UNITED STATES
NUCLEAR REGULATORY COMMISSION

ORIGINAL

IN THE MATTER OF:	DOCKET NO:
LONG ISLAND LIGHTING COMPANY	50-322-OL
SHOREHAM NUCLEAR POWER STATION	

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the matter of: :

SHOREHAM NUCLEAR POWER STATION : Docket No. 50-322-OL

(Long Island Light Company :

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State Office Building

Veterans Memorial Highway

Hauppage, New York

Monday, September 24, 1984

The hearing in the above-entitled matter was convened at 10:30 a.m., pursuant to notice.

BEFORE:

JUDGE LAWRENCE BRENNER,
Chairman, Atomic Safety and Licensing Board

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

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

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APPEARANCES:

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Office of the Executive Legal Director

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PROCEEDINGS

PRESIDING JUDGE: Good morning. We are on the record.

We will note the usual appearances. I don't see any Counsel for the State present, but we do have Counsel for the Staff, LILCO and Suffolk County present.

We have come preliminary matters to take up before getting to the testimony of the Staff's witness.

One minor, brief preliminary matter is that the Board has reviewed the Proposed Resolution of Suffolk County Diesel Generator Contention regarding some of the heads. In principle, it is acceptable to us and we have no problem with it.

As a minor point it appeared to the Board on preliminary reading that with respect to Paragraph E, which starts on page 3, the procedure spelled out there deals with the barring over and rolling over of the engines and checking the engines after that procedure, but does not spell out what the engines are being checked for and what the criteria or criterion would be for that check.

Under Paragraph F, which seems to deal with a different routine surveillance procedure, there is an explanation of that. If the parties believe the explanation in F applies to E, it was not clear to us on reading the express agreement that it is to be so applicable.

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I think we understand what is involved here. Perhaps we have misread something, and I just leave it as a suggestion to the parties as something they might wish to check.

Presumably the object of Paragraph E, like the object of Paragraph F, is the detection of any leakage.

MR. DYNNER: Judge Brenner, I should say for the record I think we will check this. It is our understanding, and it is stated in here, that there will be a modification to the existing procedure that LILCO has already in place for barring over, and we will check that procedure to make sure it is clear that the criteria are correct.

I should also state for the record that over the weekend I did confirm that this resolution is authorized and acceptable to our client. I have mentioned to Mr. Ellis that one of the things we would like an understanding on that is not specified in here is that documentation of inspections will be promptly furnished to the County. But I think that is a detail we can arrange.

And I have sent the copies of the resolution to the Special Counsel to the Governor for signature on behalf of the State of New York. As soon as that is returned, it will be returned to me and I will distribute the copies to the parties.

JUDGE BRENNER: All right. I don't want to get

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further into the details of an agreement which is still in the negotiation stage, albeit final negotiation stage, and we can leave it where it is right now for purposes of the record.

Do you have a timeframe in mind as to when you will have a final agreement for our approval?

MR. DYNNER: No.

MR. ELLIS: Judge Brenner, Mr. Dynner just spoke to me no more than five minutes ago. It won't take LILCO very long at all, but we do need to look into this latest request to see how it was handled in the past. And I think generally documentation available to the Staff they can obtain from the Staff, but I will have to look into that.

As far as LILCO is concerned, the time that we're talking about is very minimal, this week I would hope.

JUDGE BRENNER: We would not like it to drift beyond this week if at all possible to avoid that. We are making schedule decisions, some of which we will discuss in a moment, based on the supposition that the cylinder head issue is going to be settled. And it would certainly not assist our schedule plans to find out beyond this week that that assumption is incorrect.

We don't expect to find that out but nevertheless, I think we will all feel better if the agreement is executed and approved this week.

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All right. On Friday morning, September 21, the Board obtained a copy of LILCO's Motion to Admit Supplemental Testimony on Suffolk County Contention Regarding Cylinder Blocks, and the supplemental testimony was attached. Apparently the motion had been delivered to our offices some time before Friday morning, I believe late Thursday.

We have also received at the locus of the Washington National Airport this morning Suffolk County's response to LILCO's motion, and we appreciate that the logistics were such that we were able to receive it then because it gave us an opportunity to read Suffolk County's answer.

I assume, but let me check, that the other parties have also received and read the paperwork I just described.

MR. FARLEY: I just received it, Judge Brenner, about ten o'clock, and hurriedly tried to read it.

JUDGE BRENNER: All right, when you filed your motion late Thursday.

Staff?

MR. GODDARD: Staff similarly received a copy at ten o'clock and is in the process of reading it now.

JUDGE BRENNER: It is only a few pages.

Did the Staff receive LILCO's motion on Friday?

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MR. GODDARD: Yes, Friday evening.

JUDGE BRENNER: I don't understand that.

MR. GODDARD: On Friday evening the Staff-- I was hand-delivered a copy at my home in Fairfax County, Virginia. As of approximately two-thirty in the afternoon on Friday, I inquired of Mr. Edwin Reese, who is on the service list in this case, and he had not at that time received a copy of LILCO's motion and supplemental testimony.

JUDGE BRENNER: I don't want to dwell on it. There was a previous problem in this case with service of a LILCO document on the Staff. And whatever problem occurred -- and I don't know on which end the problem occurred -- it should not happen again.

MR. FARLEY: Judge, I confirmed that it was delivered to the Staff at 3:55 on Thursday.

JUDGE BRENNER: As I said, I am not inquiring into at which end the problem occurred.

Let me ask LILCO: Does the County's answer correctly represent LILCO's position in the matter?

MR. FARLEY: No, Judge Brenner.

JUDGE BRENNER: Can you tell us your position then?

MR. FARLEY: Yes, sir.

First of all, we delivered it to Mr. Dynner's

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office on Thursday evening. Now I realize he was en route. The first I heard from Mr. Dynner was at 3:35 p.m. on Friday afternoon.

Getting to the merits of the matter, we are in agreement that the subject matter of the supplemental testimony is relevant and material. Both sides agree to that.

As to his characterization of it as significant new information, we do not agree with that. From very early in this proceeding, he knew from the June report and even before that, the preliminary report from FaAA about cam gallery cracking, he new about the stud-to-stud cracking, and he knew that as far as FaAA or LILCO knew at that time -- and it was also true as of the date of the filing of the testimony -- that there were no circumferential cracks in the original 103.

Now at the time we filed the testimony on August the 14th, it was true and correct, to the best of our knowledge and information.

The problem was that people are continuing to document the matters that we have set forth in the testimony, and in the course of that documentation, two significant things occurred.

The first was that -- and we had to go to California to confirm this -- that....

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JUDGE BRENNER: Let me interrupt. And if you think you still want to proceed the way you were proceeding, I will allow it.

My question was whether the County has correctly represented your position in the matter. I should have been more specific.

MR. FARLEY: I beg your pardon. Yes, sir.

JUDGE BRENNER: The position with respect to the fact that the County is not entitled to any discovery of the new matter, and to the fact apparently that you believe we should proceed with LILCO's testimony on the cylinder blocks immediately after completing the Staff testimony on crankshafts.

MR. FARLEY: Yes, sir, you do correctly understand our position.

JUDGE BRENNER: On reading your supplemental motion, it struck me, as it struck the County in their answer, that LILCO was very careful not to disclose when they knew this information other than stating some time after August 14th.

So when did you know that there was going to be some supplemental information along the lines filed?

MR. FARLEY: On September the 6th, in the telephone conversation that he refers to, we advised him that it was likely that we were going to file supplemental

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testimony. But at that particular time the work had not been done. We had only learned at that time that it was necessary to conduct a further investigation.

So then the work proceeds from September 6th, and it was only last Thursday that we knew -- approximately in the last ten days that we knew what the results of this further investigation were. And as soon as we knew, we advised the Board and we advised the parties.

JUDGE BRENNER: What work had not been done by September 6th? You said you knew something on September 6th, but "the work" had not been done.

MR. FARLEY: The first thing, your Honor, was that we were aware that an inspection report confirming that cam gallery cracks were less than 3/8ths inches deep could not be located, and the photographs dealing with that situation were not sufficient so that necessitated an independent FaAA measurement of the cracks.

Secondly, an additional examination and analysis were performed to assess the deeper cracks by, one, non-destructive inspection of the surface and the depth, and the second, a destructive sectioning of portions of the old 103 block.

Thirdly, we learned for the first time at the end of the week before last that the data reduction used by TDI in connection with its strain gauge data that is referred to

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in our testimony was not accurate, and the basic data that is referred to in that strain gauge data could not be verified.

So then we proceeded further with a piece of the old 103 block top with the deepest stud-to-stud crack and cut that up, and that showed, rather than being .5 inches deep, it was only 3 inches deep.

JUDGE BRENNER: Excuse me. A lot of this is in your testimony. What I'm not clear on is what was done several weeks ago as opposed to what you first learned about late last week?

MR. FARLEY: I would say essentially, Judge Brenner, it was the error in the data reduction of the TDI strain gauge data and secondly, it was the completion of the destructive examination of a portion of the old 103 block.

JUDGE BRENNER: September 6th is when LILCO first knew it would have to supplement its testimony on that blocks. Is that what you're telling me?

MR. FARLEY: I'm sorry, your Honor, I didn't hear you.

JUDGE BRENNER: Were you telling me that September 6th is the earliest date at which LILCO it would have new information causing a need to supplement its testimony on the cylinder blocks?

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MR. FARLEY: We did not know that we would have it on that day. We knew that we had to proceed with these further investigations.

JUDGE BRENNER: You did not inform the Board of that.

MR. FARLEY: No, sir, because we didn't have the results.

JUDGE BRENNER: We were engaged in complex matters with regard to the schedule of the proceeding at least prior to that date, and issued a ruling in connection with the Staff's motion to delay the beginning of the proceeding. The hearing, if I'm correct in my memory -- and it fades with time very rapidly in these hearings -- started on September 10th, so September 6th was a rather important date with respect to -- not as a particular date but relative to the start of the hearing and relative to the motions before us before the Staff regarding schedule.

It was an important timeframe with respect to scheduling, and I would submit to you that LILCO was less than forthright in the matter of scheduling at least by remaining silent with respect to this matter during that period.

MR. FARLEY: I won't argue with the Board.

JUDGE BRENNER: You can argue with us. I put it out for you to respond.

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(Laughter.)

MR. FARLEY: On September 6th when we were talking about scheduling, we scheduled -- we told the Board that we wanted to schedule the block testimony last. And one of the reasons we wanted to do that was because we did not now what these further investigations were going to reveal.

JUDGE BRENNER: Yes, but also during the July and August timeframe, LILCO was ready for hearing the day before we were talking about the schedule in each instance, to exaggerate the matter slightly, but not much. And even as late as the September, the early September timeframe, and I frankly don't remember the date we ruled on the Staff's motion but it was probably the last week of August or in that timeframe, LILCO was saying it was ready for hearing.

That's different than saying we are ready on three of the four issues and we need some accommodation on the fourth issue.

MR. FARLEY: Judge, we were ready. Nobody-- From the very beginning nobody has known that there were any circumferential crackings on these blocks until old 103 was cut up last week.

Now everybody knew about the stud-to-stud crack, including the County and the Staff. We thought it was five inches. When we cut up the old block we find out it is

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three inches.

On the cam gallery cracking, I have already related that we were relying on inspection reports in connection with the testimony and in connection with our representation that we were ready on the block. We find out that the inspection reports were not available; the photographs that are available are insufficient, and so that necessitates the further investigation.

JUDGE BRENNER: I'm not criticizing the further investigation. I'm criticizing the lack of notice that these matters were on-going at that time, and the notice to us that you did not have results yet, and as a result, we should hold off on scheduling the block testimony.

From time to time even after this hearing started we have had some complex scheduling matters that had to come before us because the parties could not work it out, and this certainly would have been a factor in that rather complex consideration.

Let me leave it at that.

MR. FARLEY: Your Honor. obviously the County and LILCO have a difference of opinion but I respectfully submit that the three areas on which we want to submit supplemental testimony are not matters of substance. No opinions or conclusions have been changed, and we should be permitted to proceed with the block testimony.

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JUDGE BRENNER: We're going to let the supplemental testimony in. That's our starting point. The problem is what adjustments need to be made in the schedule as a result of that, if any.

Staff, let me get your position on the matter.

MR. GODDARD: It may be surplusage for the Staff to state that it clearly feels this information is new and significant in light of the Board's decision to admit this. The Staff feels that it is of such significance that further discovery, as requested by Suffolk County in their motion, the need for supplemental testimony, and the need to review that supplemental testimony will be required. Again, in the Staff's view, in light of the Board's comment, the only question apparent to us is how much time should be devoted to these matters and the scheduling of that timeframe.

JUDGE BRENNER: Do you have any suggestions along those lines?

MR. GODDARD: No. I think that is more appropriately a point to be raised by Suffolk County. The staff would take a position based upon Suffolk County's request for additional time. I will acknowledge that the NRC Staff has been informed of certain of the destructive and nondestructive examination results prior to this time. I don't know -- I don't believe that's the case for Suffolk County.

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JUDGE BRENNER: Well, the County has made a suggestion, although a little vague as to its particular timeframe. They want to stop the hearing cold after your witness completes his testimony on crankshafts -- your witnesses. What is the Staff's view in that regard?

MR. GODDARD: The Staff would definitely prefer to complete the crankshaft testimony because of the pending nonavailability of Dr. Sarsten.

JUDGE BRENNER: The County's willing to do that but they want to stop the hearing after that.

MR. GODDARD: The Staff would support a suspension of the hearing insofar as it relates to blocks. I have not had an opportunity to discuss with the NRC Staff and their consultants whether or not we should proceed forward on pistons. And in the event the issue of cylinder heads is not settled, whether we should proceed on that issue as well prior to any break in the hearings for the purpose of discovery or preparation of supplemental testimony on cylinder blocks.

JUDGE BRENNER: When can the Staff go ahead on pistons?

MR. GODDARD: I would prefer to discuss that with my clients during the noon break and report back to the Board at the start of this afternoon's session, if that would be permissible?

JUDGE BRENNER: Could you go ahead this week on pistons as a possibility? I'll give you a chance for that discussion but I want to know what the parameters might be now.

MR. GODDARD: Dr. Laity informs me that there is a possibility we could proceed on pistons as well as crankshafts.

JUDGE BRENNER: All right.

We don't want to stop the hearing before that scheduled break the week of October 8 and we don't intend to stop the hearing. So given that as your starting point, Mr. Dynner, we would want to go ahead with the County's testimony on crankshafts first and then pistons, perhaps after the Staff's testimony on pistons, depending on what assist to their witness problems this adjustment in the schedule might give them.

