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UNITED STATES
NUCLEAR REGULATORY COMMISSION

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

LONG ISLAND LIGHTING COMPANY

(Shoreham Nuclear Power Station)

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the matter of: :

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

(Shoreham Nuclear Power Station): :

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State Office Building,

Veterans Memorial Highway,

Hauppauge, New York.

Friday, November 9, 1984.

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

BEFORE:

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

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

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

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APPEARANCES:

On behalf of the Applicant:

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On behalf of Intervenor Suffolk County:

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P R O C E E D I N G S

JUDGE MORRIS: Good morning. Judge Brenner has given me the opportunity to start the proceeding this morning.

Whereupon,

SPENCER H. BUSH,

ADAM J. HENRIKSEN,

and

CARL H. BERLINGER

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

JUDGE MORRIS: We will proceed with Board questions.

EX MINATION BY THE BOARD

BY JUDGE MORRIS:

Q Dr. Bush, just because I don't think the record is clear, I wonder if you could tell us what you mean by a K field.

A (Witness Bush) This would be in terms of fracture mechanics, and it could be either a positive field or a negative field under the circumstances. And putting it perhaps in an easier state, if I have tensile stresses there, I would expect to have a positive K field -- tensile or bending stresses.

If I have have compressive stresses and they are

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fairly high, I would expect to have a negative field.

The significance is that in a positive field, if it is high enough, there's a possibility or a probability that a crack will continue to grow. If it moves into a negative field, a negative K field, it will tend to stop or grow much more slowly. And as the magnitude of the negative K field increases, the probability is the crack won't grow at all thereafter.

So what it amounts to is if you can visualize a case where you could have tensile loads, a crack would initiate and propagate but as it moves into a compressive field where all the forces are in compression, then the crack will essentially stop.

Q Thank you.

Dr. Berlinger, have you had an opportunity to either perform or to review evaluations of failures in the diesel generators resulting from through cracks?

A (Witness Berlinger) Judge Morris, --

Q I'm thinking in terms of the operational consequences.

A An actual review as a result of an occurrence, or a hypothetical?

Q A hypothetical.

A Yes.

Q Let's start with the cracks in the cam gallery.

WRBeb

Supposing there was a through crack from the cam gallery region into the jacket coolant region. What would be the operational consequences on the operation of the engine?

A The water from the water jacket area would leak into the cam gallery area because it is at a somewhat higher pressure, not extremely high but a higher pressure.

The water would then drain down, along with the oil that is circulated through the cam gallery area into the crankcase, and it would mix with the oil in the crankcase.

The presence of water in the oil is not good; you don't want to operate engines that way. And as I understand it, operation with water in the oil for a period of time could lead to overheating of bearings, failure of bearings, and if it progressed far enough could lead to shutdown of the engine.

If it was allowed to operate that way for a longperiod of time, it could ultimately lead to what is -- I think the phraseology is a crankcase explosion.

Q Mr. Henriksen, have you had experience or have you reviewed experience of engines operating with water in the lube oil?

A (Witness Henriksen) Yes.

Q Is it possible to describe the consequences as a function of how much water is in the lube oil?

WRBeb

A You cannot put a quantitative measure on how much oil is allowable in the oil -- how much water, the percentage of water in the oil.

Maybe I misunderstood your question.

Q Well, let me try it quantitatively.

Suppose there was 20 gallons of water in the lube oil system. How would that affect the operation of the engine?

A I do not have the necessary data to say that it will operate. Each engine will vary. The load will play a factor in it, the marginal safety in the bearing, the type of lube oi.

There are too many variables for anybody, without either tests or calculations, to determine how much water can be tolerated in the oil, and I don't think anybody wants to run that test. And to the best of my knowledge, nobody has made that calculation.

Q Were you present when Dr. McCarthy described the experience of the engine which ran with substantial quantities of water in the lube oil for a period of a week or two?

A Yes, I was here.

Q Did that sound plausible to you?

A From my experience, no.

Q If water begins to leak into the lube oil, is

WRBeb

the performance of the engine affected?

A As far as combustion is concerned, no. And obviously the engine can tolerate some quantity of water in the oil, but how much is too much I don't know. It will affect the lubricity of the oil. Definitely the viscosity will be reduced.

It will eventually move over from what this engine is designed to operate on the bearings at least, the hydrodynamic lubrication over a mixed film or boundary condition lubrication, in which case the friction factors will be prohibitive, and there will be failure. Whether it be one bearing, two bearings, piston seizure, nobody can tell.

Q Are you familiar with the monitoring program for water in the lube oil proposed for Shoreham?

A With frequent checking of the oil and running oil samples, yes.

Q Do you think it would be more likely to detect water in the oil from that surveillance or from engine malperformance?

A It depends on the conditions. Under normal conditions like this engine is supposed to operate, you probably would be more likely to detect it through oil tests and/or the fact that you have to replenish water in the expansion tank.

WRBeb

Q Shifting now to ligament cracks, Dr. Berlinger, what would be the effects on the performance of the engine if there were a through-ligament crack?

A (Witness Berlinger) Judge Morris, I will try and give you an answer but I honestly think that Mr. Henriksen can do a better job.

Q Would you rather have him start?

A Please.

Q Mr. Henriksen.

A (Witness Henriksen) Judge Morris, I have a sketch here which I think our Counsel has intended to introduce as evidence which would help in explaining what would happen.

JUDGE BRENNER: You have a different one than we have.

MR. PERLIS: Yes, Judge. For the record, I was planning to introduce an exhibit for his redirect, which I believe he would like to refer to now.

JUDGE BRENNER: Can you give it to us now?

MR. PERLIS: Yes. The document I am going to hand out is-- The drawing was first offered into evidence as LILCO Exhibit B-9, but there have been some additional markings made by the witness.

JUDGE MORRIS: Mr. Perlis, this would be Staff Exhibit Diesel 10.

WRBeb

MR. PERLIS: Judge Brenner, I would request that this exhibit be marked as Staff Exhibit Diesel 10.

JUDGE BRENNER: All right. We can even short-circuit it quickly and admit it into evidence.

(Whereupon, Section through cylinder head stud was marked Staff Diesel Exhibit 10 for identification.)

BY JUDGE BRENNER:

Q Mr. Henriksen, these additional marks on the original sketch were made by you or some other witnesses?

A (Witness Henriksen) No, it was marked up--

Q Who did it? Who marked it up?

A I did.

JUDGE BRENNER: Why don't we just admit it into evidence if there is no objection.

MR. BRIGATI: No objection from the County.

MR. ELLIS: Judge Brenner, I don't know what it is that has been marked.

JUDGE BRENNER: We are going to find out-- You mean what the changes are? Look at your own Exhibit B-9 and the comparison will tell you instantly. Anything handwritten was added; anything typed was there originally.

All right, we will admit this in evidence as Staff Diesel Exhibit 10.

WRBeb

(Whereupon, Staff Diesel Exhibit 10, having been previously marked for identification, was received in evidence.)

JUDGE BRENNER: Now you will have it so you can follow it in explaining it to us, Mr. Henriksen.

WITNESS HENRIKSEN: Well, the doctoring up which I have done on this is I have added the combustion chamber for clarification. I have added jacket water for clarification. I have indicated the gap between the cylinder head and the cylinder block, and I have indicated the clearance between the stud and the cylinder head which was not indicated on the original sketch but which is a fact, that they do exist on the engine.

So the shaded area is the crack as I visualize it as hypothesized by Mr. Dynner. As it can be seen, the water then would enter and go through to the top or the cylinder block. By the time it reaches the cylinder block, water absolutely has no more pressure, no more driving force so it will just dribble, take the path of least resistance and will run between -- in the clearance between the head and the block.

Now as for operational purposes in the event of a loop LOCA event, there is a gravity tank connected to the jacket water -- the expansion tank I mean -- I'm sorry --

WRBeb

connected to the jacket water system. The tank is equipped with an alarm which will indicate the loss of 20 gallons of water. I don't know the exact size of this tank, but I would guess it's a matter of several hundred gallons, so the loss of 20 gallons does not represent any immediate danger.

Furthermore, the system is equipped-- As has been mentioned earlier by LILCO personnel, the tank is equipped with makeup feed.

Now in the case of a long-term operation or relatively long-term operation, they can simply leave the feedline open and feed it constantly.

The tank is further equipped with a drain line which may or may not drain back to the reservoir. As has also earlier been mentioned, the plant is equipped with reservoirs literally in thousands of gallons. There should be no immediate concern.

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BY JUDGE MORRIS:

Q Do I infer properly from what you have just said that the engine would continue to operate at whatever load it started?

A (Witness Henriksen) Absolutely.

Q Shifting now to the stud-to-stud cracks -- whoever would like to go first -- what would be the operational consequences of such a through crack on the performance of the diesel engine?

A As far as the water is concerned it would be the same as a ligament crack. As to other consequences, I think Dr. Bush is in a better position to elaborate.

A (Witness Bush) I confess I can't really give a definitive answer on the thing. It's obvious if you have a crack it'll be a path from the water area to the top surface. A crack, per se, unless you lose -- continue across and lose both ligaments -- and I've never seen an analysis of this one, I'm not exactly sure what the effect would be insofar as -- I can't visualize anything falling apart as such. The worst thing I could see would be where they would tend to pull apart from the stresses but I would imagine they would be relieved, but I confess I haven't seen such an analysis. So I really can't answer the question definitively other than the water path which is a pretty obvious one.

WRBpp

Q Dr. Berlinger, did you want to add something?

A (Witness Berlinger) Judge Morris, I think that the only possible serious impact of a stud-to-stud crack is if the crack somehow opened up wide enough that it might relieve the forces that are holding the stud bolts -- the head studs down into the block. But I think it is very unlikely that that type of crack widening or expansion would occur. That, I think, is one of the items which may -- should be considered but it's a very unlikely event.

Q Finally, what would be the operational consequences on the performance of the engine if a circumferential crack were to proceed through the complete section?

A (Witness Bush) This is a try. I would think with the bolt loads and the fact that you are pushing down on the thing, that fact that you have a crack, per se, through there may not be that significant a factor. It would go across -- I presume if it goes on a 45 degree angle it would go over into the stud hole -- the stud holes on there. But I can't visualize this as affecting the fact that the studs hold and that in essence the head would tend to retain this whole ring in place.

