainly surprised that such a conversation took place.

MR. DYNNER: Well, I wanted you to know that for the record.

JUDGE BRENNER: Well, you know I've complemented Counsel and the parties many times in terms of their ability to -- not just to reach settlements but to recognize that settlement discussions should not terminate when the litigation begins.

MR. DYNNER: Well, I wanted to go a bit farther than that if I might, because Mr. Ellis informed me last night that he would not be able to have an answer for me today. He has since made a comment on the record that--

JUDGE BRENNER: Well, that wasn't a studied comment.

MR. DYNNER: It may or may not be. But I do at this point want to--

JUDGE BRENNER: Let me explain, Mr. Ellis, why I

WRBeb

said that.

You know, Mr. Dynner, that on the spur of the moment when you feel an objection is a proper objection to make, you don't necessarily think through fully all the ramifications of a statement beyond the immediate purpose of addressing the objectionable question.

MR. DYNNER: My intention in no way was to criticize Mr. Ellis. I simply would like to move at this time that the Board order that the sample in question on this fractured surface, which I think is a manageable, portable object, be made available to Suffolk County so that we can take the steps.

We have looked into it, and we would like to take that item and have it tested in an independent laboratory in Chicago. We have talked to them and we know that it can be done within two weeks, with an analysis of three different points or three different levels in the layer, or more.

JUDGE BRENNER: Let me stop you for a moment. Why don't we finish with the panel and then come back to this?

MR. DYNNER: I'd be happen to.

JUDGE BRENNER: Because that was one of your concerns, which I share.

MR. DYNNER: Yes, sir.

If you will give me one minute, I am going to

WRBeb try to run through and make sure that I have only a very small number of questions left.

(Pause.)

WRBagb

BY MR. DYNNER:

Q Dr. Bush, I thought -- and please correct me if I am wrong -- that at one point in your testimony you referred to a fatigue test or fatigue study that you thought FaAA had done on the cast iron failure.

A (Witness Bush) Yes.

Q I'm wondering whether anyone on the panel could tell me whether, as a result of that fatigue test, that beach marks were noted in the fractured surface of the cast iron that was subjected to that fatigue test?

Did you see it, Dr. Bush?

A That exclusive question was asked yesterday -- in fact, I think the words were the same.

Q I'm sorry. I apologize.

A I think it was addressed to Dr. Wachob and -- well I shouldn't put words in Dr. Wachob's mouth.

JUDGE BRENNER: He's asking you now.

BY MR. DYNNER:

Q Did you see the results of that test or did you see the fractured surface?

A (Witness Bush) No, I did not. I indicated that given that those samples were conducted and that meant that there had to be a spectrum of amplitudes -- I did not know, of course, whether they had changed the amplitude at any time, and those samples should be a logical place to go for

WRBagb

-- to see if indeed there are or are not beach marks. But I have never seen the samples.

A (Witness Anderson) Nor have I.

A (Witness Rau) I've seen them. As we indicated yesterday, the fatigue crack propagation specimens that Dr. Bush made reference to were performed under constant amplitude fatigue cycling. They did not undergo any temperature cycles, they did not undergo combinations of high frequency and low cycle fatigue; the very conditions that are conducive to producing the beach marks which are normally seen.

My recollection from looking at the fracture surface is -- I wasn't looking for that in particular -- that there were no of the obvious beach marks that you expect if you had variations in load or variations in oxidation. I mean you have to have some change during the course of your test to delineate and create the mark that you see as a beach mark.

And if you just hold the load constant and run it and measure how fast the crack grows, you really would not expect to see a beach mark in cast iron or in anything else for that matter. So I wouldn't expect them to be there and I don't recall seeing them.

As I indicated I think yesterday on the ligament cracks of the original 103 -- which have in fact been

WRBagb

through combinations of temperature cycling, high cycle fatigue, high frequency fatigue and low cycle fatigue. There were indications of beach marks or delineations of the crack at various positions.

Q I have just one other area to cover and it's brief, I believe.

Dr. Rau, you testified earlier today that -- I think you said that an ultrasonic UT was performed on EDG 101 to look for circumferential cracks, is that correct?

A That's correct, Mr. Dynner. That's my understanding.

Q When was that test performed?

A I don't have the inspection report here and don't recall the precise date. It was certainly before the destructive examination of 103, so it would have been -- it was done before the 103 ultrasonic inspections but the same procedure which was utilized at that time was utilized to inspect the original 103 and to compare the ultrasonic inspection results with the destructive measurements of circumferential crack depth. But the actual inspection on 101 had taken place prior to the detailed inspection on 103.

Q Do you recall in your testimony -- and I mean "you" to include Mr. Taylor -- on October 11th that at that time I asked you questions -- I asked the panel, you and

WRBagb

Dr. Wachob and Mr. Taylor, questions about those tests and that you told me that the inspections -- only inspections carried out for the circumferential cracks were liquid penetrant inspections of the liner landing?

JUDGE BRENNER: Mr. Dynner, I lost you. Are you talking about a deposition?