If you have a strong need to go ahead with pistons before crankshafts, we'll consider it, but it would have to be strong.

When could we go ahead with the County's witnesses on those subjects. I have observed many of the County's witnesses present throughout this hearing and I will note that for the record.

MR. DYNNER: Well, I just have to ask the Board's indulgence to try to check with that and report back to you

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at the noon break.

JUDGE BRENNER: All right. That's the bad news for you based on your motion, not all of which we agreed with with regard to that matter. That is your asserted need for further time to prepare your witnesses for cross examination after all this time it does not weigh heavily on our mind.

We do consider the fact that many of your witnesses overlap to be a factor, but not a controlling one. Because you have many witnesses and many counsel, and you can have lead witnesses and lead counsel taking care of discovery on the blocks, while other lead witnesses and lead counsel are here.

You also have a period of time, namely the one week already scheduled, when you will not be in hearing. And you can use that to prepare additional testimony.

If you think that would not be sufficient, you can tell me why now.

MR. DYNNER: The County's testimony on both the crankshafts and the pistons involves, as you know, Dr. Anderson as one of the key witnesses.

From what I have seen on the LILCO supplementary testimony, much of it, if not most of it, will deal with metalurgical matters that would necessitate, in particular, Dr. Anderson's involvement. I anticipate, although I am not

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making this request at this point. But I anticipate that it may well be that one of the things Dr. Anderson wants to do is ask for a physical inspection of the blocks and of the 103 block that was sectioned.

I learned this morning, for the first time, and I'm very disturbed about the fact that, apparently, there were also meetings held late last week on Thursday and/or Friday between the Staff and LILCO, in which inspections of the blocks were carried out and various discussions held. And I say I'm disturbed because it's been the past practice, as you know, that whenever discussions of any seriousness or magnitude involving this litigation were held, such as TDI owner's group, they were held open and transcripts were taken of those meetings.

JUDGE BRENNER: If what occurred is, as you stated, that it would be inconsistent with past practice, what you have, I think, a right to expect would continue to be the case unless and until informed otherwise by the Staff and/or LILCO.

MR. DYNNER: Yes, sir.

To get back for a moment to my reaction to the scheduling, I would anticipate that, with cooperation from LILCO in furnishing us discovery, and with the possibility of a physical inspection in the offing that, giving us the week of the 8th only, might not be enough. And that it may

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well be that we will need the following week. One week, in other words, to do a physical inspection when Dr. Anderson would presumably be free to do that. And then the following week to evaluate his findings and prepare our supplemental testimony.

So that is just my very quick, gut reaction to what you've said on the blocks.

JUDGE BRENNER: All right. We will consider that.

Have you considered the fact that starting on the 27th of this week, Dr. Anderson can begin doing whatever it is he needs to do and he will have from the 27th until Sunday, which will be the 30th, to work things out. Then if he has to be in hearing here the following week, and based on our desires he would be, he would also then have the afternoon of the 4th through the 14th during that break to do his work.

In addition, I could understand why you would need him, based on what you've stated, to both assist in discovery and possible preparation of supplemental testimony on the blocks. And also to be here testifying on the other subjects.

However, assisting in discovery is not the same as having to be present for discovery. You have other witnesses who you are relying on and with direction from

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Dr. Anderson, presumably, they can do a lot in terms of assisting either at depositions or formulating discovery requests, and so on.

Incidentally, the only type of discovery we have in mind would be documentary discovery, depositions, and perhaps, inspection. In other words, no interrogatories other than, perhaps, some simple requests for identification of when were certain things done.

MR. DYNNER: Yes, sir.

I think I have taken those time elements into account. I think that as we said in our response to LILCO's motion, it is a fact that our witnesses have not been -- have not had the benefit of preparation of their own cross examination which is normal in these cases. Insofar as to this point, some of them, as you know, including Dr. Anderson, has been absent most of the time. And others have really been focusing their attention to dealing with the cross examination that is going forward.

And we will have to use, I believe, every free second in preparation of our witnesses for their cross examination. It is not simply a matter of getting up there, as you well know, and answering questions without having carefully reviewed what they've said and then prepared.

And so, I'm not trying to be argumentative, but I would think that, given the Board's unwillingness to suspend

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the hearing for any period of time, then we're going to have to really break our backs to get our witnesses prepared for cross examination. And that would include over the holiday period this week.

JUDGE BRENNER: Does the Staff have a position with respect to its need for time on the cylinder blocks, and also whether the time I outlined would suit that need? Your previous comments seem to support the County, but I need to hear more particularly as to what the Staff thinks it needs,with respect to cylinder blocks.

MR. GODDARD: The Staff's need for time with regard to the cylinder block would be involved primarily with the review of the LILCO supplemental testimony as opposed to examination on the samples taken from the old 103 block.

JUDGE BRENNER: Don't you think you need to see those?

MR. GODDARD: We already have, Judge Breener. Dr. Bush has examined those specimens. To the extent that additional examination would be required, the Staff is of the opinion it would take a minimum of time.

Our primary time concerns would be with review of the testimony, the preparation of our own supplemental testimony and, finally, a review of -- and response if required -- to supplemental testimony prepared by Suffolk

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County in this proceeding.

JUDGE BRENNER: We're not going to have staggered testimony filing timeframes now.

MR. GODDARD: Staff appreciates that.

JUDGE BRENNER: That was an unusual accomodation last time which the staff turned around out of context after that.

Putting that aside, if we were to set a date for the receipt of supplemental testimony, if any, by the Staff on cylinder block for near the end of the week of the 8th -- either the 11th the 12th, in that timeframe -- what would the Staff think of that proposal?

MR. GODDARD: The Staff would be ready to file supplemental testimony by that time.

Did you also ask, Judge Brenner, for our position with regard to the County's request for, I believe, a two-week suspension?

MR. GODDARD: No, I did not. But you're free to offer it.

MR. GODDARD: The Staff would support it.

JUDGE BRENNER: Why?

MR. GODDARD: By virtue of our evaluation of the significance of the testimony received from LILCO with regard to the magnitude of exchanges in prior testimony as opposed to any forewarning of the Staff's evaluation of the

significance for the operability of the blocks overall. The Staff feels that a two-week period would be appropriate. This has been discussed with the ELD management. The Staff would not oppose the County's request for two weeks for discovery and preparation of testimony.

JUDGE BRENNER: I have not discussed the Board's view on the significance of the testimony or lack thereof so far, I merely said our starting point would be that we would admit it. The main stimulus for that is all the parties seem to agree on that point, so it did not call for much of an analysis by us. It's new and if it required a ruling by us we would have ruled, even over opposition, that it would have to come in in order to give an accurate, factual picture of the present state of affairs. That's different than saying it's highly significant.

And in fact, if you want my personal opinion as one Judge, while I think some of it might become significant and that's why I agree that discovery is appropriate, based on what we've seen so far the County's answer in my mind exaggerates the significanceof it. The cam gallery -- rather the stud-to-stud cracks go to three inches instead of five and a half inches. The camshaft gallery cracks, in the view of LILCO at least, are less of a problem then they were before. On the circumferential cracks, I offer no opinion. I don't know enough at this time --

MR. GODDARD: Excuse me, Judge Brenner, if I might respond briefly.

JUDGE BRENNER: So why are you saying that --

MR. GODDARD: Perhaps you misinterpreted my comments or perhaps I misspoke them. What I indicated was

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they appear to the Staff to be significant in view of the changes to previous testimony. We are not offering any opinion at this time as to the overall significance. That was the intent of my comment.

JUDGE BRENNER: Well your comment, however, was in the context of the length of time needed for preparation, including both discovery and preparation of possible supplemental testimony. And it was in that context that you used the description "significant." And when somebody uses that context then we are in that context that usually means there's a lot going on here, that a lot of time is needed. And I don't see it, based on what we have in the motion other than the circumferential cracks, about which I offer no opinion.

The Staff itself does not need a two-week hiatus, am I correct?

MR. GODDARD: That is correct.

MR. DYNNER: Judge Brenner, since we're discussing schedule I raise at this time the question as to whether anything else is going on -- on-going in terms of the matters at hand that could have any kind of real impact on the case or on the scheduling. I am aware that discussions are on-going between LILCO and the Staff considering the testing of one or more of the engines. If there is agreement on that that could, of course -- again

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we're back to saying Okay -- what kind of testing is there is not the issue, but the results of that testing could be very significant to this hearing. And I don't know anything about whether there is going to be agreement or not, I have not been involved directly in those discussions. But it seems to me as long as we're discussing this whole thing we should get everything out on the table.

JUDGE BRENNER: Well I suppose it's in the nature of the adversary process that whenever the Board says one thing it seems to get exaggerated from the point of view of a party who believes it might support them on something else.

I gave you some support and did it purposefully in terms of the fact that the County may have been excluded -- and I emphasize the "may," I don't know what went on and I'm not going to undertake a collateral inquiry -- but may have been excluded from some significant results of destructive examination of the old 103 block and some non-destructive examination as well. I tend to put some significance on that based on our expectations given the past performance in this case that when the Staff is going in to perform some major observation, whether it be called an inspection or not, that the County was usually involved -- not in performing the inspection itself necessarily but in knowing what was going on and being able to observe and

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then being able to follow up if it wished to later. My comment was in that context.

Now it sounds like you're talking about some possible on-going discussions between the Staff and LILCO with respect to inspections or surveillances that may make the Staff's equivocation less equivocal from LILCO's point of view I suppose.

That type of discussion is perfectly permissible and it's expected to go on, just as discussion between the County and any other party would not be surprising, even of a bi-lateral nature.

Now if it gets to the point of something significant that might affect either the substance or the schedule of this proceeding, we would expect to hear about it promptly.

I have already given my opinion that in my view we did not promptly hear about the possible effect on the schedule of LILCO's on-going work with respect to those cylinder blocks on a timely basis and I assume that they will not err again in the near time frame in that regard.

So they have all these remarks to consider. But the mere discussions among parties is not prohibited. I don't expect them to come to me every hour and say Oh by the way two people on our staff talked about this subject and maybe we're going to make some headway on it; that's a

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wholly different matter.

You're nodding "yes," maybe I've made my point.

MR. DYNNER: Yes, I was nodding. I did not mean to -- my remarks should not be interpreted as a criticism of the Staff having some meetings of that nature with LILCO without our being present. I was only raising the issue, which I think you have responded to, about the possibility of other significant matters being -- maybe having an impact.

But enough said. I was nodding in response to that aspect of your remarks.

JUDGE BRENNER: It was my belief -- getting back to schedule -- that we would complete the Staff's testimony on crankshafts today. We have taken some time away from that project and my estimate may prove to be wrong, but that was my expectation.

Does anybody know anything that would disabuse me of that notion?

The County?

MR. DYNNER: No, sir.

JUDGE BRENNER: LILCO?

MR. ELLIS: Judge Brenner, I am under the impression that Dr. Sarsten will be the witness and I have submitted a cross-examination plan relating strictly to Dr. Sarsten, and I would certainly hope we could finish

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today.

JUDGE BRENNER: I thought he was going to be up there with Witness Henricksen also.

MR. ELLIS: I was not aware of that. I thought it was just Dr. Sarsten.

JUDGE BRENNER: They are co-authors of almost all the answers.

Staff, can you enlighten us?

MR. GODDARD: Dr. Sarsten and Mr. Henricksen are co-authors of much of the testimony, excluding that dealing with analysis of torsional vibrations and —

JUDGE BRENNER: They'll be up there together?

MR. GODDARD: They will be up there together, yes.

The Staff would also empanel with them Dr. Bush, who has already testified as to two questions in the crankshaft area: solely for the basis of expediting matters if it turns out that some of the questioning crosses back into the line of the two answers which he has already spoken to.

JUDGE BRENNER: I would not be in favor of that. We have finished the opportunity for cross-examination on that. He was expressly noted to be up there for that.

MR. GODDARD: Very good.

JUDGE BRENNER: I have enough trouble making

WRBagb

progress on new ground.

MR. GODDARD: All right, Judge Brenner.

MR. DYNNER: Can I add one other element which may impact your ruling on the scheduling matters?

JUDGE BRENNER: Surely.

MR. DYNNER: Professor Sarsten, it is my understanding this will be his last week -- next week will be his last week.

MR. GODDARD: Next week.

MR. DYNNER: I would like to request that the Board permit us to proceed next out of turn with the cross-examination of the Staff witnesses on pistons. That would give us the opportunity, first of all, to make sure that we have Professor Sarsten's cross-examination completed. Secondly, it would give us -- since this is a short week, the holiday period this week -- to do some witness preparation so that our witnesses will be better prepared to start next week.

So I would just like to throw that out as a request for consideration.

JUDGE BRENNER: Well I had precisely that in mind when earlier this morning I asked the Staff if they could go ahead with their testimony on pistons. I'm not going to order them to do it if they say they can't, but if they say yes, we will do that precisely for the reasons you indicated

1 WRBagb

so that you will not have to bring all your witnesses in here for a short week. That's the main reason. And the fact that we will give you some other time for further witness preparation is a bonus.

MR. GODDARD: Judge Brenner, the Staff will be amenable to proceeding on that basis and having the Staff panel on pistons cross-examined immediately after Dr. Sarsten and Mr. Henriksen are cross-examined on the crankshafts.

JUDGE BRENNER: All right. We'll do that. That will be our testimony for this week. If we have only half a day left on Wednesday, we will not require the County witnesses to be here to begin their testimony for that half a day unless they are here anyway.

Are they here anyway?

MR. DYNNER: No, sir. Professor Anderson is not here and others -- as you can see Professors Christensen and Mr. Ely and Mr. Hubbard are here but those are the three who are here. The others are not.

JUDGE BRENNER: All right.

Next week, Monday, we would start with the County's testimony on crankshafts. Unless there is a strong reason to do business first, we would prefer taking up crankshafts first.

Then we will go to the County's testimony on

1 WRBagb

pistons whether it occurs before or after the break and our schedule depends on when it would occur.

Then after the break — we will decide how long the break shall be — we will start with LILCO's testimony on cylinder blocks either right away or after completion of the County's testimony on pistons, if that has not yet been completed. And then we would go, in turn, to the County and Staff on cylinder blocks.

That's all we have in terms of preliminary matters.

Does anybody have anything else?

We will let you know about the length of the break as soon as we have decided.

MR. ELLIS: Judge Brenner, the cross-examination plan which we delivered to the Board this morning is just for Dr. Sarsten.