Q I believe you mentioned an angle of 95 degrees yesterday, Dr. Bush?

A If I did, I didn't mean it. I thought I said 45

WRB pp

degrees.

Q Well, I may have misheard.

A If I did, I really didn't mean 95. I mean 45. In other words the angle would be more like a shearload which would go from the corner of the landing across and terminate. That's the one I used in the testimony and if I did use 95, I misspoke myself.

Q Thank you.

Mr. Henriksen, are you familiar with R-5 engine testing?

A (Witness Henriksen) Only as it has been reported. I have not attended any. I have not seen test data.

Q Are you able to recall how many cycles the engine performed at greater than 225 BMEP?

A Yes. Yesterday I made a statement that I thought it was 600 hours plus. I have since had an occasion to go through the records. The 600-plus hours refers to the A pistons which, as you recall, I was also involved in. But the actual figures for the block is in excess of 5000 hours.

Q Well, I asked the question in terms of operation at 225 or greater BMEP?

A As I understand it, it was in excess of 275 BMEP, the 5000 hours.

Q 275?

WRB pp

A Yes.

Q Thank you.

Does the Panel -- well, let me ask it this way. With respect to the new EDG 103, is there any evidence that there were cracks in the cam gallery before operation?

A (Witness Berlinger) All the information that we had is that the -- well, there were no reported cracks based on the inspections prior to having put the block into service in the engine.

Q But at the present time there are indications in that area?

A At the present time they have identified some cracks or linear indications in the cam gallery area, a similar area as in the 101, 102, and 103 block in the saddle area.

Q Have these cracks been examined with a view of determining -- trying to determine their origin?

A There have been no destructive examinations. The only examination that I'm aware of were nondestructive examinations to try and determine the depth of those cracks.

A (Witness Bush) Judge Morris, could I expand a little bit?

When one discusses visual examination there is a high degree of subjectivity and, in fact, there are quantitative data where on extremely tight cracks that

WRB pp

visual examination will not detect cracks. So one has to say that either, one, there were no cracks there originally or, there were cracks there that were not detected by the visual examination.

I am unaware, at least from the record, of any examination other than the visual examination in that area prior to operation, which was your question.

The cracks -- in a meeting that was held in September, certainly I came away with a definite feeling that there was no evidence of cracking at that time. Now, subsequent to that penetrant esting was done which tends to be much more sensitive for very tight cracks. They were detected, and it is my understanding, and I guess this is hearsay since I haven't a piece of paper that I've been able to look at to that degree with regard to the measurement of the depths, which I understand may go up to 15 mills. I am not stating that there were cracks there that were not detected initially, but I'm simply indicating that that possibility exists and is a very strong possibility because it has been observed in other components many, many times. You simply cannot detect very tight cracks by visual examination in many instances.

JUDGE BRENNER: Dr. Bush, if I could interject. We're getting a lot of repeat testimony and we are worried about the timeframe of this hearing.

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Judge Morris' question -- and let me remind you of that in case you did want to add something that answers the question -- was whether there has been any evaluation or analyses or results trying to or succeeding in determining the origin of the cam gallery crack indications in the new 103 block?

WITNESS BUSH: The reason for my statement was to indicate that the very possible sense of origin is that it existed from day one; that's all.

JUDGE BRENNER: But you have nothing to add directly to the question?

WITNESS BERLINGER: No, we have no knowledge of any origin determinations or analyses or inspections for that purpose.

JUDGE BRENNER: Thank you.

BY JUDGE MORRIS:

Q So to put it another way, you can't tell whether these were shrinkage induced or fatigue induced after operation; is that correct?

A (Witness Bush) That's correct.

Q Gentlemen, now I'm going to turn to the supplemental testimony of Dr. Anderson dated October 18.

I believe this was the one that got lost in the mail to you, Dr. Bush. Have you had a chance to review it?

A (Witness Bush) Yes.

WRB pp

I should clear the record. I had it but essentially all of my attachments were virtually illegible so I only had words and I'll be referring to the words mostly.

Q Will you turn to page 5, please? In the first answer Dr. Anderson says that he believes the darkness of color of what has been termed the oxide layer is attributable to graphite from graphitization or graphitic corrosion of the surface of the crack.

Do you agree with that statement, Dr. Bush?

A No, I do not. If this were true, let me site a homely example. There's nothing magic about a crack and if this mechanism were to occur there would be no reason whatsoever that it wouldn't occur over the entire surface, therefore, one would expect to see the total cam gallery area covered with a layer of graphitic carbon.

Q And from the observations made it's clear that that's not the case?

A I certainly -- that's a good question.

There is paint in that area. I guess I can't say. However, the same thing would apply in the water area which, to my knowledge, is not painted and I have heard nothing about it. It would be very obvious if there were a layer of graphitic carbon. My experience mainly in this area where I see it -- have seen graphitic carbon -- was

WRB pp

where you have anaerobic bacteria around. And, quite frankly, you can certainly get it under those circumstances. However, I've also seen physical cases of cast iron pipe that's been underground for 100 or more years with no evidence of degradation.

Q Is there any possibility of an anaerobic condition in this environment?

A Generally, this is a condition that you face when you have a very dense clay and you exclude oxygen. Oxygen is there. Normally, this is caused by a little bacteria that generates sulphur compounds and they essentially form ferritic iron sulphides and simply leave the graphite behind.

Q In his answer to question 7, which begins on page 5, there are three points. With respect to the second point, Dr. Anderson questions whether air could be present in the environment of the hot casting. Do you agree with his conclusions there?

A I think he is correct for the early phases there. One has to remember that these castings stay sometimes for days and I'm not at all certain that you would exclude the air over that extended period of time when you -- obviously when you're burning off the material the answer is yes because you could have a reducing atmosphere. I don't know how you'd keep the air out, however, because you

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essentially have a porous medium there and so I would certainly expect air movement in sometime during that period. Perhaps not in the first few hours but thereafter.

Q I believe you said yesterday, Dr. Bush, that you believed that the cracks in the cam gallery originated from hot tears?

A That's correct.

Q And those occur at temperatures which are above some level?

A Generally, hot tears where the material has a very low strength it may be very close to the solidification temperature, in general instances. Quite often they're caused by changes in section which tend to retain the metal to a degree and prevent the contraction or delay the contraction. The strengths are so low in this instance that the middle simply separates. Generally, you would expect to find such things in areas where there are changes in cross sections, thick to thin or turnaround corners, things of that nature, more so than a flat surface.

Q What I was trying to lead up to was whether one could establish in time the relationship between when the hot tears occurred and the time that air might become available to exposure in that region?

A As I indicated earlier, I would expect the cracks to occur reasonably early in life when it has very, very low

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strength particularly in there. I would anticipate that, perhaps, the movement of air in would be later but I guess one would have to get an individual who's an expert in the casting field to see what the situation is there with a regard to that possibility.

Q The third point that Dr. Anderson makes has to do with what he believes is the possibility of the oxide layer being present. Have you had a chance to read that?

A I believe so. You're talking about -- that's touched on in three different places, which one specifically -- are you still in this testimony or are you in one of the others, because I have some which I'm not sure whether they're in the record or not that discusses this too.

Q Right now I'm focusing only on Dr. Anderson's response on pages 6 and 7.

A Okay.

Q And particularly the top of page 7.

A Talking about with regard to the welding and so forth. All right.

I finally was able to do an evaluation of the photomicrographs and able to reinterpret them since it was six weeks and I'd had about 30 minutes at that time and have never seen them since.

I believe I understand the photomicrographs. Now I would like to see -- if it were at all possible -- a

WRB pp

measurement of the crystallographic structure.

Q Excuse me. In the interest of time I'm going to cut you off.

A Okay.

Q It would be fun to talk about what you would like to see but we have to go by what's before us.

A Yes.

I thought this was the same question. This gets into the graphite corrosion.

JUDGE BRENNER: There is no question pending that I know of. Judge Morris pointed you to part of the testimony.

BY JUDGE MORRIS:

Q Particularly to the top of page 7 and the question is whether you agree with that or not?

A (Witness Bush) No, I don't agree with it.

Q And the reason?

A This has to do with the removal prior to welding if that's the one you're concerned with, I presume?

Q That's the way it starts, yes.

A Okay.

I can't visualize a hot tear, even if it opens up a fair amount, is still not something that gapes open by a very large degree. So in the preparation of this, and I would presume this would be an all-grinding operation, I

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would say that there would be a removal certainly from the mount area which is, I think, the area of concern because you would have to expand that area several fold. You would be talking of a very narrow V that might open up, let's say, a tenth of an inch in that vicinity or perhaps even more than that. Let's make it as much as two-tenths of an inch. To make that weld you're talking of opening it up to roughly three-quarters of an inch. You're also beveling the thing down at an angle in order to make the weld and that would say that from the surface to an appreciable distance down you would remove metal away by a factor of, oh, a 100 or more perhaps compared to the oxide thickness. So I visualize no mechanism for retaining an oxide under those circumstances.

Q Thank you.

BY JUDGE BRENNER:

Q Dr. Bush, the portion that you were just focusing on which begins at the top of page 7 of the supplemental testimony is an alternative proposition presented by Dr. Anderson. I think, arguably, his main proposition is at the bottom of page 6. If you can turn back and look at that and in that paragraph -- the one that begins "A third". In that paragraph Dr. Anderson is saying, in effect -- I hope I paraphrase this accurate -- that the dark oxide layer is, in his opinion, uniform from the top to the bottom of the crack

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and he believes that supports the proposition that the layer occurred after the welding because otherwise it, indeed, would have been removed, in part at least, as part of the welding process.

A (Witness Bush) It should have been, that's correct.

Q All right.

So then do you agree with what he's saying in that paragraph and why or why not?

A I think he's referring to the specimens that, quite frankly, were the topic of conversation yesterday that unfortunately were mislabeled.

I can't tell in this case because the only evidence I have of the oxide is on the other surface. The surface that matches is a single fracture at 1X. So I don't know anything about the condition there. I can't look at it.

Now, I have looked at the side view there that is adjacent and certainly in that area there is no evidence of an inherent dark oxide approaching -- I won't even call it an oxide -- an inherent dark material approaching the thickness that is below the weld.

Q In this latter point you're talking about the area where the weld did not separate?

A That's where the weld did separate.

WRB pp

Q Okay. That's the area I'm interested in.