MR. DYNNER: Yes.

JUDGE BRENNER: Okay, good. I didn't remember Mr. Taylor ever being here and I thought I was losing my mind.

MR. DYNNER: No, I was talking about the deposition, your Honor.

BY MR. DYNNER:

Q Do you remember that?

A (Witness Rau) I don't remember that. Do you have a reference --

MR. ELLIS: May we have a page number?

BY MR. DYNNER:

Q Five.

A (Witness Rau) I'm sorry, page five?

Q Yes.

(Pause.)

There were liquid penetrant inspections and on page six Mr. Taylor also indicated there were no magnetic particle examinations....

WmBagb

(Pause.)

A I have read those pages of the transcript now.

Q And my question is a simple one: I asked the panel, specifically Mr. Taylor, what were the type of inspections that were carried out on the three engines looking for circumferential cracks in the blocks. And it is true, isn't it, that nobody told me during that deposition that there were ultrasonic inspections carried out, isn't that right?

A I don't know whether that is true or not, Mr. Dynner. Certainly in the page citations you have given Mr. Taylor did not so indicate. I'm not sure whether I had knowledge of those ultrasonic inspections at the time of my deposition, I may have or I may not have, but I suspect I didn't or I would have probably chimed in at this particular point in time.

I have knowledge of them now certainly from having sat through the panel descriptions and listening to Doctors Johnson and Schuster talk about what was done and when it was done, and I'm not sure whether Mr. Taylor had knowledge of them at that time either.

Q You haven't -- Let me put it this way:

Are you of the opinion that it would be very difficult to detect circumferential cracks in EDGs 101 and 102 by any of the non-destructive examination methods?

WRBagb

A Well you will have to be specific with regard to how deep a crack you would talk about detecting. If it's talking about one mil, one thousandths of an inch deep then that's not going to be detectable by any technique. If you're talking about a crack which is 3/8ths of an inch deep, then I believe there are several non-destructive inspection techniques which can identify them.

It certainly is a difficult inspection area and the mag particle and liquid penetrant -- unless the area is very carefully cleaned -- can be a difficult location.

The ultrasonic inspection I believe is quite reliable at those depths, that is, 3/8ths inch deep. It of course would not be reliable for detecting something less than a 16th of an inch.

Q Has an ultrasonic examination been performed on all of the cylinder liner landing ledges of EDGs 101 and 102?

A I don't know the answer, Mr. Dynner. I do know that on 101 that any indication they got from -- I have forgotten whether it was liquid penetrant or magnetic particle, but any indication at all they got on 101 was evaluated with the ultrasonic for confirmation that it was or was not a false indication.

With regard to 102, I just don't have any knowledge of what inspections were done there.

WRBagb

Q I want to remind you of your testimony on October 11th and ask you whether you still are of the same opinion, page 21, line 19.

You said, and I quote:

"There are no definitive inspection results which I have confidence in which would have detected circumferential cracks if in fact they were there, so we have no direct firsthand evidence that there are no cracks in the liner landing area of 101 and 102."

Are you still of that opinion?

A No, Mr. Dynner, I'm not. As I have indicated based on this statement I clearly was not aware of the ultrasonic inspection at the time of my deposition.

Now that I am aware of the fact that it was done and the conditions under which it was calibrated on the original 103, I believe we have confidence that 101 does not have or did not have circumferential cracks at the time of that inspection.

But I can't comment at this time with regard to 102 because I have no specific recollection of whether or not the ultrasonic inspections were done.

Q All right.

WRBagb

I am going to just follow the procedure we have been following and ask Dr. Bush and Dr. Anderson if they have any comments on Dr. Rau's testimony about the ultrasonic examination for circumferential cracks.

Gentlemen?

A (Witness Bush) Nothing different than I have said in the proceeding unless I were able to evaluate in some degree the ultrasonic technique I would have reservations. That would simply be a matter of examining the method of calibration and things of that nature.

It has the potential from that surface but it is not going to be easy is my suspicion because I think you are going to have to use a special transducer.

JUDGE BRENNER: A special what?

WITNESS BUSH: Transducer.

BY MR. DYNNER:

Q Any comment, Dr. Anderson?

A (Witness Anderson) No.

MR. DYNNER: I have no further questions, Judge.

JUDGE BRENNER: Do you have any special transducers that you used, Dr. Rau?

WITNESS RAU: You are asking the wrong person, Judge Brenner. I don't know what they used. They had a transducer, I know it was interrogated from below the liner land but beyond that I am in over my head.

WRBagb

JUDGE BRENNER: Let me try one more. I am certainly in over my head also.

Dr. Bush, when you were talking about difficulties area, I had the impression -- and it may be just an inference rather than something you said -- that some of your difficulties that you envisioned would be if the UT test or interrogation were done from the ledge, that difficult area of the ledge corner as opposed to the way Dr. Rau says it was done from below the liner landing edge.

I am not asking a very good question but does that change your view on the difficulty?