JUDGE BRENNER: I believe, and my memory may be incorrect, that Mr. Henriksen is not the sole author of any answer so a plan geared to Professor Sarsten will necessarily cover all the pertinent answers anyway.

MR. ELLIS: I think all of those areas are areas that are not Professor Henriksen's, they are all Professor Sarsten's.

JUDGE BRENNER: Unless you have an objection, we will let them act as a panel and they can both respond.

WRBagb

LILCO is going to cross-examine first and then the County.

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

JUDGE BRENNER: Okay. We can swear the witnesses in.

MR. GODDARD: The Staff calls Professor Arthur Sarsten and Mr. Adam Henriksen to the stand.

JUDGE BRENNER: Why don't you introduce them, then we can swear them in?

MR. GODDARD: The Staff calls Mr. Arthur Sarsten and Mr. Adam Henriksen to the stand. Professor Sarsten is sitting on the right of the panel.

JUDGE BRENNER: All right.

Whereupon,

ARTHUR SARSTEN

and

ADAM HENRIKSEN

were called as witnesses and, having been first duly sworn, were examined and testified as follows:

DIRECT EXAMINATION

BY MR. GODDARD:

Q Professor Sarsten and Mr. Henriksen, I ask you if you have before you a copy of the NRC Staff testimony, the relevant pages being page 9 through page 21 inclusive, and Exhibits 1 through 4 thereof?

A (Witness Sarsten) We do.

Q Insofar as each of you are identified therein as the sponsors of answers to individual questions--

JUDGE BRENNER: Mr. Goddard, I think you have the pages wrong. It would be 9 through the middle of 18.

MR. GODDARD: You are correct, 9 through the middle of page 18, and Exhibits 1 through 4.

3 WRBeb

BY MR. GODDARD:

Q I ask you, to the extent that you are identified as the witness sponsoring such answers, whether they are true and correct to the best of your knowledge?

A (Witness Sarsten) They are.

A (Witness Henriksen) They are.

Q Although not prepared by you, to some degree are the Exhibits 1 through 4 true and correct to the best of your knowledge, to the extent that you have relied upon them in your testimony?

A (Witness Sarsten) They are.

A (Witness Henriksen) They are.

Q Are there any corrections to that testimony that you would like to make at this time, prior to it being introduced into evidence?

A (Witness Sarsten) Exhibit 2 shows a preliminary plot of the torsional vibratory stresses in the TDI eight-cylinder crackshaft. This is with negligible damping.

I have later had time to repeat these calculations using larger values of damping and this brings some of the resonant peaks down slightly, but it does not in any way alter my conclusions.

Q Thank you, Dr. Sarsten.

Are there any further corrections from either of you?

2 WRBeb

A No.

A (Witness Henriksen) No.

Q Fine.

MR. GODDARD: As corrected, the NRC Staff moves that the testimony be bound into the record as though read, accompanied by Exhibits 1 through 4.

JUDGE BRENNER: The testimony of course was previously bound in on September 20th and appears in that transcript.

We will now admit the portion identified as being sponsored by these witnesses on the subject of crankshafts into evidence.

We will also admit into evidence Staff Diesel Exhibits 1 through 4, and they may be identified for the index by the same titles used on the Staff's Diesel Exhibit List.

I guess they are not very thick. We can bind them into the transcript, in addition, for convenience and we will do at this point. But there will also be three copies for the official exhibit record.

(Whereupon, the documents referred to were marked as Staff Diesel Exhibit 1 - 4 for identification.)

(The documents follow:)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

EXHIBITS
for

JOINT TESTIMONY
OF
CARL H. BERLINGER, SPENCER H. BUSH,
ADAM J. HENRIKSEN, WALTER W. LAITY, AND PROFESSOR ARTHUR SARSTEN
ON
CONTENTIONS CONCERNING TDI EMERGENCY DIESEL GENERATORS
at the
SHOREHAM NUCLEAR POWER STATION

VOLUME 2

EXHIBIT 1

LILCO CRANKSHAFTS

A. ABS Requirements: (Par 34.17.1 dia. of pins & journals)

$$d = C\sqrt[3]{\frac{M + (M^2 + 4T^2)^{1/2}}{f}}$$

where:

d = crankpin diameter, in

C = 1.0 (for more than 6-cyl. engines)

D = cyl. bore, 17 in

p = max. firing pressure

a) 1700 psi @ 4890 bhp

b) 1900 psi @ 5380 bhp

L = span between bearings (inner edge to inner edge of main bearings), 17.93 in

H = horsepower at rated speed

a) 4890 bhp (100%)

b) 5380 bhp (110%)

R = rated speed, 450 rpm

f = grade 4 forging, 2,310

and: $M = 0.131\, PD^2L$

$T = 63{,}000\, H/R$

Required crankpin diameter :-

a) 100% load or 4890 bhp : $d = 10.84"$

b) 110% load or 5380 bhp : $d = 11.103"$

: The 12" crankshaft is acceptable both at 100% & 110% load, as far as crankpin diameter is concerned.

B Paragraph 34.17.4 Solid Crankshaft Webs

$$wt^2 \geq 0.35 d^3$$

where w = effective width of web, 21"

* t = thickness of web 4.965"

* Note: Proportions are such that pins & journals overlap. Furthermore, the pin fillet is undercut with a re-entry into the web. Interpreting the correct method to determine t for such a case, Way to which of ABS replies to a question concerning this on p 129, line 21 to p 130, line 6 of their testimony:

" I believe that our normal practice would be to measure that dimension from the boundary of the actual crankshaft material, at one fillet to that

at its opposite fillet, rather than constructing the arbitrary lines of a face of the web and going between them.

Essentially it makes sense to count only the metal that is actually there "

Employing this interpretation, a figure of 4.965" has been determined (See full scale drawing)

): $wt^2 \geq .35\, d^3$

a) 100% load; $d \geq 10.84$ in

$wt^2 \geq .35 \cdot 10.84^3$

$21 \times 4.965^2 \geq .35 \times 10.84^3$

$518 \geq 445.81$ Satisfied at diameter required for 100% load

b) 110% load; $d \geq 11.03$ in

$wt^2 \geq .35 \cdot 11.03^3$

$21 \times 4.965^2 \geq .35 \cdot 11.03^3$

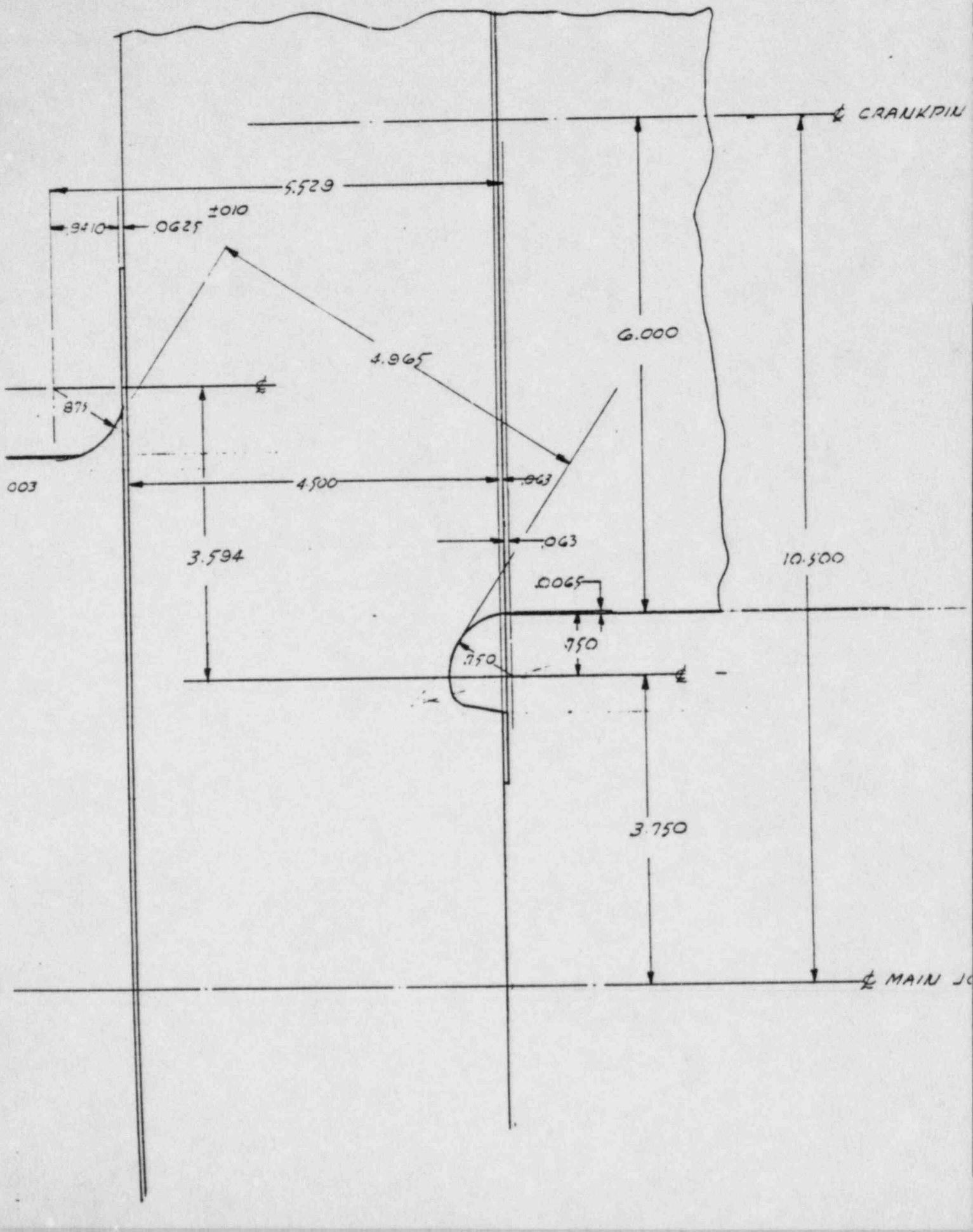
$518 \geq 479.02$ Satisfied at diameter required for 110% load

At the limit $wt^2 = .35 d^3 \Rightarrow d = 11.39$"

The crankshaft will meet ABS requirements up to a $d = 11.39$", given by formula in section 34.17.1.

i.e. for power and firing pressures in excess of 110% load.

Arthur Sarsten


℄ CRANKPIN
5.529
±010
.9410
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4.965
6.000
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℄ MAIN JO

EXHIBIT 2

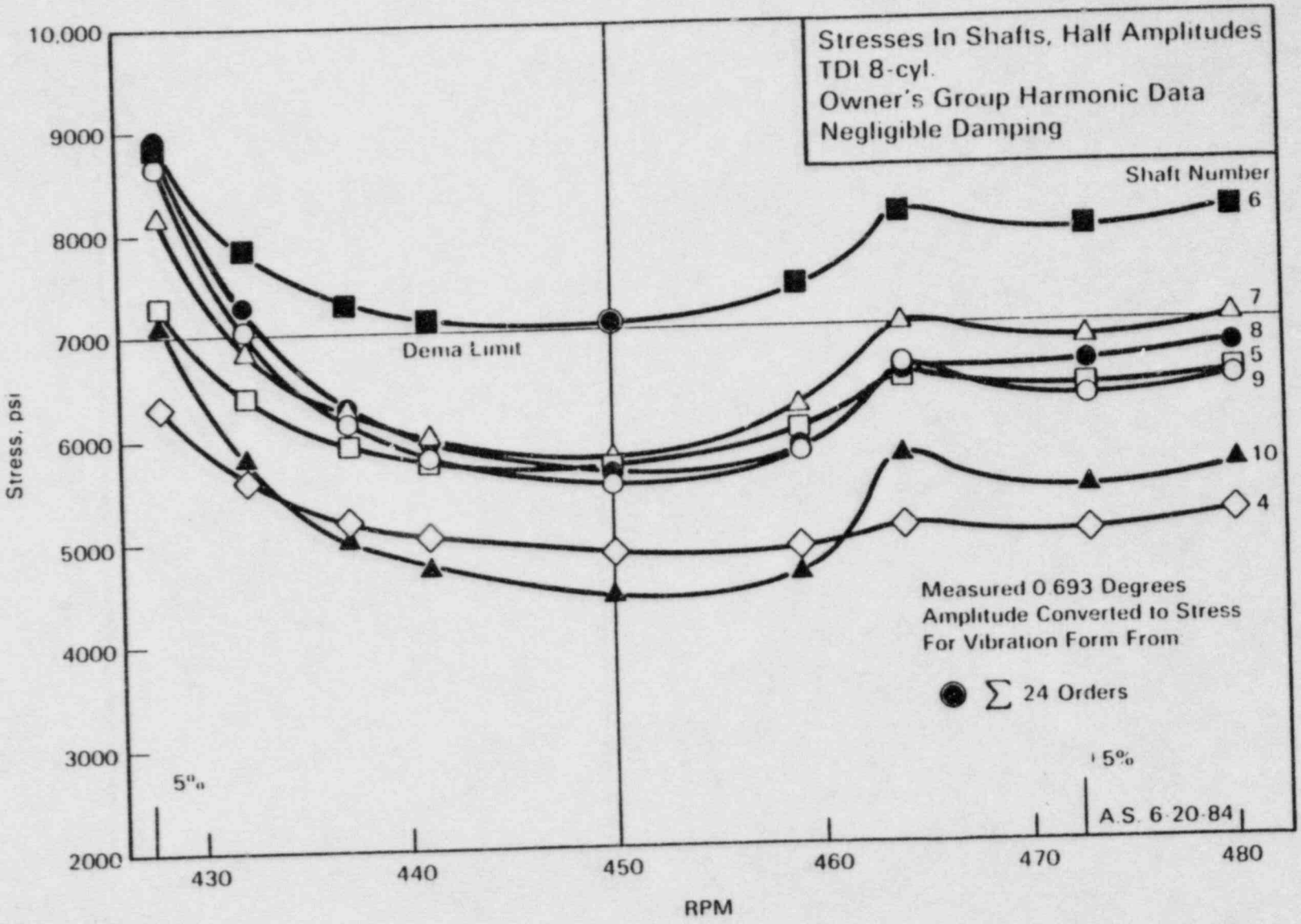

Stresses In Shafts, Half Amplitudes
TDI 8-cyl.
Owner's Group Harmonic Data
Negligible Damping
Shaft Number
6
7
8
5
9
10
4
Dema Limit
Measured 0.693 Degrees
Amplitude Converted to Stress
For Vibration Form From
Σ 24 Orders
5%
5%
A.S. 6-20-84
Stress, psi
10,000
9000
8000
7000
6000
5000
4000
3000
2000
430
440
450
460
470
480
RPM