A Yes. In other words, there are a series of cracks there. These are cross-section as contrasted to a fractograph and one can see a limited amount of material, X, if we don't want to call it an oxide, as contrasted to a more substantial amount in the thickness context as you go further and further down into the crack below the weld under these circumstances. That's the only thing I have to go by is the photomicrographic record of the thing in cross section as contrasted to, say, in the physical examination of the female section that had been removed from the weld by the fracture process.

Q Well, when you look at the photomicrograph that you just described, what does that tell you about what you said was a difference in the substance X, if you will, from the top of a crack area down to the bottom.

A When I look at it at magnifications of 50 and 100X and in some instances as 500X on there, I can see a clear separation of the base metal at the heat affected zone layer, vis a vis, the weld, per se. I can see in a few instances adhering to the one side a material that seems to be of lesser thickness than as you move down below the weld. And I am inferring that this is a similar material in the absence of anything else and I'm going on the basis that it appears -- it either is nonexistent or it appears to be

WRB pp

less thick than it is as we go further down into the crack below the weld.

MR. BRIGATI: Judge Brenner, could we have an identification of the photographs he's referring to?

JUDGE BRENNER: No, it's not important. You can do what you want later in terms of following up.

BY JUDGE BRENNER:

Q You don't know if, in fact, there is any layer in the upper levels of the crack from the photomicrographs, is that what you just said?

A (Witness Bush) I see in a few instances an example that seems to have the same color. I have no one else's on it. I have seen no indication of analysis in this particular area. I did note -- well, there also are fractographic representations, the different magnifications on it, that are somewhat difficult to interpret in this area It apparently is a film, it clearly is not the middle, per se, but that's about the only thing I have at this time.

Q What do you think it is and when do you think it formed?

A I, quite frankly, I still think it's an oxide. If I look --

Q All right. Let me focus you. Stay with the part of the crack from which the weld metal separated from the base metal, that part. Now, there's some layer there,

WRB pp

correct?

A There is in a few instances limited evidence of a layer; that's correct.

Q What do you think that is, given the fact that you think the welding process would have been -- that there would have been a grinding process performed in connection with the welding process, which you earlier testified, I believe, would have removed the oxide?

A The original oxide should have been removed by the grinding process. The thing we don't know is how they made the weld because, obviously, even if you don't put in preheat in the object, any time you put down weld beads there's substantial temperature there and you're doing this in an atmosphere that may or may not be inert, depending on what type of a welding process you're using. So it's quite conceivable that one would essentially lay down a fairly thin layer of -- for want of something better to call it -- oxide during that process, depending, again, on how they build up the weld. That's something I really can't tell.

If that were the case I would expect at least some degree of puddling of the oxide into the metal. And at least the examination, the photomicrographs I have seen, may or may not indicate that. It's difficult to tell in the iron-nickel alloy whether there is anything around such as

WRB pp

that. That's an inference only, sir. That's about all I can do.

Q Is it an equally correct inference or an equally possible inference that the weld metal separated from the base metal during operation and that whatever smaller deposit, smaller layer of deposits you saw at that point formed at that time?

A It certainly is possible. The temperatures are pretty low compared to the other conditions and I would normally not expect to see a very thick layer at 100 degrees or so. You should be talking of layers in the micron range.

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Q I'm sorry, I thought we were talking about a layer that you said was not very thick.

A Yes, but the layer we're talking about is thicker than that.

Q All right.

JUDGE BRENNER: Just to help Mr. Brigati a little bit, I don't want to get hung up on the numbers of the individual photographs because I don't need to. If he wants to he can pursue it.

BY JUDGE BRENNER:

Q You are talking about photomicrographs taken from the cam gallery area samples of the original 103 block?

A (Witness Bush) This is correct. They are all from Number 7. It's the sequence there.

And I believe, with the possible exception of one number that may be in error on what I call the female section, the record that is available there should be the same as the one I have before me here.

Q One more thing. You mentioned the color of these thinner deposits. I hesitate to call it a layer from your description. Would I be wrong to call this the area where weld metal separated? Is it incorrect to call it a layer of Substance X? It sounded like spottier deposits than the word layer would imply.

A There are some surfaces, at least in the

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photomicrographs, that seem to have nothing whatsoever attached thereto. There are others where, as one moves down where there seems to be a limited amount on there. It is not, at least in the one I examined, continuous in the ones at 50 or 100 X. That's about all I can say.

Q Well, in the areas where no deposit shows, then it would be equally possible that that separation occurred during operation, based on what you previously said, wouldn't it?

A That is possible. I can see two possibilities.

One is if they did the welding as I suspect they did, I would not be at all surprised if there were cracks that occurred shortly after they completed the welding process. I would not expect complete cracking, and certainly if you superimposed -- if you posed loads on the system, it is conceivable, quite probable in fact, that there would be additional cracking.

So one could have cracking over an extended period of time and in fact, one might re-examine certain areas, say in 101 and 102, and I wouldn't be at all surprised to see a change in the penetrant patterns around these welds from time T-1 to time T-2.

Q In passing, in one of your answers a few minutes ago you mentioned color of these thinner deposits. You didn't specify a color, you just said "color."

WRBeb

I thought you could not tell color from the photomicrographs. Am I missing something?

A Well, it's a shading. Perhaps that's the wrong term, but it tends to be what I call a gray or a tan in appearance as contrasted to the microstructure per se, so there is a gradation in here that is clearly visible to the eye under those circumstances. And in shade or color it is comparable as one would see as you move further and further into the crack, as you follow the crack down toward the tip.

Q Yesterday you mentioned I think in effect that you preferred to rely on photographs, either photomicrographs or -- I hope I have the right term -- fractographs --

A Yes, sir.

Q -- rather than looking at the samples themselves. Am I correct?

A I have nothing against looking at samples, obviously. However, if you scan a sample with a microscope, that's exactly what you're doing. You're depending on your memory to tell you what you saw as you moved from one field to another field.

I prefer, when I used to do more metallography than I've done in a long time, to look at a sample under the microscope in different magnifications and decide what areas

WRBeb

I want, and then take a series of picture that overlap so that I have a permanent record, because I have found that my memory isn't that good of something if I don't have the record to refer back to.

That's the reason, sir.

Q Okay.

I was wondering, as applied to these particular questions we've been asking you, which all go, as we all recognize, to the potential origin of these different deposits or layers and what they are, whether, if you had actually looked at them, whether that would tell you more than you have been able to tell us from the photographs, either because of color or something else.

A I don't think I could depend on that alone. If one were concerned in this case, I think you would go to a different approach. You'd go to a microprobe to get a feel for what compositionally is there, or you would do something of that nature.

Q Let's assume we learned it was an oxide, but then there's an argument that there are different types of oxides, and depending on the types, they formed at different times under different conditions.

What should we do then to try to--

A I think I placed in the record yesterday that it would really be very nice to have an analysis of the

WRBeb

crystallographic structure because I think that would resolve the issue once and for all. It is not easy, however.

Q You mean in connection with determining whether it is wustite or hematite?

A That's correct.

Q Well, tell me, if we determine that the thinner layer or thinner deposits in the area where the weld separated from the metal was not wustite, don't we still have the question of when this -- it was not wustite and it isn't oxide, don't we still have the problem of deciding whether it formed during the welding process or formed after separation during operation, although under much lesser temperatures than are present in the forging cooling process?

A I would answer it this way:

I guess my personal interest would be to establish unequivocally with regard to what is in the crack below the weld, so I would like to see if that is the high-temperature form of an oxide.

If one had a large enough sample, which looks like it is not very probable, I wouldn't be too surprised, particularly if it formed by a mechanism such as I suggested, simply by the weld bead thing, to see that this is a lower-temperature form of the oxide.

WRBeb

That would tend to indicate that they did indeed form at different times and under different conditions.

BY JUDGE MORRIS:

Q Proceeding with Dr. Anderson's testimony, Dr. Bush, on page 7, in answer to Question Number 8, Dr. Anderson concludes that the calcium which was observed was introduced after the block had been cast and cooled completely.

Do you agree with that conclusion?

A (Witness Bush) I think it's a possibility. One of the possibilities -- and again, I simply do not have information -- is that many weld electrodes have a coating that may or may not be proprietary, but almost invariably is some kind of a calcium compound on it. And when you make a weld, in fact it's the standard procedure that you deposit a bead and then you get a wire brush out and remove the layer. And so it would not surprise me too much if these were coated electrodes there.

I can find absolutely no information in the record anywhere related to what was done with regard to the welds. But that to me is a potential source for the calcium.

The sulfur could be that same thing because some of these are sulfites that are used, but I wouldn't say for sure whether that would be the case. Cast iron per se does

WRBeb

have sulfur in it to a degree. Whether it is enough to account for it, that's another matter.

Q But do you also agree that calcium sulfite could have been present during the casting?

A I would expect sulfur, yes. Calcium, less so, but it is not impossible because again what they do is they coat the molds with layers that often are a calcium compound, and it could in theory be carried in under those circumstances. So I cannot eliminate that as a possibility.

Q Turning to Question and Answer Number 10 on page 8,--

A Yes, sir?

Q -- Dr. Anderson concludes that because of its brittle nature, cast iron does not form beachmarks during the presence of crack propagation.

A I disagree with this one completely.

Globally, cast iron may be considered to be brittle, but between any flakes of graphite, you usually have areas normally of laminar perlite. And if, particularly in a high-cycle fatigue operation where we are talking of movements measured in ten's or thousand's of an inch, as it moves through an area such as this, there is no reason whatsoever that you wouldn't expect to see beachmarks.

WRBeb

Q For this particular cast iron, Class 40?

A I would make it more general than that. I don't care whether you are talking of 40 or 50, or anything, because the only thing that would affect it would be if the graphite were so thick that essentially it cored that, and in that case you wouldn't have any strength in the cast iron anyhow.

Q Would the presence of Widmanstaetten degenerated graphite affect this conclusion?

A I still think that there are enough islands. The Widmanstaetten tends to degrade the properties, but we would still have that and certainly under high cycle fatigue I would expect to see an indication of that at high magnifications.

JUDGE BRENNER: I'm sorry you used a lot of pronouns in that last sentence. What do you mean by "that"?

WITNESS BUSH: Beachmarks.

BY JUDGE MORRIS:

Q Turning now to page 10, to Question and Answer 15, Dr. Anderson concludes that the cracks in the cam shaft gallery area initiated or propagated from subsurface defects during and as a result of the operation of DG 103.