WITNESS BUSH: I would say unless they used a special technique they couldn't do it from the ledge directly. Now whether -- did they do it from below the liner ledge or did they do it from the counterbore area.

WITNESS RAU: Below the liner ledge.

WITNESS BUSH: Below the liner ledge -- this assumes that the liner has been pulled, correct?

WITNESS RAU: That's correct.

WITNESS BUSH: It would be simpler than the one that I had understood. I had understood they were going to do it from the counterbore area and that would be a very difficult one requiring a special shaped transducer. Below the liner ledge I think it is at least technically feasible under those circumstances.

WRBagb

So I had misunderstood. I thought the word was counterbore in the earlier conversation and that I think would pose major difficulties.

JUDGE BRENNER: Staff?

MR. DYNNER: Excuse me, I neglected to do one thing before and I'm going to do this just because everything else is in evidence, and that is to move into evidence Suffolk County Diesel Exhibit 81, consisting of the two photographs previously identified which will mount on one sheet, and Suffolk County Diesel Exhibit 82, which will consist of --

JUDGE BRENNER: Three photographs.

MR. DYNNER: -- three photographs previously identified. We will also mount those on one sheet.

JUDGE BRENNER: Any objections?

MR. PERLIS: None.

MR. ELLIS: None.

JUDGE BRENNER: All right. They are admitted into evidence.

(Whereupon, the documents previously marked for identification as Suffolk County Diesel Exhibits 81 and 82 were received in evidence.)

JUDGE BRENNER: Mr. Perlis, how much do you have? We are going to have to take a longer than normal

WRBagb

break as I predicted, a half-hour in fact, before we have any discussions after these witnesses leave, and that includes the subject we said we would discuss, and I cut Mr. Dynner off in the middle of talking about his possible settlement I guess, whatever you want to term it. But I want to take the break before that.

If we break now, we'll have to break twice -- how much do you have?

MR. PERLIS: Well I had originally planned on walking the witnesses through an event tree that Dr. Bush had drawn up since we have covered practically every branch of that tree already, I was not planning on doing that now and I think I can finish in probably about 10 minutes.

JUDGE BRENNER: All right. I don't want you to take any of my comments as to discourage you from doing something that would put new evidence on --

MR. PERLIS: No, I think it would have been a helpful way to proceed except that we have already covered all of the material that would have been covered by proceeding that way.

JUDGE BRENNER: Well it is up to you. If you had more questions after the time everybody else took, that would have been perfectly acceptable. I only asked so I could understand how to gear the breaks.

(Pause.)

WRBagb

MR. ELLIS: Is there going to be a break?

JUDGE BRENNER: I want to try to finish with the panel. The Board may have a few questions also but not many.

MR. ELLIS: I think if I had about two or three minutes I could decide if I had anything or --

JUDGE BRENNER: Let's go off the record or stay on the record, it doesn't matter.

Do the witnesses want to take a break?

(Indications of assent.)

JUDGE BRENNER: Fine. We'll take it. You can't do anything in five minutes so we'll take ten minutes.

(Recess.)

AGBbrb

JUDGE BRENNER: Let's go back on the record.

EXAMINATION

Q BY MR. PERLIS:

Q Dr. Bush, this is a question related to the discussion which took place just before the luncheon break today.

Could you turn to page 5 of your supplemental testimony?

A (Witness Bush) Yes, sir.

Q Just to make clear: At that page you stated that strain gaging of the new 103 block would yield more definitive data concerning the compressive and alternating stresses in the cam gallery than could be obtained from either the EDG-101 or the EDG-102 blocks.

Do you see that statement?

A That's correct.

Q Did you intend -- and do you intend now -- that that statement, that the data that would result from the strain gaging of the 103 block would be relevant to the 101 and 102 block? This is for compressive and alternating stresses, now, in the cam gallery.

A That's correct.

Q Okay.

MR. PERLIS: Judge, I have no other questions in that area. I just wasn't sure that that was clear before the luncheon break.

AGBbrb

MR. ELLIS: I have just one question.

JUDGE BRENNER: I don't think he's finished, Mr. Ellis.

MR. PERLIS: I'm finished with that area. I'm not finished -- can't be that optimistic.

BY MR. PERLIS:

Q Dr. Wachob, in your fractographic studies when the sample was broken into two pieces, did the oxide layer adhere preferentially to one fracture surface or the other, or did the layer itself divide between the two surfaces?

A (Witness Wachob) Both surfaces of the crack were oxidized to whatever extent they were before they were broken open, and so therefore there was an oxide on both sides.

Q Dr. Bush, what do you infer about the nature of the oxide from the fact that it had adhered to both surfaces after it was broken apart?

A (Witness Bush) It obviously depends on whether it was a continuous oxide between the two surfaces or whether it was two separate oxides. If it were a continuous oxide, I would infer that the substrate boundary -- the boundary between the oxide and the metal -- would be quite strong and adherent, which would be indicative, possibly, of the type of oxide that we would have.

Q Dr. Wachob, do you agree with Dr. Bush's

AGBbrb

conclusion?