EXHIBIT 3

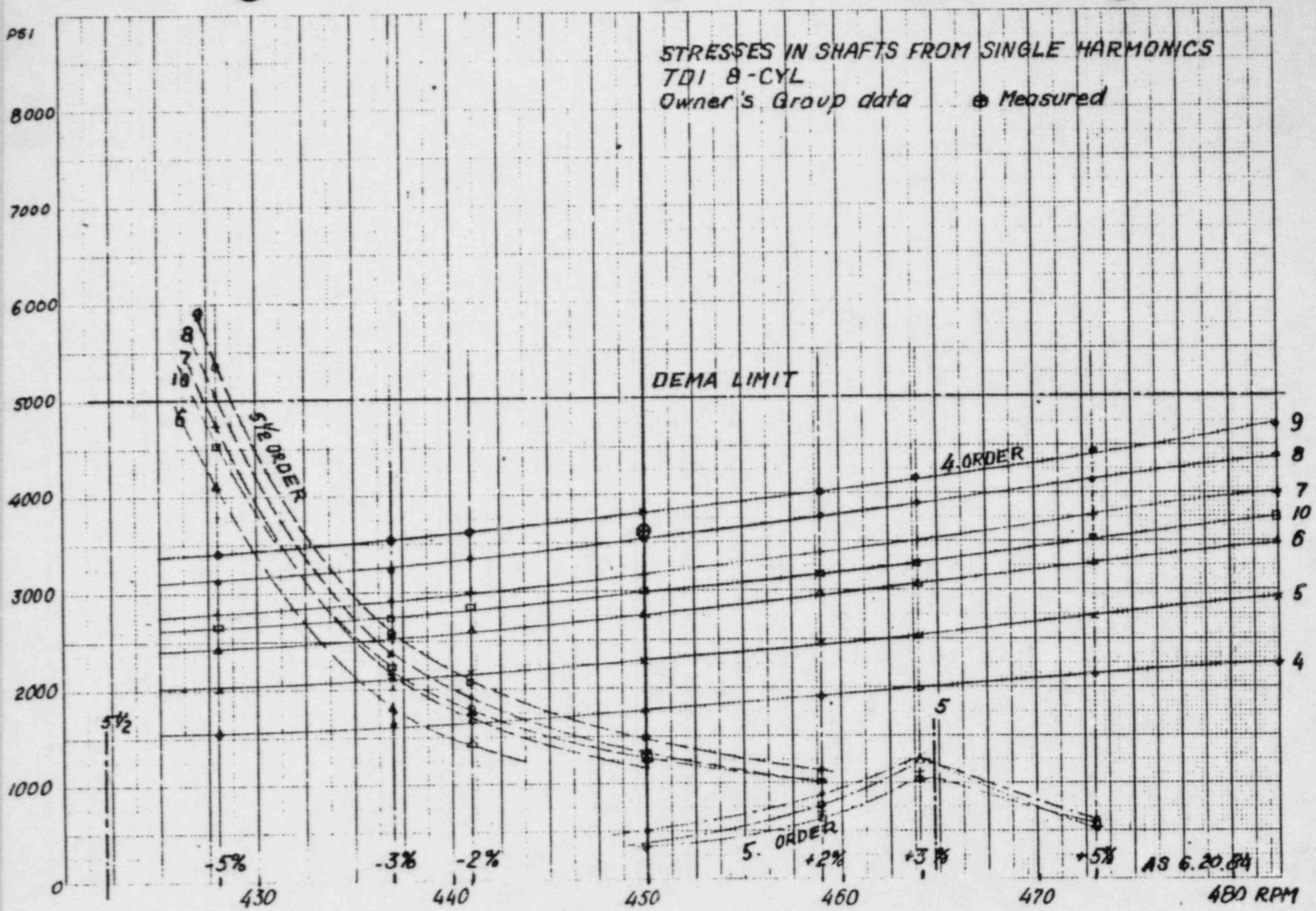

STRESSES IN SHAFTS FROM SINGLE HARMONICS
TDI 8-CYL
Owner's Group data ⊕ Measured
PSI
8000
7000
6000
5000
4000
3000
2000
1000
0
DEMA LIMIT
5½ ORDER
4. ORDER
5. ORDER
5½
5
-5%
-3%
-2%
+2%
+3%
+5%
AS 6.20.84
430
440
450
460
470
480 RPM
9
8
7
10
6
5
4

EXHIBIT 4

American Bureau of Shipping
Sixty-five Broadway
New York, N.Y. 10006

Refer to RTW:ml

3 May 1984

File No. T8-3

Transamerica Delaval DSR-48 Diesel Engine/Generator for Long Island Lighting Company Shoreham Plant Report on Crankshaft Torsional Stresses.

Transamerica Delaval Inc.
Engine & Compressor Division
550 85th Avenue
P. O. Box 2161
Oakland, CA 94621

Attention: Mr. Roland T. M. Yang
Manager Applied Mechanics.

Gentlemen:

We have your letter of 3 April 1984 submitting copies of the above subject report for our review, and with regard thereto have to advise as follows:

We note from the submitted report that the torsional vibration stress in the crankshaft for the first mode 5½ order critical speed (422 RPM) was expected to approach or exceed that permitted by the Rules for the submitted crankshaft material.

We further note from the submitted report that tests were conducted to determine the actual stresses in the crankshaft, and that these tests indicated a substantial margin of safety against fatigue failure due to torsional vibration.

Based on the submitted test data, and on submitted service experience with similar engines having similar torsional critical speed arrangements, we advise that we would have no objection to the submitted torsional critical speed arrangement for use on diesel generator sets on an ocean going vessel, insofar as our classification requirements for marine service are concerned.

Three (3) copyies of the subject report, stamped to indicate our review, are being returned.

Very truly yours,

AMERICAN BUREAU OF SHIPPING

W. M. HANNAN
Vice President

by: Robert A. Giuffra
Robert A. Giuffra
Principal Surveyor - Machinery

G. E. T. S. O. A. R. F. R. T. Y. M. H. L. C. R. C.
RECEIVED
TICKLER MAY 07 1984 UPDATE
ENGINEERING
CIRC. FORWARD COPY
TO FILE: ....; SEE ME

cc: LILCO. (E. Montgomery)
Accounting Dept. w/enclosure
Legal Dept. (M. Adams)
Subject File 460

REPORT

ON

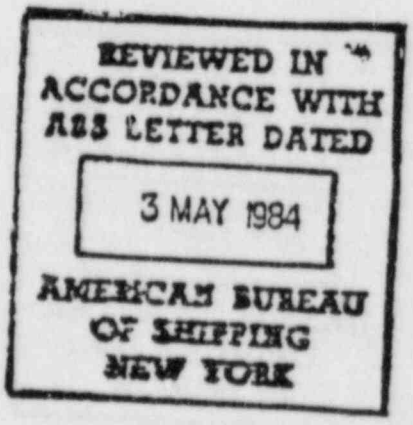
CRANKSHAFT TORSIONAL STRESSES

TRANSAMERICA DELAVAL MODEL DSR-48

Serial No. 74010/12

for

LONG ISLAND LIGHTING COMPANY



Roland Yang.
April 4, 1984
Transamerica Delaval
Oakland, CA.

TABLE OF CONTENTS

ALLOWABLE TORSIONAL STRESS CALCULATION.

Based on Para. 34.47 of 1984 ABS Rules.

$$S = \left(\frac{U + 23180}{18}\right) C_k \; C_d \; C_r$$

where U = Minimum Tensile Strength of Shaft Material 100000 PSI

C_k is .55 for propeller shafts and crankshafts

C_d is size factor, $.35 + 0.487 / \sqrt[5]{12} = .6463$

C_r is speed ratio factor, 1.38 for 90% to 105% rated RPM.

$$S = \left(\frac{100000 + 23180}{18}\right)\left(.55\right)\left(.6463\right)\left(1.38\right)$$

=3357 PSI due to single order

Total Allowable Stress = 150% of 3357 = 5035 PSI

ALLOWABLE TORSIONAL STRESS CALCULATION.

Based on Table 34.3 of 1982 ABS Rules.

Engine Speed	.3 x 450 RPM = 135 RPM	.8 x 450 RPM = 360 RPM	.95 to 1.0 x 450RPM = 427.5 to 450	1.05 x 450RPM = 472.5 RPM
Grade 2, 60000 psi	5689 psi	3556 psi	2134 psi	3556 psi
Grade 4, 100000 psi	8217 psi	5136 psi	3082 psi	5136 psi

Stress limit multiplier = $\frac{2}{3}\left(\frac{100000 - 60000}{60000}\right) + 1 = 1.4444$

for adjustment from 60000 psi to 100000 psi material.

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MR. GODDARD: Judge Brenner, for the convenience of the parties when working with these transcripts, would the Board object to binding in pages 9 through 18 again at this point in the transcript?

JUDGE BRENNER: It doesn't seem necessary.

MR. GODDARD: It is not necessary but it might be convenient for the parties.

JUDGE BRENNER: I would rather not.

MR. GODDARD: Thank you.

JUDGE BRENNER: I think it leads to too much complication where you're citing pages following certain transcripts.

MR. GODDARD: Thank you, Judge Brenner.

The panel is tendered for cross-examination.

JUDGE BRENNER: Mr. Ellis.

MR. ELLIS: Thank you, Judge Brenner.

CROSS-EXAMINATION

BY MR. ELLIS:

Q Professor Sarsten, I am going to direct a number of questions to you to begin with.

Good morning.

A (Witness Sarsten) Good morning.

Q I would like to have your answers on these if I may without consultation.

Professor Sarsten, with respect to the DEMA standard

WRBeb

for crankshaft torsional stresses that you've referred to in your testimony, did you participate in the development or formulation of that standard in any way?

A I did not.

Q Do you know when the DEMA standard was developed?

A I only know the latest edition, 1972. I believe it goes back much further than that to the late '50s at least.

Q Do you know when the 5,000 and 7,000 psi limits were inserted into the DEMA standard for torsional stresses?

A I do not know that, no.

Q Given that you indicated that you were aware that the last revision was in 1972, Professor Sarten, did you participate prior to that time in any way in the development of the methodology DEMA intended to be used in connection with calculations relating to that standard for crankshaft torsional stresses?

A There is nothing in the DEMA standards about the methodology intended to be used.

Q My question though was did you participate in any way in the development, prior to 1972, of any methodology intended to be used by DEMA in connection with calculations using its standard?

MR. GODDARD: Objection. I believe the question has been asked and answered. It is subsumed by the first

3 WRBeb

question Dr. Ellis asked Dr. Sarsten.

JUDGE BRENNER: No, we will permit him to probe a little more particularly for this fact.

The objection is overruled.

WITNESS SARSTEN: Could you come back with the question? I'm not quite sure what you're referring to by "methodology."

BY MR. ELLIS:

Q What do you understand me to mean by "methodology"?

A (Witness Sarsten) By "methodology" I would understand the mathematical calculation of the torsional vibratory stresses or the programs used in this context.

Q All right.

Professor Sarsten, with that as the definition for "methodology," did you, prior to 1972, participate in the development of the methodology DEMA intended to be used in connection with its calculations — with calculations relating to the DEMA standard for crankshaft torsional stresses?

A I have no way of knowing which methodology DEMA intended to be used.

I did, prior to 1972, of course participate in the development of methodology for calculation of torsional vibration. I assume that is what DEMA intended to be used

as a general available methodology for calculation of vibrations.

Q But you do not know, as you just testified, what DEMA intended to be used in connection with calculation of its torsional stress standard?

A I don't know if anyone really knows what DEMA intended. All we have there is their wording.

Q My question is do you know--

JUDGE BRENNER: Let him finish the answer. If you are going to ask the proverbial one question too many, he's entitled to give the answer to it.

MR. ELLIS: I appreciate the lesson, Judge Brenner.

JUDGE BRENNER: Professor Sarstan, I don't think you had completed your answer.

WITNESS SARSTEN: I think I completed my answer.

BY MR. ELLIS:

Q But you do not know what DEMA intended to be used, do you?

A (Witness Sarsten) I know what I read out of their standards. That's all anyone can do. No one can read the mind of the members of the Board in 1972. All we have is their written word and the standards.

Q Do you know what the DEMA Technical Committee is, and what its role is in connection with the DEMA standard

3 WRBeb

for torsional stresses in crankshafts?

A I have not served on that Technical Committee. I would assume their role would be the same as any technical committee, to review and revise the standards at given intervals of time.

Q Well, do you have any knowledge of the role of the Technical Committee with respect to the development of the DEMA standard for crankshaft torsional stresses?

A As I have not served on the Committee I would not know, no.

Q Do you know who the members of DEMA are?

A The manufacturers who are the members of the Diesel Engine Manufacturers Association are listed on the first pages. They are, among others,-- They were given in the testimony previously. ALCO, where I worked once, was one of the members then.

Q Is that the only one you can name?

A No, there are several members. American. I believe Cooper-Bessemer probably is a member.

I would assume that Trans-America, now DeLaval, would be a member.

Fairbanks Morse I would assume would still be, or at least was a member when this was printed in 1972.

I don't know if there are any new or revised printings of the DEMA standards.

WRBeb

Q Well, when you say you "assume," is that based on your memory or is that just based on your knowledge that these are diesel engine manufacturers?

A That was my memory of the testimony presented here last week. As I recall, there were about six member firms listed.

Q So your testimony then is based on the testimony of the LILCO panel last week?

A Yes, it is based on that.

I also read the members when I have read through the DEMA standard practices, but that was longer ago. The freshest recollection is from the panel here, yes.

Q And when you read through the DEMA standard in connection -- that was in connection with preparation for this case?

A Yes, it was.

Q Dr. Sarsten, you mentioned Cooper-Bessemer. Do you know whether Cooper-Bessemer, in the design of their crankshafts for their medium-speed diesel engines, used the DEMA crankshaft standard for torsional stresses?

A No, I would not know that.

Q Do you know whether-- You mentioned ALCO, for whom you worked. I believe you worked for ALCO for two years. Is that correct?

A The time span was longer than that, but I worked

full-time with ALCO only two years. I worked part time also with them in summer vacations while I was at RPI, studying for my doctorate.

Q Did ALCO use the DEMA standard in connection with torsional stresses for their crankshafts, if you know?

A I would not know that. That was Porter's, the torsional vibration expert's, domain. I would not know that.

I do know, however, that they have worked with some of these classifications societies when their engines have been sold for shipboard use.