Do you agree with that?

A (Witness Bush) I don't know. There is no way for me to agree or disagree.

WRBeb

Obviously if one had something immediately beneath the surface there is no doubt about it that under cyclic loads, it can propagate to the surface. There is lots of evidence of this, just not in there.

As I say, as I indicated in an answer to an earlier question, an equally plausible postulate is that the cracks were there, they were formed at or near room temperature because of high residual stress fields and they simply either opened up after the examination, or they were there but were so tight they weren't visible.

But I cannot rule out the possibility of the subsurface defects.

Q At the top of page 12 Dr. Anderson says that he observed below the tip of the 3/8th inch crack, multiple small disconnected cracks branching out into the cast iron material.

Are you aware of any other evidence for these branch cracks?

A This one-- I have only seen the words here, and I have seen the words in the testimony by Dr. Rau. I have never seen the samples myself and I really don't know what he's talking about, so I guess I can't answer this question intelligently.

Q You have not seen the samples?

A I have not seen the samples.

WRBeb

Q Dr. Berlinger, do you have anything to add on this?

A (Witness Berlinger) Judge Morris, I just want to make sure I understand your question. You are referring just to a sample of the circumferential crack, the cross-section of the old 103 block?

Q Well, I'm referring to Dr. Anderson's testimony where he says he observed that below the tip of the 3/8th inch crack, which was a circumferential crack, he observed multiple small disconnected cracks branching out into the cast iron.

WRBagb

A The only photographs that I saw were, I think, 1X scale, no magnification. It was just a photograph of, I guess, a sample, a cross-section --

Q Let me interrupt. Do you know what Dr. Anderson looked at?

A I'm not quite sure. I really don't. And it was not possible for me, from that photograph, to identify cracks such as this. So I really can't give you any additional information.

Q Mr. Henriksen, in question and answer number 20, do you have that testimony before you?

A (Witness Henriksen) Yes.

Q This relates to the consequences of circumferential cracking. And in his answer Dr. Anderson states that the liner would move up and down.

Do you agree that that's possible?

A Theoretically possible but not very likely.

Q Would such movement cause leakage of combustion gases?

A Not necessarily.

Q Well do you think this scenario that he has described here is a reasonable one?

A It's a little far-fetched.

BY JUDGE BRENNER:

Q The scenario -- quote/unquote -- Mr. Henriksen,

WRBagb

you say is a little far-fetched.

Do you say it is far-fetched that the combustion gases would get into the cooling water, is just that part of the scenario alone far-fetched in your view?

A Well I was referring to the exhaust getting into the water.

Q Okay.

And you think that's far-fetched?

A Yes.

Q All right.

Beyond that the scenario of the County's witnesses, they take it beyond that and they say if combustion gases get into the cooling water that this would cause problems for engine operation.

A I don't necessarily agree.

Q All right.

Can you tell me why or why not?

A The gases will at that point follow the jacket water, go out through the jacket water discharge and the majority of the gas bubbles would go up to the expansion tank.

Q I'm inferring from what you're saying that the jacket water cooling system in this diesel engine is not a closed system but is a system that flows, not closed within the engine jacket, but flows through and out and so on,

WRBagb

is that right?

A It has a loop. But like I said it does have an expansion tank that allows for expansion of the water from cold to operating temperatures.

Q All right.

In saying that the scenario is far-fetched, did you also have in mind what the County witnesses say in their expansion on the same point in their rebuttal testimony of November 7 at question and answer 5 on page three of that testimony?

A Page....?

Q Page three of the rebuttal testimony, the first question and answer on that page.

Have you read that, Mr. Henriksen, previously?

A I read it last night. I will have to reread it right now.

Q My question is -- after you have completed reading it -- whether any information in that answer would cause you to change your opinion that the scenario is far-fetched?

A No, it doesn't. If you look at the sketch that was presented earlier as Exhibit 10, I believe, you will see that if the exhaust gases do manage to negotiate the two gaskets it will simply go out into the gap between the block and the cylinder head which is at atmospheric pressure. It

WRBagb

will have no driving force to enter the jacket water. There is nothing to contain the gases at that point.

The only way gases could enter the jacket water in this area would be if the cylinder liner cracked, and I don't think that's a problem at the moment.

BY JUDGE MORRIS:

Q Staying with the rebuttal testimony which Dr. Anderson submitted on November 7, 1984 and at other places, at the bottom of page four -- and this will be for Dr. Bush -- Dr. Anderson states that the characteristics of nickel iron weld material are such that they minimize shrinkage and therefore minimize the likelihood of tensile stress caused by post-cooling shrinkage.

Is that correct, Dr. Bush?

A (Witness Bush) That's telling part of the story but not all of the story.

The nickel iron alloys will have co-efficients of thermal expansion that, at a first approximation, will be close to that of a ferritic material of which I will put gray cast iron.

The more important factor would be whether there was preheat on the system in the first place. If there is no preheat then you have the shrinkage from the melting point all the way down and you would develop very high tensile stresses.

WRBagb

Now the only way I could get higher tensile stresses is to go to an austenitic alloy which is not normally used under these circumstances which would have a higher coefficient of thermal expansion to get the same thing. So it does not really tell the whole story.

Q So that you do believe the weld shrank during the process?

A There is no doubt about it. The melting point is up there, the weld is going to shrink under any circumstances. And unless I have preheat on the system or unless I peen every bead essentially in the process in order to reduce the residual stresses -- and even then I should probably use a post-weld stress relieving process; I am most certainly going to have high tensile stresses.

Q In relationship to Dr. Anderson's next answer, I won't ask you about what he said but I will ask you to hypothesize that a crack in the cam gallery propagates all the way through to the jacket coolant water wall.

Can you describe how that might happen in terms of the size of the crack as it reaches the wall?

The reason for asking is that I believe Dr. Rau testified that he thought the initial manifestation of the crack reaching the wall would be a pinhole.

A I don't know if I would classify it as a pinhole. I would expect it to be very tight. I guess I

WRBagb

would have to lean on extensive experience in the austenitics with stress corrosion cracks which one could use an analogy here. And in those instances when those cracks come through they usually have leak rates that would be, say, .0005 gpm, something of that nature, extremely small values.

Now if you continue for an extended period the cracks will continue to grow and you ought to realize that these leak rates are with 1000 psi inside so it is a rather tortuous path. And I would anticipate, assuming the crack grows through, that there would be a very limited in-leakage for a period of time. The crack would have to continue to grow and spread lengthwise and open up in order to have an appreciable movement.

One can do a calculation, there are definitive equations that take into consideration the roughness of the surface and the pressure and could establish on that basis given a certain crack length exactly how much water you would infer would move from one side to the other.

Q And if that area were under compressive stress how would that affect what you have just told us?

A Well if it were under compressive stress we would have to figure out how the crack got there in the first place.

The one area that worries me a little bit is that

WRBagb

I would anticipate a compressive stress field. I get a little nervous when a crack depth is say 75-80 percent throughwall on the basis that I may have bending moments then and so my compressive stress is either reduced or actually may be changed.

Looking back it would have been very nice to have had a few strain gages on the inside of the water side -- on the water side in addition to the cam gallery side.

Q With respect to such a through crack we discussed earlier what the consequences might be in terms of water in the lubricant.

In the next question and answer Dr. Anderson describes --

JUDGE MORRIS: And I believe, Mr. Brigati, that a couple of times he used the word "crankshaft" when he should have said "camshaft."

BY JUDGE MORRIS:

Q But assuming he meant "camshaft," he was concerned about the horizontal support of the camshaft. He concludes that there could be horizontal flexing of the camshaft as a result of lack of structural integrity.

Are you able to comment on that?

MR. ELLIS: Judge Morris, could you direct me to which one....

JUDGE BRENNER: It's the rebuttal testimony,

WRBagb

question and answer nine beginning.....

JUDGE MORRIS: The bottom of page five.

MR. ELLIS: Thank you.

JUDGE MORRIS: -- and over to page six.

MR. BRIGATI: I believe you're correct, he meant camshaft there, Judge.

MR. ELLIS: What confused me was I think Judge Morris --

JUDGE BRENNER: Well wait a minute, let's get an answer instead of all these digressions.

You have the reference now, right?

MR. ELLIS: Yes, sir.

WITNESS BUSH: I believe for the record you're talking about the Christensen/Eley testimony, is that correct?

BY JUDGE MORRIS:

Q That's correct, I'm sorry.

A (Witness Bush) I read this testimony three times and I still don't understand what the point is, and I guess I would have to go back. Perhaps Mr. Henriksen can understand it because quite frankly I don't.

A (Witness Henriksen) Yes, I think I understand the question. I don't have the necessary data either to refute or agree, but I think yes if the crack should develop into that size that you have lost complete support for the

WRBagb

bearing into the block itself. I suppose there would be some relative moment. But I think in that case that the crack would be big enough that the water would be a problem before the bearing would.

WRB pp

BY JUDGE MORRIS:

Q Dr. Bush, are you aware whether or not FaAA did finite element analysis in the circumferential crack area?

A (Witness Bush) If it has been done I haven't seen such.

Q So you're not aware?

A I'm not aware.

Q With respect to the FaAA finite element analyses that you are aware of, you have expressed some reservations, I believe, with respect to the inputs?

A That's correct.

Q Could you be more specific as to any specific inputs that you think are incorrect or uncertain?

A I attempted to re-read the document to refresh my memory in this respect. The one I'm principally concerned with, that I can't establish, is handled in here from the information that has to do with the fast startup phase where one develops a thermal gradient fairly rapidly from the liner side over towards the bolt area in there. The statement is made of thermal gradients relating to the hoop area -- or to the liner expansion and contact and in the absence of any definitive information in there I can't really establish the values of the inputs as such. There are some tables but you need more than tables in order to walk through this.

WRB pp

Now, questions have been raised on this, this particular document, and unless I've missed them I haven't seen a followup document that answers the thing so my -- anything I've expressed is based on the June 1984 report entitled, "Design Review of TDI R-4 and RV-4 Series, Emergency Diesel Generator Cylinder Blccks and Liners."

Q Is the finite element analysis a time dependent analysis?

A You could put a time factor in it if you wish to in the thing. Usually what you're doing is looking at the stress fields and you could look at the stress fields -- you could look at the change in that, if you wish to, as a function of time.