I'm sorry. Dr. Rau, did you want to say something first?

A (Witness Rau) Yes. I agree with what Dr. Bush has said. I just wanted to add, for clarity, to what Dr. Wachob had said.

If you look at LILCO Exhibit B-63, you can see the -- again, the thick dark oxide on both sides of what was originally a graphite flake. And when you break open the crack, the weakest link is the graphite, and so you end up with the oxide on both sides of the fracture surface where the graphite was.

And, in between -- if you move over at the 500 magnification, in between the graphite flakes, it breaks in the oxide, too, at least for the most part. So you end up with oxide on both sides.

Q Dr. Wachob, did you have anything to add?

(No response.)

Dr. Anderson, do you have any comments on this?

A (Witness Anderson) I believe there was oxide on both sides of the crack, and that seems consistent.

Q Does that tell you anything about the nature of the oxide?

A No.

Q Dr. Rau, does the model for Widmanstaetten

AGBbrb

graphite formation envisage the direct precipitation of Widmanstaetten graphite from melt, or does it assume that a more normal form of graphite precipitates initially and serves as nucleation sites for the formation of Widmanstaetten graphite?

A (Witness Rau) Okay. The formation of the graphite doesn't actually precipitate from the melt. It's a eutectic reaction, so there's a simultaneous formation of the graphite and austenite -- which is a form of steel, if you like -- at the eutectic temperature.

When that initially occurs, it's my opinion that, if you like, normal graphite forms first as part of the eutectic cells of the graphite. There may be some of the degenerate Widmanstaetten graphite formed at that time; but it's my opinion that the majority of the Widmanstaetten graphite forms during the subsequent slow cooling from the eutectic temperature towards the eutectoid temperature.

Without going into great detail, the ability of the austenite to retain carbon in solid solution decreases as the temperature goes down. So the austenite portion -- that is, the steel portion -- has to get rid of this carbon which it can't maintain in solution as it's cooling down. And so what happens is, basically, that either grows on the existing graphite, in the form of conventional graphite, or, in this particular case of the original 103, because of the

AGBbrb

factors -- collate and trace element contamination -- it led to the precipitation of the degenerate Widmanstaetten graphite in the vicinity of the graphite flakes, but not necessarily on them, during this cooling process.

Q Dr. Bush, would you agree with that?

A (Witness Bush) That's the mechanism I visualized, rather than formation completely at the eutectic temperature.

Q Dr. Anderson, are you in agreement with both of them?

A (Witness Anderson) Yes.

Q This is to everyone on the panel. Does this tell you -- let me first ask:

Dr. Rau, are you saying, then, that the Widmanstaetten graphite forms over a range of temperatures?

A (Witness Rau) Yes.

Q Does everyone agree with that?

A (Witness Anderson) Yes.

A (Witness Bush) Yes.

Q Dr. Rau, does that tell you anything about the temperature at which the fabrication-induced cracks in 103 occurred, the old 103?

A (Witness Rau) Well, it is certainly one of the factors which is related to my opinions about when and how it formed. It is my opinion that it formed between the

AGBbrb

eutectic and the eutectoid temperature; and the combination of many other observations along with that lead me to believe that the cracks formed and oxidized, perhaps, at temperatures below the eutectoid temperature once the Widmanstaetten graphite was already there.

Q Dr. Bush, do you agree with that?

A (Witness Bush) I think the evidence tends to at least indicate that as a strong possibility.

Q And, Dr. Anderson, do you have a comments?

A (Witness Anderson) I think that is possible, yes.

MR. PERLIS: Judge, I have no further questions.

JUDGE BRENNER: I think you have the record for sequential answers in which they're all in agreement.

MR. PERLIS: I guess I should apologize.

JUDGE MORRIS: Good questions.

JUDGE BRENNER: I'm not giving you credit, Mr. Ellis. You said you had one before; maybe you have two now.

MR. ELLIS: I have one small topic.

EXAMINATION

BY MR. ELLIS:

Q Dr. Anderson, you, I think, testified earlier -- correct me if I'm wrong -- that your 100X view of the crack surface was not conclusive, and that you wished you had had

AGBbrb

a 500X.

Is that correct?

A (Witness Anderson) I did not have a view of 500X in the area of the weld. That would have been helpful and definitive.

Q Well, Dr. Anderson, why didn't you just click the gizmo, change the objective lens to 500 from 100 and look at it?

A At that time I felt that I could see the cracks. There was no question in my mind about the coverage of the surface, and there was no contention that I could see -- certainly not from the depositions. Apparently everybody was in agreement that it was a uniform coating from the surface to the root of the crack. So I went as far as I thought was necessary.

Q Dr. Rau, did you look at it at various magnifications?

JUDGE BRENNER: The answer to that is yes.

AGBeb

WITNESS RAU: Judge Brenner is correct.

MR. ELLIS: No further questions, your Honor.

JUDGE BRENNER: Very well.

Dr. Rau or Dr. Wachob, why didn't you just simply include another photograph at 500 X in this series of photographs of the crack in the area of the weld?