Q But you are not familiar with their use or lack of use of the DEMA standard for crankshafts?

A No.

Q By "no" I take it you mean yes, I am correct in my assertion?

A Yes, you are correct.

Q Thank you.

Professor Sarsten, you also mentioned TDI or DeLaval. Do you know whether DeLaval uses the DEMA standard in connection with the design of crankshafts?

A Well, in this specific case they evidently have.

Q But your knowledge then is limited to what you have learned in connection with this case?

A It is in connection with this case and with the

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1 WRBeb

other engines they have sold for nuclear standby service, the 12-, the 16- and the 20-cylinder engines.

Q And your knowledge with respect to the 12-, 16- and 24-cylinder engines, all of that knowledge was obtained in connection with this case, was it not?

A Yes, that is true.

Q Let me mention some other names to you.

MR. ELLIS: It might be easier, Judge Brenner, I have some excerpts from DEMA which I can hand out to the Board and the parties now. I don't intend to introduce it as an exhibit, but I think it would be convenient for the witnesses and the parties.

JUDGE BRENNER: What do you want them to do? Look at the names of the members of DEMA?

MR. ELLIS: Yes, sir. I can suggest them to him.

JUDGE BRENNER: This is going to be material for some finding later as to whether he can read the rates correctly?

MR. ELLIS: No, sir, not as to whether he can read the names correctly. I just thought it would be simpler, rather than my suggesting who the members might be, to have that in front of him.

JUDGE BRENNER: You've got testimony through your witness that has not been contradicted, to the best of my knowledge. Do you know that?

MR. ELLIS: That's correct. I don't know if it is every member, though.

JUDGE BRENNER: I don't know if it is either. I don't know if I care, though.

MR. ELLIS: Well, I care.

JUDGE BRENNER: All right. Go ahead. I will look with interest for the finding that that is related to later.

MR. ELLIS: Well, I know I have disappointed you in the past but....

JUDGE BRENNER: I was kidding by that remark. If as the case develops you don't feel compelled to include a finding on it, I will understand that that's a result of your evaluation of the entire case later.

We won't make it an exhibit for now. As suggested, we will see what you do with it first.

MR. ELLIS: Thank you, Judge.

BY MR. ELLIS:

Q Professor Sarsten, I have handed you a xeroxed copy of some excerpts from the Standard Practices for Low and Medium Speed Stationary Diesel and Gas Engines by the Diesel Engine Manufacturers Association, or DEMA, and I would like for you to turn to the second page which lists the members.

JUDGE BRENNER: You did note the date of this,

3 WRBeb

didn't you, Mr. Ellis?

MR. ELLIS: I did not, but I will. It is copyright 1972, Judge Brenner.

BY MR. ELLIS:

Q Professor Sarsten, I have asked you about ALCO, Cooper-Bessemer and DeLaval. Let me now ask you about Chicago Pneumatic Tool Company.

Do you know whether the Chicago Pneumatic Tool Company uses the DEMA crankshaft standard for torsional stresses?

A (Witness Sarsten) No, I do not.

Q Would it be fair to say that you do not know whether any of the members listed on the second page of the excerpt I have handed you from DEMA use the DEMA crankshaft standard for torsional stresses?

A Except the DeLaval, what is called here the DeLaval Turbine Incorporated, which I referred to a couple of questions ago.

Q Yes, sir.

And your knowledge, as you indicated there, is based on this case. Is that correct?

A That's correct.

Q So it would be fair to conclude, wouldn't it, Professor Sarsten, that with respect to the members of the Diesel Engine Manufacturers Association, the companies that

I've asked you about, that you would not know how many orders these companies sum in the event that they do use the DEMA standard for crankshaft torsional stresses?

A That is correct. I base all my witness on how I interpret the DEMA standards.

Q Are you aware of any other diesel engine manufacturers of medium speed diesels that are not listed on page 2 of the excerpt I handed you? And I'm talking about in the United States.

A Well, it would depend upon how you define "medium speed," but I think most people would consider the larger engines as medium speed engines. No, I am not aware of any in that context.

Q Professor Sarsten would you agree that you are -- do not consider yourself an expert on the interpretation and application of DEMA with respect to its use in the United States?

A All I have to base my interpretation is the rules themselves. I would say that the rule as much is quite clear.

What you are perhaps asking is do I have knowledge how other firms in the United States would like to interpret the rules. That I do not have: that's true.

Q Well, let me repeat the question then.

Would it be fair to say then that you are not an

expert on the interpretation and application of the DEMA standard in the United States with respect to how many orders are summed in the application of that standard?

A I would not agree to that formulation. I would say that the DEMA rules there, in my opinion at least, are quite clear, and with my background in torsional vibrations, I would say that I think I have a fair understanding of how these rules should be interpreted.

Others may like to interpret them differently. That's another matter.

Q You said that the rules are quite clear. Do you mean that the rules tell the user how many orders should be summed?

A No, they do not tell how many orders should be summed.

Q So would you agree that in determining how many orders should be summed, there is a matter of interpretation?

A There's the matter of perhaps determining how many orders are significant.

Q Well, is that the term that DEMA uses, "significant" orders?

A No, it is not.

Q All right. Well, let me ask you my question again.

Given that DEMA does not specify the number of orders to be summed, would you agree that it has to be interpreted or construed by the user in order to arrive at a number of orders to be summed?

A I would say the user has to follow standard engineering practice in this regard, yes.

Q And you would agree that that would be standard engineering practice in the United States, wouldn't you?

A I do not see why the standard practice here deviates significantly from other countries in the world in this respect.

Q Well, you say you do not see that it does, but isn't it true that you do not have any knowledge of what the practice is with regard to how many orders are summed by manufacturers in the United States using DEMA?

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A I do not have -- I have to think back now.

No, I do not have knowledge of how many orders are summed by individual firms in the United States when they use DEMA.

JUDGE BRENNER: Mr. Ellis, excuse me.

Professor Sarsten, in your answer prior to the last answer you referred to your belief that you saw no reason why the practices in the United States should differ significantly from those elsewhere in the world. What you left unstated, at least expressly, is what the practice is elsewhere. Could you tell me what that is?

DR. SARSTEN: Yes. The standard practice elsewhere in the world is to sum 24 orders for a forestroke engine. That is, orders from one-half to 12. That is, for example, as specifically stated in the proposal for the new CIMAC rules for torsional vibration where, in 1979 they mention 24 orders as standard. That's the first 12 for four-stroke engine.

BY MR. ELLIS:

Q Professor Sarsten, you say the practice elsewhere, am I to understand that that is -- that these manufacturers you're talking about are in Europe?

A (Witness Sarsten) This would hold for the world in general. This was for the main classification societies. They are combining to see if they can arrive at

a common set of rules that also includes the ABS, the American Bureau of Shipping.

JUDGE BRENNER: It does not include DEMA does it?

A DEMA is not a classification society. It would not be included, no.

Q You refer to the CIMAC rules. That is not DEMA either, is it?

A No. The CIMAC rules are also the proposed rules from the Association of Classification Societies. Both names are sometimes used.

Q And you refer to those rules. Isn't it true that those rules are in draft form?

A Those rules are in draft form and they probably will be in draft form for a number of years yet, that's true.

Q So that the practice that you refer to of summing 24 orders, to your knowledge, does not involve DEMA and is -- strike that.

The practice of summing 24 orders then, does not involved DEMA, does it?

A I would say it does involve DEMA. Because if you're going to apply the DEMA rules, you would have to include the significant orders. I would include 24 orders. That is standard practice elsewhere in the world.

Q When you say elsewhere in the world, you've

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already testified you don't know what they do in the United States. That's correct, isn't it?

A I do not know what they do in the United States. I know what they do in the rest of the world.

Q On page 12 — well, you would agree with me then wouldn't you, Professor Sarsten, that you are not an expert on the application of the DEMA standard as that standard is used by American manufacturers of medium speed diesels?

A I can only read the DEMA standards. I know how I would apply it. I do not know how all the engine manufacturers in the United States, many for that matter, do apply it.

Q Professor Sarsten, on page 10 of your direct testimony you indicate, and I will paraphrase a little here, that the rules — I'm reading now, four lines down — "The rules are often subject to or often require interpretation discussion with the classification society." You were referring to DEMA in this instance, weren't you?

A I was not referring to DEMA in that instance. I was referring to the classification societies. DEMA is not a classification society.

Q Would you agree, though, that that statement would also apply with respect to DEMA?

A I think the rules are quite clear for DEMA for my part.

Q Well, are they clear on the summation of how many orders should be summed. If so, could you point out to me where it says that?

A It does not specifically state the number of orders.

Q So it's not clear on that point, is it?

A I would say that you must follow standard practice. Which is, today, 24 orders. Which are significant. To more than that, they taper off and did not influence the results very much.

Q Why do you say, then, that the rules are often subject to or often require interpretation or discussion with the classification society?

A I was then referring to the classification society's rules. They do often require interpretation.

Q In your opinion, DEMA requires no interpretation at all?

A I would say that DEMA, at least if you follow standard practice, this would not require interpretation in this respect. You're referring now to the number of orders. I would say you must use the number of orders commonly used, which is 24.

Q And you've already testified that 24 is the number of orders used in the rest of the world, other than the United States?

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A I did not testify that it was not used in the United States.

Q You don't know whether it was used in the United States or not?

A We have performed calculations for ALCO products. I believe then we used the standard number of orders.

Q Was that for DEMA?

A That was not for DEMA. That was for a specific calculation some years ago.

Q Have you had any conversations or discussions with DEMA concerning how many orders they deem appropriate should be summed for the application of the torsional stress standard?

A No, I have not.

Q Has anyone on the Staff had such conversations?

A That you would have to ask the rest of the staff.

Q To your knowledge, have they?

A To my knowledge, no.

Q Dr. Henriksen, do you have any knowledge of that?

A (Witness Henriksen) Correction. I am not a doctor.

Q Neither am I. So we're together on that.

A Will you repeat your question, please?

Q Yes. Do you have any knowledge of whether the

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Staff has contacted DEMA to discuss the interpretation of that standard?

A I do not. I do know that the Staff has contacted DEMA members, but not DEMA as an organization, no.

Q Do you know who was contacted?

A I did.

Q I beg pardon?

A I did.

Q I'm sorry. I didn't hear.

A I contacted DEMA members.

Q Which DEMA members did you contact?

A ALCO, Waukesha Motors -- those are the two members I contacted.

Q Professor Sarsten, let me come back to you.

On page 12 of your direct testimony -- strike that.

Professor Sarsten, have you ever used the DEMA standard for crankshaft torsional stresses in connection with crankshaft evaluation or design before you were retained by the NRC in connection with this case?

A (Witness Sarsten) No, I have not.

MR. ELLIS: Judge Brenner, at this time we would move to strike Professor Sarsten's testimony relating to the application of the DEMA standard on the ground that, as he has clearly and very forthrightly testified, that he has no

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experience with respect to what DEMA uses, how the standard was developed, the methodology, or what the American manufacturers in this country do in the application of the DEMA standard. And he has not, before this case, used the DEMA standard for crankshaft torsional stresses. I think, under the circumstances, I do not think even a liberal standard would be met to permit a conclusion. And he is an expert in the application of the DEMA standard.

JUDGE BRENNER: Could I get Mr. Ellis' last question read back, please?

(Whereupon the reporter read the record as requested.)

JUDGE BRENNER: Well, we'll certainly hear a response from the Staff and then from the County if it wishes to make on. If the Staff would prefer to ask Professor Sarsten some questions in the nature of redirect or voir dire prior to making a response, we'll give it leeway to do that also.

MR. GODDARD: Fine.

JUDGE BRENNER: Do you want to do that now?

MR. GODDARD: Yes, I would.

VOIR DIRE EXAMINATION

BY MR. GODDARD:

Q Dr. Sarsten, it is your testimony that based upon your professional engineering judgment, the DEMA rules are

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not susceptible to significant interpretation. And you feel that you are capable to interpret them, is that correct?

MR. ELLIS: I object to that question. It's leading in the most obvious way.

JUDGE BRENNER: I will grant the objection because I don't like overly leading questions either. And I want all counsel to remember that and this is a good time to make my point. Mr. Goddard, don't feel as though you'll be the sole recipient of it. But this way those making the objection as well as those receiving the objection will remember it for the rest of the hearing.

MR. ELLIS: I hope I am permitted to do it, though, on cross examination.

JUDGE BRENNER: On cross examination, you are. One of your co-counsel thought that shouldn't be permitted either, but he lost.

Go ahead, Mr. Goddard. Try again.

You don't need to repeat the testimony. I did not mean to imply that you had to ask Professor Sarsten questions. I just thought that maybe you had something in mind that you knew that has not yet been brought to light. You certainly should have an opportunity.

MR. GODDARD: Certainly.

BY MR. GODDARD:

Q Dr. Sarsten, in your evaluation of these

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crankshafts under the DEMA rules, you work with other members of the PNL staff and consultants?

A (Witness Sarsten) I did speak with Mr. Henriksen concerning this and I also believe I had some conversations with Paul Louzecky.

Q Did you include information obtained from those persons in formulating your answers to the questions regarding the applicability of DEMA standards?

A Of course. Their information was also included in my answer.

Q And in fact, Mr. Henrickson was employed --

MR. ELLIS: I think we have another leading question coming here.

MR. GODDARD: Why don't you wait till you hear it, Mr. Ellis?

Excuse me, Judge Brenner. That was a spontaneous remark by the Staff.

JUDGE BRENNER: Your remark was correct, nevertheless.

BY MR. GODDARD:

Q Dr. Sarsten, do you know whether either Mr. Louzecky or Mr. Henriksen has, in fact, been employed by members of DEMA?

A (Witness Sarsten) I do know that both have been employed by members of DEMA.

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Q And who were those members?

A Nordberg Manufacturing Company.

Q In your opinion, do the DEMA rules require significant interpretation prior to their application to the evaluation of a crankshaft for torsional vibratory stress?

JUDGE BRENNER: That has been asked several times by Mr. Ellis almost to the point of where I was tempted to jump in before. Although he got slightly different answers each time, so I hesitated.

Professor Sarsten, in the course of an answer discussing your prior employment with ALCO to one of Mr. Ellis' questions, you referred to others at ALCO who perform the torsional vibration analyses, is that correct?

WITNESS SARSTEN: Other firms than ALCO?

JUDGE BRENNER: No. Other persons at ALCO other than yourself?

WITNESS SARSTEN: Oh, yes, yes.

JUDGE BRENNER: I inferred from that that you did not perform torsional vibrational analyses in your employment at ALCO, am I correct?