Q But you are more concerned with a particular stress situation, not the rate in which it changes; is that correct?

A I'm concerned with a changing stress gradient as it may effect an area that has an high discontinuity. That, quite frankly, is where my concern arises. My major concern is on the ligament side down in the -- on that one particular side of the counterbore as much as anything because I haven't seen enough information that convinces me. I recognize the stresses, per se, may be higher at the top surface but I am always worried about a very high stress concentration factor because I recognize that one can have

WRB pp

lower stresses and still have a crack introduced in contrast to higher stresses when there is no severe stress concentration factor. That's my problem.

Q So you're concern here is with what, I guess, has been characterized as a low cycle fatigue situation; is that correct?

A That would be a good way to state it, yes, sir.

Q Do you have any concerns with the high cycle FaAAs?

A Not particularly because this, in essence, is the way that a diesel operates under steady state conditions. And so I think one can extrapolate pretty well from online conditions under this.

Q Do you have any other concerns with the low cycle stress analysis?

A That's the major one that I'm concerned with. I can see that one and I haven't been able to satisfy it myself that it was handled satisfactorily and this -- as I say, this has been posed as a series of question and answers.

Q But you have not pointed to anything that you think is in error, is that correct?

A That's correct and I'm not saying that the model that they suggest where the crack initiates at the top surface isn't the correct one. I simply don't have enough

WRB pp

information to rule out the other one and see what the factor would be.

Q So is it correct that you do agree with the methodology that FaAA has used for cumulative damage?

A You changed that on me.

I'd say generally, yes. This is really -- a lot of that is based, quite frankly, on the fact that you looked at the behavior of a lot of blocks and then kind of back calculate what appears to be a quasi-steady state or a steady state condition of after a crack gets to a certain depth and you measure it, I think. Which is quite often used, of course.

BY JUDGE BRENNER:

Q Dr. Bush, in the last series when you're talking about your concern about input for the finite element analysis, a minor pedantic point, you said counterbore, and there are two counterbores. Which counterbore do you mean?

A (Witness Bush) I'm thinking of the stud counterbore in this instance on the ligament side.

Q You say your concern about those ligament cracks in conjunction with finite element analysis for the reasons you gave. Does your concern go to what the effects of ligament cracks might be or are you only limiting your thinking, at least, to the occurrence and propagation of ligament cracks?

WRB pp

A Pretty much to the occurrence and propagation of the ligament cracks. My problem is if I find that it doesn't seem to match up in this area then I begin to worry about other areas so it's kind of chain reaction thing. So I'd like to be able to put this one to bed, so to speak, and say, yes, I'm satisfied that this is not a major factor and it will not, therefore, perturb the overall model that has been developed. I'm generally satisfied with the model. If I could tie down this one then I would be able to step back and say, yes, all of the parts of the model seem to make sense.

MR. ELLIS: Judge Brenner, he said this was not a major factor. I was just going to request that while we're here we clarify that now. It would be impossible to come back later and try and clarify what was meant by "this is not a major factor".

WITNESS BUSH: What I'm really stating -- maybe I should state it more clearly is that any analysis of this nature starts out with a series of assumptions. If you invalidate some of these assumptions it may simply alter the model to a minor degree. On the other hand, it may essentially destroy that particular model. What I would like to see is if this is a significant factor. My suspicion is --

JUDGE BRENNER: Mr. Ellis wants to know what

WRB pp

"misquote" is.

WITNESS BUSH: That's what this is, I think.

JUDGE BRENNER: You worry about it later, Mr. Ellis.

Let me ask a question.

BY JUDGE BRENNER:

Q I understand what you said about if you see things different than would have been predicted for ligament cracks then you might begin a question other things for which the same analysis is used.

But I thought that your main concern as to whether or not the inputs are even considered or correctly considered related to phenomenon that would have a much lesser effect on the potential for stud-to-stud initiation and propagation. So if they're wrong for the reasons you're concerned about on those inputs with respect to ligament cracks, why should we then be worried about use of the analysis for stud-to-stud cracks.

A (Witness Bush) Probably shouldn't be.

Because what I'm suggesting is mainly aimed at the ligament and not the stud.

BY JUDGE MORRIS:

Q Dr. Berlinger or Dr. Bush, there was some discussion yesterday of putting wire gages or strain gages on the cracks in the cam gallery area. That's for the new

WRB pp

engine 103?

A (Witness Bush) No, sir.

Q Where would they --

A Oh, I'm sorry. The discussion, at least, earlier discussion had been with regard to 101 and 102, which had the deep cracks where the concern was to establish that they are truly static. That they aren't moving any -- I guess my personal opinion would be that considering the depth of the existing cracks and presuming that the measurements that are being made during this time interval confirm that the cracks haven't changed and I wouldn't suggest -- my personal opinion would be that it wouldn't be necessary to use wire gages on the new 103 block. That's a personal opinion only.

A (Witness Berlinger) I can answer with regard to the Staff's position. The wire gages at this point would only be suggested or requested for the 101 and 102 blocks in the cam gallery area. And we agree with Dr. Bush's suggestion with regard to 103, the new 103. Unless there is some unusual discovery during the presently ongoing inspection, there would be no reason to instrument those cracks.

Q That's 103?

A In the 103.

Q And your decision is not yet made on 101 and 102; is that correct?

WRB pp

A I think the decision is made. It's just that we haven't done anything with it yet.

Q Well, supposing that such gages were used what do they measure?

A (Witness Bush) They are crack opening displacement gages. So essentially what they would do is show a separation of the crack and the inference where the crack separates is that it also gets longer. I believe that has been presented in testimony. If they are essentially static, that's the answer.

Q What would be the sensitivity of such an instrument.

A That one, I think, is beyond me. That got sent to -- it should be certainly in the mill range but I don't consider myself enough of an expert to state for certain it should be a very, very -- providing it's calibrated correctly, it should be quite accurate.

A (Witness Berlinger) But it would be used primarily to observe any relative changes during operation of the engine.

Q Well, I guess it doesn't know the initial width of a crack but would tell you if there were subsequent displacement.

A When it's installed, it's installed in such a way that there is a non-zero reading. In other words, it's

WRBpp

called prestress, and then if the crack were to open more it would show a change in measurement.

Q Well, just for talking purposes, let's suppose that it showed you a displacement after going to the operation of two mills. By what criteria would you decide to take any section?

A (Witness Bush) Obviously, I'm not writing criteria or can establish criteria for the NRC. One has to apply a kind of rule of reason in this. And I think what one would like to do you would expect some changes on that thing and I don't think we're concerned. I think we're concerned with larger changes and this is -- in fact, if these welds cracked a little bit more, which is quite possible, you might get more than two mills. But I think what you're looking for is what I call a steady change, an increase over a period of time, a continued increase. That's what you're really worried about because that indicates that perhaps our model wasn't very accurate and the crack is continuing to move toward the back face..

It's a conservative thing, is all.

Q So would it be correct to say that you're not concerned so much about the actual separation at that point but you're concerned about continuing opening up of such a crack?

A That's my concern. Because if that crack

WRB pp

continues to open up one can pretty strongly infer that it is getting deeper and that indicates generally that many of the tenets about compressive stresses may or may not be valid. That's the thing we're interested in examining.

A (Witness Berlinger) Judge Morris, that's what I meant by saying we would look at that at the relative change during operation.

Q So just to finish up on that there won't be any definitive criteria. It'll be a question of observing the experience and making the judgment based on that experience; is that correct?

A That's correct. Looking for a gross change in the condition in that area.

Q I just have one final question. Why is an analysis for the situation of one loop LOCA incident sufficient to satisfy General Design Criterion 17?

A A loop LOCA is not the only event that is evaluated in determining what the maximum required load would be. I think what you look at is you look for the most limiting event, the combined loss of offsite power and LOCA event turns out to be the most limiting because of the specific electrical loads that are required from the onsite power source, given that the offsite power is lost. It requires the most electrical power to power the emergency equipment.

WRB pp

Q Well --

A Maybe I misinterpreted your question?

Q No, you understand the question, but I don't think you see what I'm trying to get at which was indicated a little bit by some of Mr. Dynner's questions yesterday in talking about the rated load in these engines. The rated load is described in terms of service continuously for a year at some kilowatt rating combined with a two-hour in any 24-hour period at an added load. However, in the analysis that you've done for this situation you have described as the most severe requirements on the machine, you take not the rated load but you start at the high load and then decrease it in terms of what you say the demand will be on the engine for the equipment needed as a function of time and terminates at the end of a week.

That's correct; is it not?

A Yes. The adequacy of the diesel generators to satisfy the requirement is done separate from determining what that requirement is.

WRBeb

There is a separate analysis that is done to determine whether all the assumed loads are in fact counted when you add them all up.

The review as to the adequacy of these diesels will be done in determining whether or not they will provide reliable service for their intended function. Their intended function is to provide emergency onsite power in response to an event, of which a loop LOCA is the event.

We do not require that the engine be run for an hour continuously to prove that it is a qualified engine. We don't require that during this one-year period of testing that it be run two hours out of every 24.

Q I understand.

A I'm not certain....

Q I may be wrong, Dr. Berlinger, but I don't recall that qualification of diesels, emergency diesels, has used this approach for a long period of time, say going back 10 or 15 years. Is that correct?

A You may be right. Prior to about a year ago, I was never involved in this aspect of NRC's review, so I cannot attest to what has been done that far back in the past.

Q But is it your opinion that a careful consideration of this approach has been made, and that the Staff's position is that qualification using this approach

WRBeb

does satisfy General Design Criterion 17?

A Yes, that's correct.

I tried to clarify one point yesterday, but I don't think I really completed my answer.

Basically GDC 17 states the requirement for onsite emergency power.

Q Yes, I am familiar with that. Of course it states it in terms of functional requirements --

A That's correct.

Q -- in terms of the integrity of the fuel and the pressure boundaries, and so forth.

A Right.

Q Thank you.

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

BY JUDGE BRENNER:

Q Picking up on your last answer, you said a careful analysis has been made. I guess what I'm trying to find out and what I think some of Judge Morris' questions were going to is what is that careful analysis that leads to the conclusion that the performance criteria that you are going to apply to these Shoreham diesels now gives you reasonable assurance, with whatever margin is appropriate, of meeting GDC 17, reasonable assurance that the intended function will be carried out?