I got the idea for that question from Mr. Ellis.

WITNESS RAU: In my opinion, your Honor, the presence of the oxide on the casting shrinkage crack and the absence of the oxide on the weld shrinkage crack are perfectly obvious from the 100 X magnification photograph and it wasn't omitted for any particular reason. I didn't think it was necessary.

JUDGE BRENNER: I'm sure my memory is poor, but I thought the other day when we first talked about the absence of that 500 X magnification of the crack alongside the weld that Dr. Wachob said he didn't have one here as opposed to that none existed. I don't remember.

Could you remind me, Dr. Wachob?

WITNESS WACHOB: I did not say that. All of the photographs that we have in the cam gallery books are in these albums that everybody has been passing around, so there was no 500 X magnification photograph.

JUDGE BRENNER: Could you still take one? The

AGBeb

sample still exists in the prepared form that is properly prepared in the same way it was for a 100 X magnification, Dr. Wachob?

WITNESS WACHOB: With slight preparation, because it sat around, one could take that photograph now, yes.

JUDGE BRENNER: Mr. Dynner?

MR. DYNNER: No, sir, I have nothing further.

JUDGE BRENNER: We're done.

Well, while the witnesses start packing -- I see they are -- and while we're on the subject of schedule, -- keep packing -- I will tell you that-- Let me put it this way:

We appreciate the fact that the witnesses have had other schedule considerations besides this hearing, some of which we have had to discuss here unfortunately, and much of which I'm sure was the case that we didn't discuss here, and if you think that the Board is not aware of that and does not appreciate that fact and have some concern for that fact, then you're wrong, because we do.

However, if you believe that we think that the substance of this hearing is more important than your individual schedules that is also correct. And sometimes we have to balance things out, and it was our view, as applied to this issue, that this combined panel would be helpful. And now that we've done it, I am of the view -- perhaps I'm

AGBeb

the only one -- that it has been quite helpful to me. Even though much of the testimony has been repetitious, it had the advantage of getting it all together where the other witnesses could respond.

I believe it may be less frustrating for expert witnesses to be able to do that. Maybe I'm wrong. But one reason the panel process worked, and the point I'm getting to in a very long-winded way here, is because of the abilities of the witnesses in two different areas. One is an appreciation of the hearing procedure, and the other is the substantive expertise in the subject matter.

And because each of you have been able to combine those two, I think the panel worked very effectively. And we thank you for that.

I also want to assure each of you that I will never think of rust as just plain rust again.

With that, you are all excused to catch your planes or whatever. Thank you again.

(Witness panel excused.)

JUDGE BRENNER: All right. Mr. Dynner, I cut you off earlier when you were talking about what I guess was a settlement proposal. But give me your own label.

MR. DYNNER: Actually I didn't refer to it as a settlement proposal. It was a motion I was trying to make, and it was in the form of a motion to compel. And the basis

AGBeb

for the motion was simply that it now appears to us at least that, based upon all of the testimony that we have heard, that there are sharply divergent bases concerning the cam gallery cracks, most of which, at least to my ears, appear to be differences of observations, opinions based upon the analyses of -- none of which appear to be definitive.

And it does appear to me on the basis of what I have heard that there is a test which at least the County believes would be definitive, at least potentially definitive and dispositive of the issue concerning the origin of the cam gallery cracks, and accordingly, the issue as to whether or not they are propagating or not.

And it therefore seemed to us appropriate, since this matter I must say only came out as I sat and listened to varying views of the experts including my own, that we have a way of carrying out what appears to be a very simple procedure. We have checked into it and found that the cost is not great, that it could be done in a turn-around time of two weeks. If we pay them double it can be done in three days.

It is a company which I am told by Dr. Anderson he has no connection with. He didn't know the people there. He is aware of them, however, by reputation as being a capable, competent, and well-regarded independent laboratory, experienced in doing these x-ray analyses.

AGBeb

And on that basis I asked first LILCO's Counsel whether or not they would voluntarily do that, and it was my feeling that while we have the hearing in session and the parties all in one place, that I would, because LILCO is not in a position to respond as quickly as I might have liked, and with the understanding why they couldn't, because it was on very short notice, that the County would undertake to have that test performed if we could have access to the sample in question so that it could be sent to Chicago and tests performed and the results of the tests made available to the Board and all the parties.

And it is for that reason that I have made this comment in the form of a motion.

JUDGE BRENNER: Have you thought through what the County's position would be if the tests were performed and if it showed to the County's satisfaction that -- I'm not going to state this in an evidentiary fashion so it may not be literally correct -- but that when looking at the results of the tests, they would prove that the County's theory of what might have been the formation of the cracks would be inconsistent with the results?

MR. DYNNER: I think that the answer is Yes, we have thought about it and we have discussed it with our consultants and it would, in our view, be a test which potentially would show that if in fact the oxide was a

AGBeb

high-temperature oxide, that would show that FaAA's thesis was correct.