WITNESS SARSTEN: That is correct. I had close contact with these people on other calculations, but the torsional vibration calculations themselves were performed by Mr. Fred Porter.

JUDGE BRENNER: Putting DEMA aside for the

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moment, can you tell me what your prior experience is in performing torsional vibration analyses of either crankshafts or of objects that you would think would be similar to crankshafts?

WITNESS SARSTEN: My first torsional vibration calculation, I believe, was made in 1957 for an engine firm in Norway. I have since developed numerous programs for calculation of torsional vibrations. The first one was in 1962, I believe it was. I have performed numerous torsional vibration calculations after that time. We have sold the programs, also sold calculation services to numerous firms, among them, ALCO Products at Auburn, New York.

JUDGE BRENNER: Could you give me some examples of the torsional vibration analyses that you performed? That is, what were they performed for, and also some examples of the application of the program you developed used by consumers of the program.

WITNESS SARSTEN: The programs -- there are several of them -- have been sold, among others, to what was previously Montreal Locomotive Works. They've been used for their calculation of the ALCO engines, when used outside locomotive service.

JUDGE BRENNER: These are -- are these for calculations of crankshafts in the engines?

WITNESS SARSTEN: They are for the calculation of

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torsional vibration.

JUDGE BRENNER: Of what?

WITNESS SARSTEN: Of the crankshafts in the four-stroke engines.

JUDGE BRENNER: I interrupted you. I'm sorry. You were going to give me a few more examples.

WITNESS SARSTEN: Well, we have, of course, made numerous calculations of various engines up through the years, and the University also has consultants. Our main activity, however, has been in the development of programs and sales, or lending of these to various firms.

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JUDGE BRENNER: In developing these programs, what experience do you have in actual application of the programs and/or feedback of results of applications of the programs to experience?

WITNESS SARSTEN: Well of course we make trial calculations for the customers, I have made numerous calculations for both the Norwegian engine manufacturers, Wichmann Motorfabrikk and Bergen Diesel. At times, as study projects for the students get actual cases in farm industry, which we calculate if they are interesting enough -- the run of the mill stuff, of course, is done by the engine firms themselves.

JUDGE BRENNER: Have you participated in or otherwise become aware of any tests used to validate any of the programs that you have prepared for torsional vibration?

WITNESS SARSTEN: Yes, of course. We have tested them against other programs where they are available -- and it's very easy with a little ingenuity to construct very large vibratory systems which can test the accuracy of the program.

If this is done, you can use the analytical results for the torsion vibration of a bar and, for example, check your natural frequencies which would come out as pi, three pi, five pi with a large number of significant digits.

Secondly, you have analytical solutions for single mass and two mass systems which may be put back-to-back and added on and a 60 mass or 100 mass system made whereby you can check the accuracy of the -- well of the natural frequencies, of course -- and mainly the amplitudes of vibrations and the stresses in these large systems.

You will find that they usually have four or five significant digits which are accurate, even in a large 60 mass system.

JUDGE BRENNER: You stated at the first part of your answer that it was fairly easy to put together, I think you said, a vibrational field; I may have the term wrong.

Can you first correct me on the term and, second, tell me whether that's been done for your programs either by you or by other....

WITNESS SARSTEN: Of course. It's a standard way for us to check the accuracy of the programs. They're, of course, also checked against other existing programs using other codes and other languages; instead of FORTRAN, the earliest versions of some of the programs were programmed in ALGOL.

By comparing these programs for typical cases, we find that the discrepancies or the differences creep up first in the fifth significant figure. So we have very good

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verification of the accuracy of such computer programs

JUDGE BRENNER: Incidentally, as long as I have interrupted this much, previously in talking about ALCO, with which you have had prior experience, I believe you stated that it was a member of DEMA when you were there, am I correct or did I get that wrong?

WITNESS SARSTEN: Let me see. I think ALCO then -- this was in the -- around 1960, was a member of DEMA. I'm not quite sure of this.

They are now, I think, listed a the White Motor Corporation.

JUDGE BRENNER: All right. That was my next question. Thank you.

WITNESS SARSTEN: Here we have them: White Superior Division. They are now a part of White Motor Corporation of Springfield, Ohio and, as such, they should still be members.

MR. ELLIS: Judge Brenner, I may not have been as clear as I should have been.

JUDGE BRENNER: Do you want to strike him because he doesn't know anything about DEMA?

MR. ELLIS: It's his interpretation of DEMA that I --

JUDGE BRENNER: I understand. I want to see what else he knows to see if that may be pertinent. You're not

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challenging him as an expert in the performance or analyses of torsional vibration, are you?

MR. ELLIS: No, sir.

JUDGE BRENNER: But you didn't ask him about what he knew, so I thought I was ask that part and then put it together with what he said he didn't know.

MR. ELLIS: Yes, sir, I understand.

JUDGE BRENNER: And in addition, if we were to grant your motion, you have not yet gotten to Mr. Henriksen, who is the co-author of much of the same answers, and you would have to work your way through him, even if we granted the motion.

MR. ELLIS: No, sir, because the answers that I would have stricken do not have Mr. Henriksen on them.

JUDGE BRENNER: All right. That would take care of that problem if we get to that point.

I suppose it would help you to know now, so we can take a moment.

Does the County have anything to add, either by way of argument or questions to Professor Sarsten?

I'll get back to you for your argument, Mr. Goddard, I wanted to hear from the County.

MR. ELLIS: Judge Brenner, while you're waiting, would you like me to give you some of the questions and answers that I have in mind?

JUDGE BRENNER: No, I can probably figure them out if I went through them also.

MR. SCHEIDT: Judge Brenner, I think it is clear that Professor Sarsten is an expert on torsional vibration calculations, that he understands DEMA and thus far there has been no showing that DEMA is anything other than what Professor Sarsten has stated it is and what the rest of the world has interpreted the number of orders to be summed in making those calculations. And I don't believe there is any basis for striking his testimony, as Mr. Ellis has asserted.

JUDGE BRENNER: Mr. Goddard.

Do you have any more questions?

MR. GODDARD: No, Judge Brenner, I have more than covered the ground.

The Staff would only submit that based upon Dr. Sarsten's expertise in the area of torsional vibration and his experience with the rules of other worldwide classification societies, he should be able to -- in the opinion of the Staff -- interpret the DEMA rules which he testified are susceptible to minimal interpretation, they are quite clear on their face. And that if any weight be given to Mr. Ellis' position, it should go to the question of the weight and not the admissibility of Dr. Sarsten's testimony.

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

MR. ELLIS: May I be heard further?

JUDGE BRENNER: Yes.

MR. ELLIS: Judge Brenner, I think central to what we're talking about is the interpretation and application of DEMA. DEMA is there for the Board to read and the Board has heard the witness' testimony on that. But it seems to me that if one is going to be an expert on whether something meets DEMA and that is the brunt -- the thrust of the testimony, then one has to have some experience in the application of that standard. And if the record is clear on anything, I certainly agree that Professor Sarsten is an experienced torsional stress analyst but he is not experienced at all in the application of DEMA to crankshafts and his view of how many orders to be summed is certainly an important issue in this case and he is not an expert on the application of DEMA in that respect.

And therefore we don't see any way that it can go to weight, it is either -- it would be no different from asking anybody else who knows a good deal about torsional stress analysis and they had never heard of DEMA, well how many orders would you sum. That isn't the standard. If you're going to be an expert before this Board, it seems to me that you must come to this Board with some substantial

experience in the interpretation and application of DEMA. That does not mean that his other testimony on ABS or other matters is similarly inform. But I certainly think this one is. He does not bring to the Board the kind of expertise with DEMA that I think is plainly required by even the most liberal standard.

JUDGE BRENNER: Maybe I should accept your invitation to give us the particular answers that you would strike if your motion were granted.

MR. ELLIS: Yes, sir.

On page 12, we would strike the portion of the answer at the top of the page relating to testimony that 24 orders are now normally used. There is no basis for that with respect to DEMA.

We would also strike his portion of the testimony on page 13 relating to the DEMA standard, the second paragraph of that answer in the middle of the page and also the next question and answer and the following question involving the computer program, it follows the question: "How do your results compare with those by FaAA," that would also go out.

To the extent that his answer on page 17, he is there both with Mr. Henriksen, his answer should not be accepted with respect to DEMA.

There was one other one I think as well, Judge

Brenner.

JUDGE BRENNER: All right. Well you've given us the picture and if we need to we'll come back with specificity on anything you might have left out.

MR. ELLIS: Thank you.

JUDGE BRENNER: In fact we would need more specificity on some of the ones you ran through, if we need to.... Why don't you give us a moment and we'll see if we can give you a ruling before the lunch break.

MR. SCHEIDT: Your Honor, could I make one point?

There has been no evidence in the record that DEMA deviates in any way from the standard practices in the rest of the world.

JUDGE BRENNER: Well I don't think that is an accurate statement. There may be evidence that you disagree with.

MR. SCHEIDT: I'm sorry?

JUDGE BRENNER: I don't think that's an accurate statement on your part, you said there is no evidence in the record. That's a strong statement.

MR. SCHEIDT: I don't believe there is, Judge Brenner.

JUDGE BRENNER: I have a recollection -- I don't think it's going to matter for our ruling, but I have a recollection that Dr. Chen offered some testimony in that

regard as to what he believed was the appropriate procedure in terms of the number of orders to meet DEMA and he talked about his experience with what has been done over the years to his knowledge. So to say there is no evidence -- that's why I said your statement was a strong one.

MR. SCHEIDT: Well --

JUDGE BRENNER: You may not agree with it or you may later show in findings that he was speaking in generalities and then when he was attempted to be pinned down by cross-examination could not support it in the detail necessary to believe the statement, but that's different than saying there is no evidence in the record.

And I would add that it's solely based on my memory. That would certainly be the kind of thing I would want to search for in the transcript before making a ruling on it, but I don't have to make a ruling on that point now.

(The Board conferring.)

JUDGE BRENNER: We are going to deny the motion. Professor Sarsten, as everybody can see, is clearly an expert in the performance of analysis of torsional vibration that is sufficient to give the testimony he is giving.

He has also testified and has sufficient expertise to be permitted to give the testimony on what he thinks our proper standard practices should be. He has explained candidly as to how he is applying what he has

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done to DEMA.

Later we will evaluate the weight of whether or not this is the way it should be done under DEMA. But that would be the weight and not the admissibility.

Our starting point is -- One of our points is the obvious one that LILCO surely is not moving to strike all testimony that refers to DEMA as some sort of benchmark by witnesses who analyses employ 24 orders or orders greater than six because otherwise some of FaAA's testimony would fall for that reason, so clearly that is not what LILCO has intended by the motion.

When we evaluate Professor Sarsten's testimony, it is very similar in certain regards to FaAA's, that is, a presentation of the approach to how the calculations are made by the witness and then the matching up of those results with certain guidelines or benchmarks, including DEMA's, and then different opinions as to whether or not that's an appropriate matchup to be sure. But that is something we will evaluate in terms of the evidence.

MR. ELLIS: I understand the Board's ruling. It does seem to me, however, that there is a distinction between an expert on the calculation of torsional stress or torsional stress analysis of the crankshaft and a person who indicates that he is an expert on the interpretation and application of DEMA. That is not the -- the interpretation

and application of DEMA was not, I don't think, an FaAA -- it was Dr. Chen who was the interpreter and the applier of DEMA. And to the extent that Professor Sarsten would put himself in the same category, we do not believe he has met that standard.

JUDGE BRENNER: Well you have our ruling. He has explained what he knows and what he doesn't know about DEMA and why he has taken the approach he has taken to using the 24 orders and we'll put it together with the weight.

Incidentally, even if we were to accept the fact that there was some subset known as an expert on DEMA under which we should strike testimony, just using by example the testimony you pointed to as falling under that motion, Mr. Ellis, it's overly broad because much of that testimony does what FaAA did: it performs the calculations, shows what the results are and then points out something which we could do for ourselves as to whether or not it's over the 5000 and 7000 psi limits of DEMA.

MR. ELLIS: Yes, I understand.

The reason that I gave that testimony —

JUDGE BRENNER: Let's end it right here. We have our ruling.

MR. ELLIS: The reason that I gave that testimony —

JUDGE BRENNER: I think we have enough on it.

MR. ELLIS: — was as a predicate for the conclusion that it did not meet DEMA.

JUDGE BRENNER: You have some other questions in your cross plan which are similar to questions we have in our mind as to pursuing the point of is it proper to take this approach given DEMA and what was known back when DEMA was promulgated and so on? And we expect you to pursue those and we have some testimony from other witnesses for LILCO already in the record in that regard.

MR. ELLIS: Yes, sir, I do want to follow up on some of these.

JUDGE BRENNER: All right. Right after lunch. We're going to break for lunch at this point and we'll come back at 2:00.

(Whereupon, at 12:26 p.m., the hearing in the above-entitled matter was recessed, to reconvene at 2:00 p.m., this same day.)

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AFTERNOON SESSION

(2:00 p.m.)

JUDGE BRENNER: Good afternoon.

Whereupon,

ARTHUR SARSTEN

and

ADAM HENRIKSEN

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

JUDGE BRENNER: We have discussed the matter of scheduling for the discovery and possible preparation of supplemental testimony by the County and Staff on cylinder blocks. In our own mind we believe it a close question as to whether the hiatus of one week is sufficient, or whether two weeks is in fact needed.

Since it is a close question, if it is determined -- and I will get to the timeframe for such a determination in a moment. If it is determined that two weeks are in fact needed we will permit it, our reason being that to a reasonably large extent, LILCO is in control of the schedule with respect to the further testing and imparting of the knowledge to the County of that further testing, and steps could have been taken to impart a good deal of that knowledge earlier than it was. Even three or four days earlier could have made a difference in our mind in

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choosing between one week and two weeks.

Furthermore, the fact that the tests were conducted when they were as opposed to an earlier time is also in LILCO's control. We certainly don't know whether it could reasonably have been done sooner or not, but nevertheless LILCO was in control of its own testing and examination.

We infer from the discussion this morning that the present state of affairs of the County's plans are that the County has not yet determined that supplemental testimony by its witnesses will in fact be necessary but wants time to consider that.

Am I correct?

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

JUDGE BRENNER: All right.

We also recall from this morning -- and let me check with the Staff to make sure we recall correctly -- that if the Staff decides to submit supplemental testimony on the new information, it can do so by late in the week of October 8th.

MR. GODDARD: That's correct, Judge Brenner. And I have spoken with my witness and we do intend to present supplemental testimony based on LILCO's.