A (Witness Berlinger) Well, first of all, whether

WRBeb

we talk about the FSAR as it is approved today or--

Q That's what I mean, today, not the proposed.

A In that particular case, the FSAR includes analyses and information which document what the required loads would be in the event of a loop LOCA. In that particular event, the loads are identified based on a design analysis, not experimental information but a design analysis.

That information indicates that two of the three engines require somewhere on the order of 3450 kilowatts. The 103 engine I think was identified as requiring just under 3900 kilowatts.

The determination as to whether or not these diesels are adequate to provide that service by the Staff has in fact not been reached, and the recommendations in our original testimony as a means, a possible means to resolve this particular question is to test the engines at the required load, or call it the rated load, and if necessary, the overload condition.

Clearly, we have not been able to determine, based on the evidence, that the diesels are qualified at 35 and 39 hundred, but clearly we have not been able to say that they would not provide adequate service. So the best way would be to prove it by running the engines at conditions for a long enough period to be able to verify

WRBeb

their capability.

That is basically what our recommendation has been to the Board in our testimony.

JUDGE BRENNER: Let's see if I can extend the break a little more to finish my questions so people will have the benefit of the break.

BY JUDGE BRENNER:

Q In terms of what the cam gallery crack strain gages for 101 and 102 would measure -- and you told Judge Morris what the Staff's purpose would be to have them -- why wouldn't any movement disprove the assumption that the forces are compressive, any widening of the crack?

A (Witness Bush) I can visualize that because of -- that there could be one of the weldments where there has been essentially no cracking but there is still a high residual stress field, or there may be cracking on one side only, and it is quite conceivable under those circumstances that even in a compressive field that that crack -- that a crack could initiate and of course there would be a movement on there.

And that would be an example of something that may be relatively innocuous but would certainly show a movement.

A (Witness Berlinger) Just to add, if I am not mistaken I think on the 101 and the 102 blocks at each of

WRBeb

the cam gallery locations there has been a weldment and to the best of my knowledge, I think that they have all indicated cracks. So I don't think that there would be any new cracks develop in the weld area.

WRBeb

The chances are that the only movement you are going to see during the operation if the engine might very well just be vibration which would be picked up by the gage.

Q You are aware, Dr. Bush, of differences between the new 103 block and the 101 and the 102 block, are you not?

A (Witness Bush) To a degree, yes. The dimensional difference is the depths of the counterbores and things of that nature. I wouldn't say that I'm aware of all the changes; I am only aware of changes in areas where I had a look at it.

I certainly haven't tried to make a comparison dimensionally across the board of the two.

Q All right.

You aware that it is claimed by LILCO to be a Class 45 gray iron rather than a Class 40, are you?

A Yes, sir.

Q All right.

The 103 block is the one that is being used in the endurance run to attempt to verify whether or not the cam gallery area is compressive. Correct?

A Yes, sir.

Q And that some of the verification in your oral testimony you said you would find helpful. Correct?

A That's correct, sir.

WRBeb

Q Is there anything about the 103 block that would make those results not fully valid for the 101 and the 102 blocks, given the differences in the blocks and the greater existing cracks -- the believed to be greater existing cracks in those blocks' cam gallery cracks?

A I suppose it's conceivable. The obvious reason for picking 103 was that the instrumentation be possible and be meaningful because the absence of cracks is a highly desirable condition under these circumstances to measure the actual stress profiles in there.

Certainly if you have cracks and if the stress fields are less compressive than one would assume, it would be an indication, in the case of the 101 and the 102, that we might be faced with continued growth. There is no evidence of it so far, but that's the type of thing you're trying to get at.

So that could be a function of mechanical properties and of the existence of the cracks.

A (Witness Berlinger) Judge Brenner, to try to directly answer your question, the strain gage measurements on the 103 are intended in part to confirm that the stress field is compressive. Structurally the blocks are quite similar.

The differences, as I think we have addressed in the testimony, such as the thickness of the block top

WRBeb

surface, the depth of the boss areas, the increased heaviness or weightiness in the boss areas, and the particular way the bolt-up is done in this engine, whether we're talking 101, 102, or the new 103 block, I think that the loads as transmitted down through the cam gallery area would be the same.

I don't believe that they would be different in any significant way.

Q What about the factor of the greater cracks in the 101 or 102? Could that result in the net effect, if you will, in the 101 and 102 cam gallery of being less compressive than the results that you receive from 103, if we assume for the moment that the 103 results show that it is in fact compressive?

A No, I don't think there would be any difference.

Q Dr. Bush?

A (Witness Bush) I was going to say about the same thing.

From a bolt-up point of view I would expect that the bolt stresses, compressive stresses to be about the same. Whether they would be exactly at the crack tip would be another question, but I would not expect that much of a difference I guess.

Q Remind me if you will the endurance run that is being done -- and I don't want to get into details of any

WRBeb

results at this point, but there is also gaging of-- Is there also gaging in the block top, strain gages or other type indications?

A (Witness Berlinger) No. The only instrumentation on that engine were the strain gages in the cam gallery area. We did not require them to strain gage the block top.

Q From a point of view of all the cracks -- of each of the cracks we're talking about, cam gallery type cracks, ligament cracks and stud-to-stud cracks and circumferential cracks, I'll ask you a general question. And if it is too general I will try to do better.

Could you tell me whether or not, and if so how, those cracks are sensitive to different loads, both steady operational loads for a relatively longer period of time, say days, a week, and also high startup type peak loads? Is there any effect at all?

A I assume you are looking for some insight as to whether or not these cracks would be affected individually or as a group by repeated startup and shutdown of the engine, or under conditions of continuous operation at full load.

Q Right. And whether it matters if that repeated startup is at 3900 versus some lower level, in the vicinity of 33 or 34 hundred Kw, and whether the longer-term load

WRBeb

would make a difference at something like 3500 or something in the vicinity of 3300.

A As a general response I would say that the most strenuous loads that you put on the engine are during rapid starts, fast starts. The Staff is in the process of modifying their approach to the technical specifications which would require frequent fast starts to high loads.

And basically our recommendations would be to reduce the number of fast rapid starts and also to, as far as loading, we would not want to routinely load the engine during testing, surveillance testing above the maximum load that would be required in response to an accident.

The main reason for this approach -- and it is not an approach we are using just on the Shoreham engines, but on the TDI engines as a first place to start, and we are also going to look at other diesels. The NRC will be evaluating this approach with regard to other diesels.

But basically we could want to minimize the stresses placed on the engine during quick starts where you go up to speed and become synchronous in less than ten seconds, seven to ten seconds. That puts a worse load on the engines than continuous operation.

My own personal opinion is I think if you started up these engines, you could run them for hundreds and hundreds of hours without any problems at all at maximum

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WRBeb

load, at -- call it rated load or nameplate load or whatever. I think they will run and will continue to run.

But I think some of the problems that we have seen have been more related to fast starts.

Q Let me ask a more particular question or two.

Dr. Bush, you talked about the fact that the rapid startup effect on ligament cracks might not have been properly modeled and might not be fully known at this time. Am I correct so far?

A (Witness Bush) Yes, sir.

Q All right.

In that context, would there be--

MR. ELLIS: Judge Brenner, may I have your question read back, please?

JUDGE BRENNER: Surely.

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

BY JUDGE BRENNER:

Q In that context, would it be material to the possible effect as to whether or not the rapid startup was going to a load of 3900 Kw as opposed to a load in the neighborhood of 3300 Kw?

A (Witness Bush) Yes, I think it probably would. Obviously the one condition would be more severe-- Well, I shouldn't say "obviously," but I believe that the one

WRBeb

condition would be more severe than the other, namely, the 3900 vis-a-vis the 3300.

Q All right.

What about the effects of either-- Well, let me try to ask my general question again.

What about the effects of different loads, 3500 as compared to 3300, at a longer time of operation, to, say, a week, days, many days, and also a comparison of short -- a relatively short period of operation, say, an hour at 3900 versus 3300?

Would those kind of load differences be material in terms of the effect on the initiation and propagation of each of the cracks we have been considering?

A I think that the short time higher kilowatt loads would have a greater effect on the initiation of the cracks in the early stages of propagation than would the longer period of operation at a lower kilowatt value.

I think the question that isn't quite resolved is, would a certain number of cycles from cold startup have a higher value, end up ultimately driving the crack deeper than you would see under a steady-state condition at either that same kilowatt value or at a lower kilowatt value.

WRBagb

Certainly the possibility exists. I personally feel that the initiation phase would be affected. I simply don't have enough information to draw too many conclusions about the final propagation aspects, the depths, in other words, whether they stabilize regardless.

Q But am I correct that nothing in the Staff's testimony, either written or oral, calls for any more test data of rapid startups at any load in conjunction with cracks in the block?

I'll let you think about it over the break, if you want.

A (Witness Berlinger) I want to make sure I understand. Could you run that by me one more time?

Q Yes.

My background context is that I certainly am aware of your testimony of the endurance run and the strain gaging of the cam gallery cracks during that run. And there's also a requirement as I reca for -- I don't want to get into the details, but looking at the block top cracks but without disassembly -- I guess it's eddy current of the stud-to-stud area and certain liquid penetrant things also. But that is on this endurance run at a steady level. And as I recall, the Staff is not seeking any further rapid startup tests at any load in terms of the block cracks.

A If you like, I'll give you a brief answer.

WRBagb

The Staff doesn't have a problem as far as the reliability of TDI diesels to start. Compared to other diesels manufactured and in service in nuclear plants. The TDI reliability to start is as good if not better than most of the other manufacturers' engine.

In addition to the items that have been addressed in our testimony the Staff intends to issue a Safety Evaluation Report which will address not only the particular components which are the subject of this litigation but the entire engine design. It will also address all of the components pertinent to the TDI owners' group program review. We will also address any additional maintenance and surveillance programs which we feel we would like to have the utility put in place to increase reliability over time.

Q The only thing I had in mind was the potential effect on any of the different types of cracks on the blocks.

A If we are going to do anything by actions relative to that limited subject, we would modify the technical specifications to reduce the number of fast starts that we would require these engines to perform on a monthly surveillance basis.

Q You discussed the Staff recommendation in the written testimony and also orally of -- I don't know if strain gage is the right term, but gaging of the mouth of

WRBagb

the cracks.

A Wire gaging.