That would therefore mean that the oxide was in fact formed at the time that the hot tears were formed for the entire length of the crack. And the County at that point, with regard to the cam gallery cracks, would be inclined to move to the Staff's position. That is to say we still believe that there isn't any hard evidence as to whether or not these cracks exist in 101 and 102 below the weld material and in a manner that is disconnected.

There is no evidence at all I think in 102 because that--

JUDGE BRENNER: You would still want the--

MR. DYNNER: We would still want the monitoring that both the Staff and Dr. Anderson alluded to, and we would still want to see the -- some periodic depth probe measurements taken, as Dr. Anderson stated in his testimony.

But with respect to the cam-- And we would still of course want to see and analyze testing results, for example, look at it as I think the Staff has said they would do at the first refueling outage.

But for those issues, it seems to me that that would resolve in our own minds the concerns that the County has and has expressed here, that propagating cam gallery cracks, which we think that an oxide -- if it's shown that

AGBeb

the oxide is low-temperature, in our minds that would show that they are propagating, that those propagating cracks are dangerous and might lead to catastrophic failure during a loop LOCA, which has been our consistent position.

So that would change, and we would move towards the -- or to the position that the Staff has taken with the modifications that Dr. Anderson stated in his testimony.

JUDGE BRENNER: Mr. Ellis, you earlier indicated, but it might have been off the record, that you wouldn't be in a position to respond today. We will accept that.

AGBagb

MR. ELLIS: Yes, sir, I can offer some preliminary remarks if that would be useful to the Board.

JUDGE BRENNER: Don't do it if it will polarize your position.

MR. ELLIS: No, sir, as you have perceptively pointed out, I have changed positions in the past.

JUDGE BRENNER: That's not a criticism, reasonable people change positions in light of circumstances.

MR. ELLIS: I hope you will continue to bear that in mind.

Judge Brenner, first of all, I must mentioned what is most immediately in the forefront of my mind and that is that Dr. Bush and Dr. Rau said that they would not recommend the test.

Dr. Rau -- I'm not sure about Dr. Bush, I don't have reference to my notes, but Dr. Rau said that he did not believe that it would be definitive or conclusive, there are difficulties with the X-ray tests that I would want to submit affidavits on, we think that it would have to be done by more than one laboratory, we think the evidence that already exists is enough and we are prepared to rest on the record with that.

We have the burden and it seems to me that if the County thinks that there is a substantial doubt about it,

AGBagb

that we haven't carried our burden, they should be satisfied with the record as it is. I think we have carried our burden on that issue and we are satisfied with it and we are not at this point in time willing to perform any more -- particularly since it means we still have to monitor, according to the Staff and according to the County. And between now and the first refueling outage these engines aren't going to get more than about 50 hours a piece. So --

JUDGE BRENNER: That's something I want to talk to you about tomorrow.

MR. ELLIS: Yes, sir.

Do you want to have a better figure tomorrow?

JUDGE BRENNER: No, you finish and then I will give you a coming attraction of one thing I was going to ask you tomorrow.

MR. ELLIS: All right, sir. I would appreciate that. It might help me decide whether I can find a hotel room or not.

Judge Brenner, that I think is basically -- we think there are very substantial technical difficulties which we would want to address if we were able to -- or if the Board wanted us to respond in writing formally to the motion.

JUDGE BRENNER: I would like you to see if you would be in a position to say anything more on it

AGBagb

tomorrow.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: -- while we're on the record and while you have some people here you can talk to.

MR. ELLIS: I'll try. Dr. Rau is going back to California tonight and so that might make it a bit difficult for him to consult with me and make inquiries and that sort of thing.

JUDGE BRENNER: I understand.

MR. ELLIS: Yes, sir, I'll do my best. And some of the LILCO people are in the PSC hearing.

JUDGE BRENNER: I'm not sure what you said about Dr. Rau's testimony that the test would be definitive is fully correct in light of how --

MR. ELLIS: I believe Dr. --

JUDGE BRENNER: -- depending on what you mean by "definitive."

MR. ELLIS: Right. I believe Dr. Rau testified that yes, if all of it were the low temperature oxide it would be inconsistent with his theory.

But that just -- what happens if you have other oxides and other things and I'm sure --

JUDGE BRENNER: I don't want to repeat the testimony but I think there is a range of results that might disclose useful information.

AGBagb

MR. ELLIS: But when it's all over with all you get is well they may be process cracks but we still want the monitoring, we still want this and so forth.

JUDGE BRENNER: Are you still -- LILCO opposes the monitoring, is that right?

MR. ELLIS: Yes, sir, it is our opinion -- of course, if we are required to do it by the Staff and the Board we will certainly do it.

JUDGE BRENNER: I understand that.

MR. ELLIS: But our position, based on the advice and the recommendations from our consultants that Dr. Rau testified to, we don't believe that it is necessary.

MR. PERLIS: Judge Brenner, if I could be heard briefly.

First of all I am a bit disappointed the Staff was not apprised of any of this until Mr. Dynner mentioned it in the courtroom earlier today. As a result I have not had a chance to talk this over with Dr. Bush, who now is happily on his way back to Washington, D.C.