JUDGE BRENNER: All right. So the Staff would be prepared to file its supplemental testimony by a received

date of Friday, October 12th. Is that right?

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

JUDGE BRENNER: All right.

Our order is that discovery on the new information begin at once, such discovery to involve any and all means of expedited discovery other than interrogatories.

I also do not mean to preclude the simple obtaining of data such that further discovery would be made more efficient such as where certain things are located, what documents exist, what people perform certain things, and so on, and preclude interrogatories. We do not preclude simple identification-type questions which should and could be done informally.

The discovery should be concluded just as soon as possible and certainly some time before the end of the week of Friday, October 8th. I don't want to set a more precise date than that. Well, maybe I should say no later than October 12th, so the parties don't end up in a dispute, but we would expect that it could be completed earlier than the 12th by at least a day or two.

As soon as possible from the County's point of view next week we would like to hear whether the County plans on submitting supplemental testimony and if so, whether it is going to be brief enough such that the County, too, could file its supplemental testimony on October 12th,

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and we certainly need to hear that from the County on the record of this hearing by the morning of October 4th. To the extent the County can tell us earlier, we would appreciate that earlier advice.

If the County tells us that (a), it will be filing supplemental testimony and (b), that it will be extensive enough such that it could not file it by a received date of October 12th, then we will accord the County the two-week break in the hearing.

We expect good faith on the part of the County in terms of giving us its serious and considered opinion that if it can indeed accomplish the task by Friday, October 12th, we can avoid taking a lengthier break in this hearing than the Board would like to see for reasons of our own prearranged schedules.

Let me add that if the County's problem is that October 12th is too tight but it can make it the day or two or three after that, such as October 15th, we could probably come up with some accommodation for that that would avoid the need to take a full two-week break. If it gets much beyond that, we will probably have to take the full two weeks.

So that's where the matter will stand until we revisit it as soon as the County is ready to revisit it next week no later than the morning of October 4th.

Mr. Ellis.

MR. ELLIS: Judge Brenner, does the Board contemplate that in this period of time during which there is discovery, if the County has new opinions or changes of views on the basis of that LILCO, too, and the Staff will have an opportunity to take their depositions to know what their views are?

JUDGE BRENNER: No, we did not contemplate that.

MR. ELLIS: Well, I guess I'm asking you to contemplate that because I think it would be appropriate.

JUDGE BRENNER: You are not going to make it in a week if you discover them at the same time they are trying to discover you and decide whether they want to prepare testimony. We certainly contemplate that you will have any supplemental testimony that they are going to file at least a few days before you have to cross-examine it.

If you want to conduct discovery of them, I might as well make it two weeks.

MR. ELLIS: If we could keep it the way it is, I suppose we wouldn't. If it does go to two weeks because the Board for some reason decides that it is appropriate, then we would.

JUDGE BRENNER: All right. We will consider that point again when we get to October 3rd or October 4th.

MR. ELLIS: Judge Brenner, does that mean the

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block testimony will then begin with the LILCO panel on October 15th?

JUDGE BRENNER: Not necessarily. We will find out on October 3rd or October 4th whether we are going to take a week break or a two-week break.

MR. ELLIS: I see. With a week break it would be October 15th, and with a two-week break it would be the 22nd?

JUDGE BRENNER: Except that we are going to finish up the County's panel on crankshafts and pistons before we go back to blocks.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: And I indicated in passing that an adjustment of a day or two might be accommodated without having to lose a whole week. And that's why I purposefully did not give particular dates for particular events. We will have to go back to this on the 3rd or the 4th of next week.

In short, the County has prevailed in the timeframe that it believes it needs. However, we do not want to assume at this time and do not believe the County has to assume at this time that it will need that full timeframe. And we want to try to save some time and hope we can do that when we discuss the subject again on October 3rd and October 4th, based on greater information which the

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County will rapidly and efficiently be able to obtain from LILCO.

MR. ELLIS: Judge Brenner, where does the Board contemplate we do after these witnesses are completed?

JUDGE BRENNER: These two witnesses?

MR. ELLIS: Yes, sir.

JUDGE BRENNER: I thought the Staff has agreed we could go to its witnesses on pistons.

Am I correct, Mr. Goddard?

MR. ELLIS: I think the Staff said that but I think the Board had indicated that would be one of the things it would consider.

JUDGE BRENNER: I'm sorry, I meant to say that that was very good news to us because we did not want to require the County's witnesses to be here this week for a number of reasons, the inconvenience to the County's witnesses due to lack of notice that some of them would have to be here this week, and more importantly, the fact that they are going to be efficiently engaging in discovery this week, and that could be one of the reasons why we won't need a full two-week break.

And we know we are not going to hear about any discovery disputes unless they are absolutely, positively matters of the utmost importance and privilege.

MR. ELLIS: I hope not, Judge, but I hope that is

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also not an invitation to the kind of blanket request that sometimes comes. I am sure that both sides can be reasonble, but I hope the Board's views are not taken as an invitation to those kinds of requests.

JUDGE BRENNER: They won't be, and if they are, we will deal with it. And your point is well-taken.

We are at the point of very specific information based on very specific things that have occurred in the uncertain timeframe subsequent to August 14th. Of course they are going to have to find out better what occurred from LILCO.

We can proceed. Continue with your cross-examination now, Mr. Ellis.

MR. ELLIS: Thank you, Judge Brenner.

CROSS-EXAMINATION (Resumed)

BY MR. ELLIS:

Q Professor Sarsten, let's continue along a line that--

JUDGE BRENNER: Mr. Goddard, did you want to say something?

MR. GODDARD: No, I just turned my microphone on, anticipating Mr. Ellis' first question, Judge.

(Laughter.)

JUDGE BRENNER: All right.

I'm sorry, Mr. Ellis. Proceed.

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BY MR. ELLIS:

Q Returning to the subject that we were discussing before, Professor Sarsten, namely the summing up orders, look at page 12 of your direct testimony.

You say there, and I'm paraphrasing, that Dr. Chen summed 12 orders and that that accounted for only half, as you put it, of the 24 orders now normally used.

How many orders were formerly used?

A (Witness Sarsten) Before the advent of the digital computer and hand-calculations were made, it was customary to only look at one order. The vectorial summation is a very laborious process if not done by a digital computer.

JUDGE BRENNER: Off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

BY MR. ELLIS:

Q Professor Sarsten, you said or I believe you said that prior to the digital computer and hand-calculator, only one order was used. What period of time was this?

A (Witness Sarsten) We made our first computer program for forced torsional vibration and summation of a number of orders in 1965.

I also believe that Det Norske Veritas made their first computer program for summation of forced torsional

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vibration orders also in 1965.

It, however, took some time before the majority of the engine manufacturers started to use digital computers to sum their orders, and I believe that at least in Europe, it has been standard practice since around, oh, '72, '73, for all of them.

Some of the engine manufacturers used it previous to that date.

Q Now that is summing of orders in Europe. Is that correct?

A That's correct.

I must also add we have performed calculations for American engine manufacturers. We have there also used our program and summed 24 programs.

Q But the summing of 24 orders was not with respect to DEMA, was it? It was just summing of orders? It is not the application of DEMA?

A This was for the calculation of a specific application which was critical. I do not know the use this American firm made of our computer results.

Q So your answer is you don't know whether it was for DEMA or not?

A No, I do not know.

Q What was the name of that firm?

A The name of that firm was ALCO Products.

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Incorporated. They were then, I believe, already associated with White Motor Company in Auburn, New York, at the time.

Q So is it your testimony then that until approximately 1972, the number of orders normally used by manufacturers in Europe was one rather than 24?

A No, that was not my testimony. My testimony was that it was not universal for the computer calculations submitted to the major classification societies -- I am now speaking actually of one, Det Norsek Veritas -- to include force vibration. Before roughly 1972, it was not universal.

When you make forced calculations you will include normally a large number of orders, now usually 24, because if we are in a loop it doesn't make any difference really how many orders you include as long as you have the data available.

Q Well, then as I understand your testimony, it was prior '65 and prior to use just one order in connection with torsional stress analysis.

A For force vibrations, yes.

I seem to recollect that Porter had summed some orders but it is very laborious and will not be done by hand unless in very special cases and then only a few orders.

Q I take it you would agree with me that when a classification society or an organization like DEMA sets a

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stress limit which has 7,000 psi for summation of orders that it has in mind certain calculational techniques that exist at that time. Wouldn't you agree with that?

A No. I do not know that I would phrase it in that manner.

Q How would you phrase it?

A When they say that they refer to a sum of major orders, I would say that is to include as many orders as is significant for the accuracy of the result.

Q All right.

Will you agree with me that there are in theory anyway an infinite number of orders?

A There is an infinite number of orders, granted.

Q All right.

You indicate in your testimony that 12 orders include the most significant ones. Did you do any of your calculations summing 12 orders, as you term them, the most significant ones, on page 12?

A No, it is standard practice to use 24 orders. I would never use as few as 12. I would use more, but never fewer.

Q May we have an understanding that when you use the term "standard practice" you are referring to the testimony you have given about the European manufacturers? Is that correct?

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A Also the other classification society, I would assume, would use 24 orders as a standard practice. The proposed rules -- I would call them CIMAC, or International Association of Classification Societies' proposals includes the Japanese society and the American society, ABS. They specifically refer to the use of 24 orders.

Q Okay, that's interesting.

You say first of all--

MR. ELLIS: Let me have the answer read back, please. I think you said you assumed something.

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

JUDGE BRENNER: Excuse me. Off the record.

(Discussion off the record.)

JUDGE BRENNER: Back on the record.

BY MR. ELLIS:

Q You said that you assumed that the other classification societies would use 24 orders.

Do you, as a matter of fact, know what ABS -- how many orders ABS sums?

A ABS does not sum any orders. It only moves on the calculations submitted to it. There is nothing specific in their rules, I believe, which requires 24 orders.

Q I see.

So that's an instance where you would agree that

since there is nothing specific in the classification society's rules that it is a matter of interpretation and you have to consult with the society. Is that right?

A You would have to consult with the society, and if they did not agree that the number of orders you submitted were suitable, or if your torsional or vibratory stresses lie close to the allowable limit, they would ask you to refine your calculations. They would ask you perhaps to make measurements.

Q Well, then, do you know how many orders ABS accepts as adequate for being summed?

A That is something ABS would have to rule upon. I do not know that.

Q Well, have you reviewed the testimony given by ABS witnesses in this proceeding in depositions, together with the exhibits?

A Yes, I have.

Q Well, do you know from having reviewed that testimony how many orders they accept as adequate for summing for torsional stresses of crankshafts?

A I cannot recollect. I read it through but it was some time ago.

If you could point to a specific page I would be grateful.

Q Well, it is fair to say then that you do not

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know what number of orders ABS will accept as being adequate for summing for their torsional stress analysis?

A No. That would be something they would have to rule upon.

Q You are aware, however, that they have ruled upon that in connection with the 13 by 12 inch crankshaft figures submitted to them by TDI?

A I'm aware that they have ruled upon that crankshaft, yes.

Q Necessarily wouldn't they have to rule on whether the number of orders summed there was adequate for them?

MR. SCHEIDT: Objection.

WITNESS SARSTEN: Necessarily--

JUDGE BRENNER: There's an objection. You have to stop.

MR. SCHEIDT: The question clearly calls for the witness to speculate as to what ABS might have done or might do, and on that basis, the question is objectionable and improper.

JUDGE BRENNER: I will allow the answer. I will allow the witness to answer, but the weight which it will be accorded may be minimum, depending upon what else the witness knows and what the basis for the answer is. And I will recall for Counsel some words with respect to our view of ABS and our ruling on the motion to strike some of the

2 WRBeb

County's testimony filed by LILCO, so we are already on our own very wary about this area.

It depends in part on how controversial some of the information is among the parties, but we will allow the answer because at this point I don't know what Professor Sarsten knows as to the bases for it. If he is just repeating things ABS said, we will evaluate things in that light, along with how complex some of the things are that he is repeating.

Do you need the question back after all that?

WITNESS SARSTEN: Yes, please.

MR. ELLIS: I will give it to him.

BY MR. ELLIS:

Q You are aware, Professor Sarsten, that the ABS has ruled with respect to the present 13 by 12 crankshaft. Does that not mean that necessarily ABS has ruled on what the appropriate or adequate number of orders for summing would be as applied to the case of the new crankshaft for the Shoreham emergency diesel generators?

A (Witness Sarsten) I would say not. You can submit additional evidence, and I believe in this case the Applicant submitted evidence on a number of other plants which they stated had similar torsional vibratory characteristics.

I must also point to the fact that the torsional

WRBeb

stress levels submitted by the Applica[illegible] actually lay over the permissible ABS rules, in my opinion.

Q Professor Sarsten, you indicated that you did not know how many orders were summed by TDI in its submission to ABS. Did you review that calculation?

A I reviewed the calculation. TDI, as I recall, did not sum orders at all. They only submitted the individual resonance peaks in their calculation.

Q Did you also review the ABS calculations relating to the TDI submission for the 13 by 12 inch crankshaft?

A Which page are you referring to now?

Q I'm not referring to any specific page. I'm asking you whether you reviewed the calculations made by ABS with respect to any calculation made by ABS with respect to the 13-inch by 12-inch crankshaft of TDI?

A As I recollect, ABS did not make their own individual check of the calculations. They have, however, accepted the crankshaft dimensions as being satisfactory.

Q Did you review the exhibits to the depositions of the ABS witnesses as well as the transcripts?

A I reviewed the transcript. I did not recollect having seen— I'm not sure, but I don't recollect having seen any exhibits to the ABS transcript.

The crankshaft itself, the crankshaft drawing is not available, but it's stated that it has been approved.

WRBeb

Q Well, suffice it to say, Professor Sarsten, if ABS summed any orders in calculations of its own, you are not aware of them?

A I can't recollect right now, no.

Q Now you indicated-- Strike that.

Was there a period in connection with your experience in the European sphere when it became customary to sum six or 12 orders, or some number other than one or 24?

A In my experience the jump was made from hand calculation to computer calculations, and when you first did that, you went to the number of orders for which you had data available.

I specifically know that in 1964 when I was at Sulzer, they had the first 10 orders printed on sheets and added on in pencil, I think, up to the 12th order.

I also know that for certain applications, computer programs have been sold which sum less than 24 orders. This is due to the minicomputer capabilities. But with a little knowledge and more rational programming you can get 24 or 36 orders easily on what would be termed a minicomputer.

We did it, around 1974 or '75, for the students. They used a minicomputer program which sums 24 orders.

Q These calculations for Sulzer, what code were

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they for compliance with?