Q Wire gaging.

Is there any consideration of the need to have instrumentation on the block top during operation?

A No, we have not considered that to be absolutely necessary and most probably it would be a very difficult thing to do.

Q Okay. It would be difficult to place gages during operation that could detect signs of beginning of stud-to-stud cracking, for example?

A A simple answer is I think it would be very difficult, if not impossible, to put them in the right locations.

Q Do you agree, Dr. Bush?

A (Witness Bush) I think it could be done but it would be difficult.

Q I thought the stud-to-stud area at least was available, if you will.

A I think one method is that we made an assumption that near the studs is where the cracks are going to initiate. Since everything indicates a compressive area in the middle region if one put them quite close to that area and if there were a gross perturbation in the strain gage reading, assuming you were getting continuous readout, it

WRBagb

would be highly suspicious. So I guess that would be the way one would look at it. Whether one wants to do it or not is another question.

Q All right.

I guess in lieu of that recommendation and if you agree or disagree with me, Dr. Berlinger or Dr. Bush, that's why the Staff has the block top inspection requirements after each operation of the diesel?

A (Witness Berlinger) That's correct.

Q I think one more question.

Dr. Bush, can you tell whether or not Widmanstaetten structure is present from looking at these replications that FaAA prepared?

I have in mind the plastic-like replications that were done.

A (Witness Bush) Well I suspect if they are an accurate enough replication of the surface that you might get a feel for the structure of the thing. I must confess that I haven't looked at too many of those in quite a while.

I have seen them used in other purposes and they gave a very faithful reproduction of the surface. And so I see no reason that it shouldn't be able to do that.

But my -- it is secondhand information, not firsthand information.

Q All right. Thank you very much.

WRBagb

JUDGE BRENNER: That's all I have.

I apologize for the late break but I wanted everybody to be able to have the break to put their questions together when we come back. I don't know if we are going to make it or not today with these witnesses so we took longer than we thought, so we now join the crowd of many in the hearing who have done that.

We'll come back at 11:25.

(Recess.)

JUDGE BRENNER: Back on the record.

Mr. Perlis.

MR. PERLIS: I have brief redirect, but I do have one scheduling problem I feel compelled to mention before getting into redirect.

Dr. Bush has a number of conflicts next week which were mentioned earlier but there is one in particular next Thursday which involves an ASME section meeting which is the culmination of two years of work on a question and I am wondering if there is some way we can arrange on the schedule where the Board panel -- the panel that the Board is requesting could meet some day other than Thursday of next week.

JUDGE BRENNER: I don't know at this time because I don't know how next week is going to play out, and I'm sorry --

WRBagb

WITNESS BUSH: Then I think you would have to subpoena me, Judge, because --

JUDGE BRENNER: Dr. Bush, I don't want to have an argument or any other discussion with you on the record. I don't know how it will play out next week. If there is flexibility we will attempt to achieve it, and if there is no flexibility it will be not because we started out saying we would refuse to be flexible but just because the circumstances had that result. And that's where I leave it. I just can't do any better than that now. If you ask me my best guess, I think Thursday may turn out to be a problem.

I don't know how long everything is going to take before we get up to that because after we finish this witness panel we are going to go to LILCO's cross-examination of the County's witnesses on blocks, and it is after that is completed that we are going to put the panel together. And that's the best I can say.

If there is flexilibity we'll adjust, but I don't know if there is going to be.

MR. PERLIS: Okay. The only thing I would request is I was wondering if it was possible to have the panel get together on Friday as opposed to Thursday.

JUDGE BRENNER: I don't know if that will allow enough time to finish the panel, that's the problem.

WRBagb

And I'm not going to go -- it would not be very useful to go to the subject of pistons -- this panel is going to be the last witnesses on the subject of blocks and it is not going to be very useful to switch subjects completely to pistons and then have to come back here. You haven't been here for all of the schedule problems in this hearing, Mr. Perlis.

MR. PERLIS: I am familiar with a number of them.

JUDGE BRENNER: I'm just saying I can't do any better at this time.

MR. PERLIS: I just have very brief redirect.

JUDGE BRENNER: There is the obvious fact that whatever flexibility there is gets to be less at the end of the hearing and we have already exhibited considerable flexibility for witnesses for all parties including Dr. Bush earlier in the hearing. It worked out so that there was no problem but we were prepared to be flexible at that point if there had been a problem, and we were in fact in part.

MR. PERLIS: I just did want to alert the Board that we would greatly appreciate it if it could be some day other than Thursday.

JUDGE BRENNER: We can't take those witnesses ahead of the completion of the cross-examination of the County's block witnesses for obvious reasons, given the purpose of that panel.

MR. PERLIS: I understand.

WRBagb

JUDGE BRENNER: And because I don't know when that will end I don't know what to tell you. And I'm not going to have everybody in this hearing sit here doing nothing on Thursday and then come in on Friday and try to finish in half a day for one person. I'm sorry.

REDIRECT EXAMINATION

BY MR. PERLIS:

Q Dr. Bush, there was discussion Wednesday about the monitoring of potential stud-to-stud cracking and, in particular, over what diesel operating conditions should trigger such monitoring.

Under what operating circumstances do you believe such inspection should take place?

A (Witness Bush) I think because of the difficulty in establishing the loads in there that any time there is a run -- and I will define it -- the crack or the eddy current device should be used to monitor.

Let me go back and define what I mean by a run.

For example, if one made several starts in a period of 24 to 48 hours, I would classify that as a run. I wouldn't expect an examination after every one of these, however, after you finished a series of these -- and perhaps the next one might be assumed to be a month or so downstream -- then I would anticipate that you should do such an eddy current examination.

WRBagb

A (Witness Berlinger) Mr. Perlis, can I add something?

Q Please.

A Basically I agree with what Dr. Bush has said but I would put it slightly differently. I would say that after the engine has been run but prior to being put back into service that the eddy current inspection should be done for stud-to-stud cracks and that would permit some maintenance or some surveillance tests to be performed or repeated without having to repeat the inspections many times.

Q Thank you.

Dr. Bush, on the same subject, do you make any differentiation between blocks 101 and 102 and the new 103 block in terms of inspection for stud-to-stud cracking?

A (Witness Bush) No, not particularly. I think you should really examine -- no, I have the caveat that I wouldn't worry about the 103, say, until after the refueling and you have taken the block apart and if you observe or do not observe ligament cracking. Now until you observe ligament cracking I wouldn't be concerned with looking for the stud-to-stud cracking. That's a subjective judgment.

Q Just to make things clear, is it your recommendation that the block 103 be inspected after each operation before the first refueling, or does that recommendation only extend to blocks 101 and 102?

WRBagb

A I'm afraid you lost me on that one.

Q In the context of the stud-to-stud cracking, you have recommended that the diesels be examined after service before they are declared operable again and my question is in the period before the first refueling does that recommendation go to all three diesels or does it just go to diesels 101 and 102?

A The use of the eddy current device, assuming that the examination that's currently underway shows no ligament cracks, would be applied to 101 and 102. That would be my recommendation.

Q And not 103?

A And not 103.

Q Thank you.

Dr. Berlinger, do you agree with that recommendation? Does the Staff agree with that recommendation?

A (Witness Berlinger) Yes, I do.

Q Thank you.

Dr. Bush, you were asked yesterday whether you were aware or had performed any analysis of residual stresses in the block top area. In your professional judgment do you believe any such analyses are necessary in order to determine whether the engine blocks are adequate for nuclear service?

WRBagb

A (Witness Bush) I do not consider them necessary.

Q Thank you.

This morning there were a number of questions dealing with page five, question nine, of the County's rebuttal testimony, and in particular whether there might be horizontal flexing of the camshaft bearing supports in the event of a crack in the camshaft area.

I would also you to also please refer to the sketch at the bottom of page two, the lower sketch in the Staff's supplemental testimony. And my question to you, Dr. Bush, is:

Does the bottom sketch on page two represent the configuration of the camshaft gallery as you have observed it on the original engine 103 block during your examination of that block on September 21?

A Yes, sir.

Q Given the structure, would you anticipate that known cracks in the camshaft gallery could influence horizontal flexing of the camshaft bearing supports?

A No, I do not, if I understand the question. If one examines the amount of support -- you have effectively a vertical ligament that extends down to the plate. You have the base plate, that is not unaffected, and then the horizontal or another vertical ligament. And what we're talking about is a crack that essentially affects virtually

WRBagb

none of this major ligament. Therefore I would not anticipate any effect.

MR. PERLIS: I have no further redirect of these witnesses.

JUDGE BRENNER: Is there followup from LILCO?

MR. ELLIS: Yes, sir.

RECROSS-EXAMINATION

BY MR. ELLIS:

Q Dr. Berlinger, we had some testimony concerning the cam gallery geometry for 101, 102 and new 103. Am I correct that it is the Staff's position that strain gage testing to ascertain whether the stresses are compressive in the cam gallery area if done on 103 would be appropriate and applicable to the 101 and the 102 blocks as well?

A (Witness Berlinger) Yes, that's correct.

Q And the reason for that is that the Staff has determined that the geometries of the 101 and the 102 blocks and the new 103 blocks in the cam gallery area are essentially the same for that purpose?

A Yes, that's correct. And I will also add that the strain gage installation on the 103 block was determined by the Staff to be the preferable block to be instrumented because of the absence of repair welds and that we could get more reliable strain gage data from that block than either the 101 or the 102. But clearly the Staff believes that the

WRBagb

data is applicable to all three blocks.

JUDGE BRENNER: Mr. Ellis, I don't mean to jump on your first two questions but I will do it mildly and just point out my view that you have just got a repeat of testimony just now and nothing now and that your questions were in fact asked and answered previously this morning. I just make the comment. You don't have to respond.

MR. ELLIS: All right, Judge. My silence won't be taken as --

JUDGE BRENNER: No.

BY MR. ELLIS:

Q Mr. Henriksen, do you know how much oil is in the crankcase in the TDI engines?

A (Witness Henriksen) I have heard the number 700 gallons mentioned.

WRB pp

Q Assuming there are 700 gallons of oil in the crackcase, isn't it true that you always get water in the crankcase as a result of blowby from the combustion chamber?

A You probably do get some quantity, I cannot tell. The majority of the vapor that would come down with the blowby would go out with the crankcase vacuum system.