JUDGE BRENNER: I understand your statement. I'll only tell you that the thought came as no surprise to me when Mr. Dynner mentioned it. I didn't know that he had discussed it with Mr. Ellis, of course, but the fact that this thought might occur to people sitting through this hearing is no surprise.

AGBagb

MR. PERLIS: No, all I mean to say is I have not had a chance to talk over with Dr. Bush a number of questions which I would need to discuss with him before I could reach a position on this. We don't know anything about the laboratory or the nature of the test. I think some sort of acceptance criteria would be necessary beforehand, if in fact any acceptance criteria are possible that the parties could agree to. I don't know. I just again didn't have a chance to discuss it with Dr. Bush and I wish I had been told about it last night.

Other than that it has been our position in the hearing that the testing is not necessary. That is not to say that we wouldn't -- we might agree that it would be helpful, I don't know. I haven't had a chance to discuss it again. I wish I could give the Board more, unfortunately I can't at this point.

JUDGE BRENNER: Why don't you see if you can talk to some people between now and tomorrow morning over the phone?

MR. PERLIS: I will try and contact him.

JUDGE BRENNER: If you cannot I understand that but it might be helpful.

MR. PERLIS: I'm just not sure that I know where he is going to be staying in Washington.

JUDGE BRENNER: I just said it might be helpful.

AGBagb

MR. DYNNER: One last remark, if I may, about this thing procedurally.

I don't want procedure to get in the way of what we are trying to get at. We would be happy to have this viewed as an offer, an open offer on the table of a way of at least a partial settlement of this issue. However, if that is not successful --

JUDGE BRENNER: In fact you've made a motion.

MR. DYNNER: -- we would also like this viewed as a late but, in our view, justifiable motion to compel so that we can put new evidence before the Board of this nature, sir.

JUDGE BRENNER: I understood that and we didn't have to get that far in our discussions today but we might tomorrow and in the context of whatever we might do on the other subjects, one thing I might ask is what would be the objection, even if LILCO doesn't want to do the test and even if the Board doesn't order LILCO to do the test, to providing the County with the material so the County could have the test done if it wishes. So you can think about that.

One thing I was going to ask you tomorrow -- everybody, but -- well I was going to ask LILCO, that in looking at the schedule as proposed and what may realistically be assumed, what you had in mind as to the

AGBagb

potential decision dates by this Board under those schedules and how those schedules factored in to the dates by which the Colt diesels will be available.

MR. ELLIS: I'm sorry, I was listening and writing at the same time. Do I understand that you would like to understand how the dates that we proposed or would be agreeable to would mesh with when the Colts are going to be available?

JUDGE BRENNER: Yes. I will even give you a starting point. Assume, just for the sake of assumptions and for no other reasons that if we were to permit re-opening, that further hearings concluded around the end of February and then you take it from there as to what you would expect in terms -- and you know what the normal findings -- what findings schedules are normally and whether you have some adjustments in mind, we can hear about that also, and then just again for the sake of argument factor in two months for Board decision time after the last findings are received which would presumably be a reply. And then you tell me what date you get to. And then you check on what dates the Colts are going to be available.

MR. ELLIS: Do you also want us to estimate when a Colt litigation might be over?

JUDGE BRENNER: I don't know of any Colt litigation pending before me.

AGBagb

MR. ELLIS: Not yet.

MR. DYNNER: Is that an invitation?

MR. ELLIS: It is a prediction.

Everything has been litigated --

JUDGE BRENNER: I could paraphrase Nathan Hale at this point and say I regret that I only have one life to give to a diesel litigation.

(Laughter.)

But you didn't mean us, you meant some adjudicatory body.

MR. ELLIS: I just was trying to understand the relevance so that I could focus on --

JUDGE BRENNER: Well I want to know whether we are going to be sitting over a moot hearing.

MR. ELLIS: Well I can assure the Board that that's not the case because these diesels the company intends to use, as I have indicated in the pleading, whether or not the Colts are -- whenever the Colts are installed, the company intends to use these diesels.

JUDGE BRENNER: All right. We'll come back to it some more tomorrow.

But the use, as I understood it, beyond what LILCO had asked for, that is, the first refueling, would be a backup use, and the reason you were only asking for findings until the first refueling -- although you were

AGBagb

careful not to want to put a time limit on that, you wanted to leave it as I have just stated it, to the first refueling -- the reason you weren't requesting any findings beyond that is because they would just be backups and therefore not part of any regulatory support.

MR. ELLIS: No, sir, let me just clarify that:

The reason for that is that the Staff cannot reach a conclusion about the full life of the diesels until it is fully reviewed by DRQR and it will not complete that review for some considerable period of time. And the whole purpose of the SER was to find an interim basis to the first refueling outage and that's why we felt it reasonable that findings would be generally limited to the first refueling outage unless something happened in the evidence that justified the Board in going beyond that.

JUDGE BRENNER: Then what did you expect to do at the first refueling outage in terms of seeking approval for anything beyond that.

MR. ELLIS: We will have to do whatever is required. If further litigation is required at the time we will have to do that. If not, it may be by that time that the County and LILCO are marching together arm and arm into the sun and it will only require approval of the Staff for us to go beyond that, particularly in view of the 20 megawatt turbine and the other diesels.

AGBbrb

So, predicting what is going to happen then, is difficult to do. But I can tell you that it is the Company's position that they intend to use both; and they intend to use both, at this time, for the life of the plant.

JUDGE BRENNER: All right. I think that answers my mootness question; but I'd be interested in how you envision the timing, in any event.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: All right.

We have nothing else for today, except -- well, go ahead. I'll give you a chance now.

MR. ELLIS: I think this might help in the Board's consideration.

In our motion, we made an effort to limit or circumscribe the kind of evidence which we would consider ought to be added to the record. We did that in an effort to keep the size of the litigation, as we envisioned it, to what we thought was appropriate.

From the pleadings of the County and the pleading of the Staff, it appears that the Staff and the County would prefer to have more to do -- specifically, I suppose, the block top inspections, as well. And I think it would help the Board in its deliberations if I advised you, as I do now, that LILCO has no objections to the use of those inspections in a hearing.

AGBbrb

JUDGE BRENNER: You also had a circumscription -- since you used that word -- on the calculations that would be pertinent for the crankshaft, and you limited it to DEMA.

MR. ELLIS: Yes. Let me address that.

I think the Company's position would be that it would be agreeable to expanding that to permit any party to submit a calculation at 33, based on a standard or a method that the Board had previously ruled was admissible and relevant, and that they had previously done.

In other words, if Party X had previously done an ABS calculation --

JUDGE BRENNER: Yes. That's what you said in your pleading, so you haven't changed that.

MR. ELLIS: Well, no.

What I have suggested is that it need not be limited to DEMA.

JUDGE BRENNER: I think, in your pleading -- I have to refresh my recollection -- you also -- the reason you gave was because -- you said unless a party had actually done a calculation under the particular standard -- well, all right.

MR. ELLIS: Well, I'm not sure, Judge Brenner. I thought I was expanding. I think that may be a moot point, because there may be certain limitations on the parties' abilities to do it. So I don't think that's a major issue

AGBbrb

with LILCO either.

I just thought that might help the Board in its deliberations.

JUDGE BRENNER: All right.

Let me mention one other thing that might come up tomorrow. If we were to reopen, there is testimony by certain witnesses, so then the test becomes later the extent to which different information and different circumstances may or may not change the conclusions of the prior testimony.

When you're dealing with the same witnesses, you can more easily ascribe the cause of certain changes, or the reasons for not changing. If witnesses start changing, then there's the other permutation of, well, is this coming out differently because there's a difference in view and approach of the witness, or is it solely due to something in the testimony? And I point that out, too, for the parties to consider; and we might ask tomorrow who the witnesses are going to be for each party if we permit reopening.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: Don't take that to mean that the witnesses have to be the same, by any means. Often a Board will put out things for discussion, and we sincerely mean just that. Sometimes I fear that when we put things up for discussion, parties mistakenly leap to the conclusion that

AGBbrb

we're trying to subtly direct something; and often that's not the case.

All right. We're going to -- Mr. Perlis, did you have something?

MR. PERLIS: No.

JUDGE BRENNER: We're going to adjourn in a moment.

I would ask the parties to try to take the time out of what I know is a busy schedule for you all to talk about the block issue so more, at least among counsel, in terms of the test that was mentioned.

There were some other things that came up on the record that might be pertinent for possible narrowing of views. I think that if the parties had put all the witnesses together before we started this procedure that the testimony might have been narrowed somewhat. To be sure, there still would have been disagreement, apparently; but at least matters would have been narrowed, and then there would have been time for parties to decide what to do about those points that still remained in controversy prior to the hearing.

But life is not perfect. There still may be time for certain things to be done. I don't know. For example -- and it's just an example; don't take it as any indication of any view by the Board -- maybe a 500X magnification for

AGBbrb

the witnesses to look at together would show something. Maybe not. I don't know. Maybe a replication, non-destructive, of another area of the 101 and 102 would show something or not show something; I don't know. And when I say these things, you have to understand I'm totally ignorant of feasibility, on everything that's involved in feasibility -- time, expense, effort and so on.

And when we put the findings together, based on the present record, we might conclude that none of these other things were necessary or that they wouldn't matter anyway, for some other reason. And that, too, is an uncertainty.

We're going to be talking about a Findings schedule tomorrow as part of the overall motion; and I can give you the view that our preference would be to set a schedule on blocks, regardless of our ruling on the motion. But we'll talk about it tomorrow, because I think we -- well, I'll leave it at that, and that's another subject that will come up.

All right. We'll adjourn until nine o'clock tomorrow morning.

(Whereupon, at 4:25 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 15, 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

**Official Reporter**

**Reporter's Affiliation**
Ace-Federal Reporters, Inc.