Q And the water that does get into the crankcase from blowby, does that evaporate?

A I don't think I understood your question.

Q What happens to the water vapor or water that gets into the crankcase, into the oil, from blowby?

A I just said I think -- I would believe that the majority would be going out with the crankcase vacuum system. It comes down in the vapor form, it mixes with the lube oil vapor and there is a crankcase vacuum system on there which will maintain vacuuming the crankcase. Most of the vapors would go that way.

Q Doesn't some water get into the oil which evaporates as a result of the temperature of the oil?

A Some water, undeniably, will mix with the oil, yes.

Q You say, I think, you haven't done any calculations to determine how much water would get into the crankcase from blowby?

A No, I have not.

WRBpp

Q Given the size of the engines and the other factors that you know about the engine, would you be surprised at 4 to 9 gallons as being the amount that would get into the crankcase from blowby?

A As I recall the 4 gallons was calculated by Failure Analysis. The 9 gallons was calculated by TDI. The fact that there is better than 100 percent difference between them would indicate that there is some difficulty in determining the exact quantity that goes in.

Q Do you have any reason, though, to disagree with the 4 gallons that FaAA calculated?

A No, I don't.

A (Witness Berlinger) Mr. Ellis?

Q Yes, sir.

A Is that 4 gallons or 4 gallons per minute or 4 gallons per hour?

Q The 4 gallons I intended to be 4 gallons steady state in the oil.

Is that what you understood, Mr. Henriksen?

A (Witness Henriksen) I understood it to be 4 gallons of water.

Q Okay.

On the basis, did you have something you wanted to add, Dr. Berlinger?

A (Witness Berlinger) No, I needed that definition

WRBpp

in order to evaluate the question and the answers.

Q Dr. Berlinger, in your description of what would occur in the event of a crack that was in the cam gallery propagating through, given the testimony that you've heard this morning about the size of the crack as it would propagate through, given the other information that you have, would you expect cam gallery cracks if they propagated through to be an operational problem, a realistic operational problem.

A Are you asking me to evaluate on a realistic basis a totally hypothetical case. Do I understand your question correctly?

Q Yes, sir.

A You want me to hypothesize that the crack does propagate through to the water jacket with nc limitation on the size of that crack?

Q No, I'm asking you to -- let me restate the question for you.

Given the low water alarm that is on the engine, assuming that the crack propagates through the cam gallery, and assuming further that the propagation of the crack through results in a very small leak, as I believe Dr. Bush testified to, would you realistically expect that to be an operational problem with the engine?

A I do not believe that it would shut the engine

WRB pp

down immediately. The affect on any quantity of water, say, up to 20 gallons would have on the ability of the oil to provide adequate lubrication, I really can't address sitting here. There are a lot of factors which I think Mr. Henrikser has mentioned which would have to be taken into consideration including the quality of the oil and the film pressure that would have to be maintained on particular bearing surfaces, et cetera. And the ability of the oil mixed with some water to carry that I could not determine at this point. I have not analyzed that.

Q Would you agree with me, Dr. Berlinger, that the scenario that you discussed that culminated or ended in what you term a crankcase explosion is not a realistic result to expect in this instance?

A No -- the answer to your question is yes. I do not believe that my answer was intended to be a realistic assessment. It was response to a totally hypothetical question in which there were no limitations on the amount of water that was being added to the crankcase. Ultimately, the water continued to leak into the crankcase and the concentration built up to the point where it would destroy the effectiveness of the oil, it could ultimately lead to crankcase explosion.

Q If 20 gallons leaked in you would have an alarm, wouldn't you?

WRBpp

A Yes, I believe so.

Q And wouldn't you expect some portion of that 20 gallons to evaporate from the hot oil?

A I think that's a reasonable assumption.

Q And it's fair to say, isn't it, that there are no -- strike that.

Can you tell me whether or how much of the 20 gallons you would expect to evaporate if it leaked into the oil?

A No, I have no way of guessing at it.

Q Would you be able to tell me whether, even if all of the 20 gallons leaked into the oil, have you done any analysis to determine whether the lubricating qualities of the oil would be of the 700 gallons of oil would be substantially degraded?

A I think I've already indicated that I have not. I have no way of calculating that at the present time.

Q Dr. Berlinger, I think that earlier today either you or Dr. Bush testified that the indications in the new 103 block were on the order of 15 mills. Will you agree with me that these are of a size that, I believe, you term very tight cracks that would be difficult if not impossible to detect visually?

A Yes. And I would go so far as to say that I have viewed the cam gallery saddles number 2 and 7 as recently as

WRB pp

last evening and, to be perfectly honest with you, of the two cam saddles that I looked at, one of them had a black marking pen circle drawn around what has been identified by liquid penetrant inspection to be location of the crack. And even with that identification I could not identify location specifically of that crack.

So I've been able to verify with my own eyes that I can't see anything visually of those cracks.

Q Thank you.

Dr. Bush, with respect to the origin of these indications on the new 103 block would you agree with me that the existence of what you have testified to as process cracks in the 101 and the 102 blocks and the FaAA analysis predicting compressive stresses in the cam gallery area would make it more likely than not that these indications in the new 103 block are process cracks rather than fatigue cracks?

A (Witness Bush) I would suspect that's the case. Obviously, I don't know for sure.

Q When the date relating to the strain gaging of the cam gallery blocks -- if that were to show that the stresses were in compression in a direction perpendicular to the indications would that give you greater confidence that they are process cracks and not fatigue cracks?

A If the compressive stresses were high enough at

WRBpp

the surface that would give me some degree of confidence; that's correct, so far as initiation is concerned.

Q You referred, Dr. Bush, this morning to a thick, dark layer in response to some questions from the Board. Is that thick, dark layer -- strike that.

Are you aware that FaAA has done a microprobe analysis to confirm that this is an oxide layer?

A I have seen it stated in testimony by Dr. Anderson. I have not been able to locate a piece of paper specifically that tells me that that's the case.

Q I take it's your opinion based on what you now know that that thick, dark layer is an oxide layer?

A I suspect it's an oxide layer.

WRBpp

MR. ELLIS: Judge Brenner, maybe I need some guidance here. I will skip ahead. I'm anticipating the formation of this Panel and that might assist me. Am I correct in my anticipation? We certainly would support that.

JUDGE BRENNER: That's our plan and I heard no objection from any parties. Obviously, the Board asked questions on that same subject this morning and the reason we did was we wanted to get some further initial testimony from Dr. Bush about what he thought about those things. We already had quite an insight into what Drs. Rau, Wachob, and Anderson thought about those things from a combination of the oral and direct and supplemental and rebuttal testimonies. So we wanted to have that initial indication even though we expect to come back and probe as necessary with that Panel. Am I right that no party objects on that procedure?

MR. ELLIS: LILCO has no objection.

JUDGE BRENNER: I knew that.

MR. PERLIS: The Staff has none.

JUDGE BRENNER: I knew that because you told me that the other day.

MR. BRIGATI: Judge, I'm not sure what the procedure is.

JUDGE BRENNER: I'm sorry. I don't want to go

WRBpp

through the whole thing again. Mr. Dynner was here when we discussed it.

MR. BRIGATI: I know you're reconvening the Panel. Are you suggesting we defer any further questions on the examination by the Board this morning concerning the oxide layer on the cam gallery cracks from the 103 block until the reconvention of that Panel?

JUDGE BRENNER: I think that would be a more efficient way to proceed, yes. And the Panel won't be limited to the oxide layer. It'll be limited to the subject of metallography or metallurgy. You can tell that from the makeup of the Panel we're talking about. And, for example, there are some things in your rebuttal testimony presented by Dr. Anderson which is not limited to the oxide layer. But the short answer to your question was yes, I think that'll be a better way to proceed at this point. But we're not requiring that you do it that way.

MR. BRIGATI: The County has no objection to that procedure at this point.

JUDGE BRENNER: And to fill out the thought I think you can understand you can ask witnesses for all the parties that affect the same question or to immediately comment on the previous answer of the other witness. They'll all be up there together.

MR. BRIGATI: I understand.

WRBpp

JUDGE BRENNER: All right.

How much more do you have, Mr. Ellis, if you skip questions on the oxide layer?

MR. ELLIS: I would estimate a half an hour to 40 minutes. I might be able to shorten that a bit. I'm working hard at that even right now.

JUDGE BRENNER: We might as well break now, then.

MR. ELLIS: I can cover two more quick ones, if that might help.

BY MR. ELLIS:

Q Dr. Bush, you and Dr. Berlinger were asked questions concerning Suffolk County Exhibit 79, an eddy current inspection report; do you recall that?

A (Witness Bush) Yes, sir.

Q Are you aware that LILCO and FaAA independently investigated this eddy current dedication using liquid penetrant techniques to confirm that the crack indication did not grow out of the liner landing?

A I read the pages of the testimony, yes.

Q That transcript at 25,538?

A Yes, sir.

Q Do you have any reason to disagree with Dr. Johnson's testimony at transcript 25,538 that all the reinspections are consistent with the fact that no crack was found running down out of the liner land area?

WRB pp

A Yes. I would anticipate that the most definitive method would be -- at this location might be the penetrant test and if that didn't show anything I would have a considerable confidence.

Q So you're testimony is you would agree with Dr. Johnson there?

A Yes.

A (Witness Berlinger) Mr. Ellis, can I answer?

Q Yes, sir, you may.

A I concur with Dr. Bush. I don't quite understand why one person found an indication and another person didn't but I also would believe in that particular geometrical location that if no crack was identified as existing using liquid penetrant, that it didn't exist, because I don't believe it healed itself.

MR. ELLIS: Judge Brenner, maybe this would be an appropriate time and I will make an effort to shorten it even more.

JUDGE BRENNER: All right.

One reason we think short followup is in order of these witnesses is a lot of people have asked a lot of questions of the witnesses. Take a look at some of the questions you asked this morning -- well, you don't have to, but if you do at any time, see if you agree with me that a fair percentage of them -- I'm not saying a majority, but

WRB pp

some percentage of them had, in fact, been asked and answered and we really have no additional testimony on the point as the result of it.

I'll just leave it at that.

Okay, we'll adjourn and we'll be back at 10:30 on Tuesday.

(Whereupon, at 11:55 a.m., the hearing was adjourned, to reconvene at 10:30 a.m., Tuesday, November 13, 1984, at this same place.)

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 9, 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

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