A The Sulzer calculations were for compliance with the code which the engine purchaser specified. They were for compliance with Det Norske Veritas, with Lloyd's of London, Germanischer Lloyd, and so forth, depending upon the specific engine.

I worked in their torsional vibration balancing computer — I'm sorry, torsional vibration and balancing computation department for some months while I was in Switzerland.

Q On page 12 you indicate that although the 12 orders, referring to the 12 orders that Dr. Chen summed, include the most signficant ones, the remaining 12 contributed to the accuracy of the analysis and should be considered.

Wouldn't an additional 24, 36 or 48 orders also contribute to the accuracy of the analysis?

A Yes, they would, but insignificantly.

I must here add that as the order number increase, the effect on the computational accuracy decreases, and for sake of computer time, it is standard practice to cut them off at 24.

I have at times used up to 36 orders in order to calculate the accuracy of the calculations when compared to a formal integration of the equations of motion. The

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higher orders do not appear above — that is, above 24, do not appear to add anything significant to the results. However, there is a slight ripple on top of the calculations which will continue to be there even if you have 48 orders or more.

This small ripple on top of the results is, in everyone's opinion, very insignificant and is neglected in practice.

Q Is the program you used or have capable of summing 12 orders, or is it only capable of summing 24 or greater?

A It is capable of summing any practical number of orders you wish. I believe the present program has a cutoff at 48 orders but if you wished to use more you can use added excitations, so called, and finagle the program into accepting 48 plus two times 24 orders. But this is never used. It is wholly impractical and only used for purely theoretical work.

Q Did you make any calculations using just 12 orders?

A No, I did not.

Q Do you know what contribution the second 12 orders — that is, from 12 to 24, make in terms of percentage?

A No, I do not. I would have to do it, do the

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calculation to ascertain that.

Q You reached the conclusion I think that a summation of 24 orders led you to the result of 7,096 psi.

A That's correct.

Q The 96 or 97 psi, would that be about 1.5 percent of the total?

A Roughly, yes.

Q And you cannot tell me how many orders contribute to that 1.5 percent, can you?

A Not without making a digital calculation.

Q Well, would it be fair to say that we are only talking about one or two or three orders that make up 96 psi, or are we talking about the 12 additional orders that make up the 96 or 97 psi needed to meet DEMA?

A It depends also on the phasing of the harmonics. It is hard to say without calculating. I would assume that there were several orders needed to-- Well, again it depends on the phasing. That is not to say anything off the top of my head.

Q It depends on what? I'm sorry.

A I was going to say it depends on the phasing of the order, the phase angle, but I would not like to guess. I would like to calculate it to see in this specific instance.

Q Well, is it fair to say that as an engineering

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rule of thumb that orders that contribute 10 percent or less to the result are not significant ones?

A No, I would not say that. Far from it.

Q All right.

From 10 percent, what would you say down from that would you say ceases to be a major order in terms of contribution?

A I can here only abide by the standard practice in industry which is to take the 24. I would have to look at the difference between the 23rd and the 24th to say that.

It is not based upon a variable number, depending upon a magnitude. It is a fixed number of orders that is commonly used.

Q Do you know how DEMA defines the orders to be summed?

A If we had the rules. But it's the major orders which, if my memory is correct, come into phase simultaneously, or something of that order.

Q Prior to the lunchhour, I handed Professor Sarsten -- I gave you excerpts of DEMA, and I might just help you by asking you to turn to--

JUDGE BRENNER: Mr. Ellis, some of the DEMA rules are already an exhibit. If you can refer to a portion already in evidence, that might help. Don't ask me which ones.

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MR. ELLIS: We'll find that, Judge.

JUDGE BRENNER: LILCO Diesel Exhibit 14 perhaps..

MR. ELLIS: It is C-14, Judge Brenner. And for purposes of the question-- I haven't asked you a question yet, Professor Sarsten, but did you want to say something?

WITNESS SARSTEN: I wanted to correct my memory. I said "simultaneously" but it says coming to phase "periodically" here.

BY MR. ELLIS:

Q It's a big difference, isn't it?

A No, it's just a matter of semantics.

Q All right.

Look if you would, please, and I'm referring to Exhibit C-14 -- it's page 53.

How does that define the orders to be summed under DEMA?

A (Witness Sarsten) I'm sorry, this is C-14. Would that be the same as page 55 on the handout you have just given us?

Q Yes, it is.

JUDGE BRENNER: You said 53. Did you mean--

MR. ELLIS: I was incorrect. I meant 55.

JUDGE BRENNER: All right.

WITNESS SARSTEN: I'm sorry, are you waiting for an answer?

WRBeb

MR. ELLIS: Yes, I am.

BY MR. ELLIS:

Q I asked you how does that define the orders to be summed for DEMA purposes?

A (Witness Sarsten) All right. Here is says:

"....or a superimposed stress of less than 7,000 psi created by the summation of the major orders of vibration which might come into phase periodically."

Q Is there any definition in DEMA as to how many are the major orders?

A There is not.

Q Well, then this requires some interpretation, doesn't it?

A I would not say it does. An engineer, looking at this, would say that it is-- Let me first add that the series of orders of course goes to infinity. An engineer, looking at this, would read it, or at least I did, that this is all the orders of vibration which are significant for the accuracy of the result.

They cannot say summation of the all the major orders because that would be an impossibility. There is an infinite number of them.

Otherwise, if one is to choose a lower number of orders than that which is commonly used, this DEMA standard,

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which is supposed to be standard, would then allow the user to choose from a menu of different orders and choose those which he, to his own mind, would define as major orders which would allow him, when summed, to bring the stress down below 7,000 psi.

I do not believe that this is the right way to construct a standard practice. It will allow the user all the leeway he wanted to bring the stress level down to a, for him, acceptable level.

Q I think you testified this morning that you did not know when this standard was set, but if it was established as I believe testified to by Dr. Chen in the 1958 time period, you would agree with me, wouldn't you, that you could not sum 24 orders in that period of time for purposes of DEMA?

A No, it would be quite a laborious exercise; granted.

Q And indeed you have already testified that at least until 1972 or '73, it did not become universal, even in Europe, to use 24 summed orders, so that if there were— Strike that.

JUDGE BRENNER: Are you going to ask him a question about that, or are you going to testify yourself?

MR. ELLIS: I was using it for a leading question.

1 WRBpp

I'll withdraw that.

JUDGE BRENNER: It's okay to lead in cross-examine, but the problem is if you have double assumptions and don't give the witness the chance to answer as to --

MR. ELLIS: I agree.

BY MR. ELLIS:

Q Professor Sarsten, are all orders in the first 24 considered major?

A (Witness Sarsten) There are two definitions of major orders. One is the major critical orders. The second is major, which as used here, in the sense that they contribute to the accuracy of the answer. Of course, all the 24 orders do not contribute the same amount to the final result, obviously.

Q How much does the third order contribute in terms of percentage, if you know?

A I do not know. I would have to look that up. I have made these calculations. A third is, as I remember, a relatively large order. It is also a large order as regards the effect of the oscillating mass. The third order employed is the difference between the gas forces order and the result of the oscillating inertia forces.

Q You don't know whether the third order, then, is a large or small one in its contribution to the torsional stress summations?

1 WRBpp

A Well, I've been sitting all evenings punching these in. I have them in the computer printout. The third order is a relatively large order.

Q All right. Would you look, please, at the Exhibit C-17, page 3-14, Professor Sarsten?

MR. ELLIS: For the Board's convenience, that's the crankshaft report.

WITNESS SARSTEN: Which page?

BY MR. ELLIS:

Q 3-14, Professor Sarsten.

Do you have that before you?

A (Witness Sarsten) I do.

Q Let me direct your attention to the stress for the third order. It says, "The amplitude and displacement for the third order," — it says, ".001." Do you see that, sir?

A I do.

Q That's very small in relative contribution, isn't it?

A I thought you were asking about the magnitude of the harmonic excitation. The others would depend upon the specific example cited. It may be large, it may be small. Depending upon the vibratory system being considered.

Q Well, is the third order, then, a fairly minor contributor to the summation process that you go through?

A Referring to this specific case, we're not now speaking of the magnitude of the harmonics. Then the third order is a minor.

Q It's a minor one, isn't it?

A It's a minor contribution. But it is a major order. I would say any of the 12 are major -- the first 24, then, are major orders. Some of them contribute more. Some contribute less.

But I distinctly do not want to accept a method of calculation which allows the user to sit and choose among a menu of contributions to suit his own needs.

JUDGE BRENNER: Professor Sarsten, I'm a little confused. Could you explain to me your distinction between the contribution to the magnitude of the harmonics of an order in this example, the third order, from the contribution to the total and the summation of all the 24 orders processed?

WITNESS SARSTEN: I would like to try. What I referred to originally in my answer was the harmonic excitation of the third order. However, that excitation may, for a specific system, not result in a large amplitude of vibration of that order. The 0.001 here is the result. It depends upon the number of cylinders and the phasing and so on.

Now this will, in this case, not contribute

WRBpp

very much to the vector summation if they are in phase. In can, at the most, contribute only one-thousandth to the vector summation given at the bottom of the page.

JUDGE BRENNER: While I'm at it, if you will forgive me, Mr. Ellis, I have one or two other things I was confused on with regard to Professor Sarsten's use of these orders.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: Maybe I can clear it up in my mind.

Looking at your Exhibit 3, Professor Sarsten, -- let me check. Yes, your Exhibit 3, which is your graphic representation of the single orders.

WITNESS SARSTEN: That's correct. It shows a fourth order and, to the left, the five and a half order, which is here nearing resonance and increasing in magnitude as we go toward the left towards lower revolutions of the engine.

JUDGE BRENNER: Are those the only two orders shown?

WITNESS SARSTEN: There is also at the bottom shown the fifth order, which is a very insignificant contribution. But it has a slight peak at its natural frequency. The line is shown as five.

JUDGE BRENNER: What do the numbers in the right

1 WRBpp

vertical scale mean, four, five, six; then seven, eight, nine?

WITNESS SARSTEN: Those are the various shafts. There are different stresses in each of the various shafts along the engine.

JUDGE BRENNER: Thank you.

Mr. Ellis?

BY MR. ELLIS:

Q Professor Sarsten, getting back now to the third order with respect to the Shoreham 13 x 12-inch crankshafts. Am I corred that I heard you say that that would contribute no more than .001 to the summation of stresses to meet the 7,000 PSI DEMA standard?

A (Witness Sarsten) That would be the maximum, yes, if it were phased correctly.

Q So that would be less than 1 percent of the 7,000 allowable?

A I'm not good at mental arithmetic, but it would be less than 1 percent of the allowable.

Q Would you agree with me, then, that this is not a major order in terms of summing stresses for the DEMA allowable?

A No, I would not. In this specific case, it turns out that this order has a low value. It may not in other cases.

2 WR3pp

Q Do you know whether Dr. Chen used number three in his summation of 12 orders?

A No, I do not.

Q Professor Sarsten, you referred to a graph in which you showed the fourth order and the fifth and a half order. Are those the two orders that contribute the most to the allowable limit of 7,000 psi?

A It would depend upon their phasing.

Q But I'm referring now to the Shoreham 13 x 12-inch crankshaft?

A I am too. It would depend upon the phase. You have to take these two individual orders and run them for the phase angles that are relevant. I've not done that.

Q You've not calculated the phase angles?

A The phase angles are given as input, of course.

Q So you've made no assumption about phase angles, then.

A I think we're speaking on different wave lengths.

The input to the computer program has, among other things, a list of 24 amplitudes of harmonic excitation. There is also a list of 24 phase angles of harmonic excitation. I've had to have all these, of course, in order to calculate the results.

Q Well, when you depicted on your graph, the fifth

1 WRBpp

and a half and fourth order, why did you select those two for depiction on your graph?

A Because those were the orders which, in the speed range we were considering, the rate of speed plus/minus 5 percent, had significant stress levels and some of them were near residence, so therefore, the magnitude of stresses caused by the single orders were largest.

JUDGE BRENNER: Mr. Ellis, while you've paused, I wonder if I could ask a question about that also?

MR. ELLIS: Yes, sir.

JUDGE BRENNER: Professor Sarsten, in giving your results for the largest single order at 450 rpm at the bottom of page 13, you report that -- this is in the very last line of that page -- you report that as approximately 3800 psi. Whereas -- do you have that?

WITNESS SARSTEN: Yes.

JUDGE BRENNER: Whereas, on page 15 in the next to the last line of the first answer, you report that as being 3608 psi. Why is that figure different? Am I missing something?

WITNESS SARSTEN: Yes. The one figure is the results as they came out of the computer. The second figure are the results corrected or refined to take into account the measured values of the front end amplitude of the engine.

1 WRBpp

JUDGE BRENNER: Which is the refined one?

WITNESS SARSTEN: The 3608 calculated value of 3 — where was it -- 3800 psi came out of the computer. This was based on the fourth order harmonic amplitude given by the owner's group data and, I believe, calculated by Failure Analysis Associates.

On page 15, the figure 3608 psi is the same figure diminished, or scaled down slightly, to agree with the measured front end amplitude due to the fourth order.

JUDGE BRENNER: I'm still confused, I'm sorry. Because when I look at your Exhibit 3, which is the graph, the measured value bowing at, what looks like it might be the 3608 point — it's thought to be precise from that exhibit — but a little above 3500, falls on the eighth position of the shaft. Whereas you still have a higher value which looks like about 3800 falling on the ninth position of the shaft. So aren't they two different values for two different shaft positions?

WITNESS SARSTEN: Actually the figure given is for the most highly stressed shaft, which is the ninth shaft, in this case. We have only one measured value at 450 rpm.

JUDGE BRENNER: And the measured value is for the ninth position?

WITNESS SARSTEN: Right. Perhaps I should have

3 WRBpp

noted that.

JUDGE BRENNER: All right.

Yes, again comparing two different portions of your testimony, you apparently made no adjustment for your sum or the 24 orders, in that you report that figure both times as 7,096 psi, correct?

WITNESS SARSTEN: That figure has also been adjusted. The calculated figure was 7,060-something. But I calculate that to agree with the measured front end amplitude of .693 degrees. It was a very, very minor adjustment there because the calculated front end amplitude agreed so well with the measured value.

JUDGE BRENNER: All right. But your testimony only reports the adjusted value, then, in both places?

WITNESS SARSTEN: Correct, correct.

JUDGE BRENNER: I'm sorry, Mr. Ellis. I interrupted because I wanted to try to get straightened out before your cross-examination zeroed in on these specific numbers.

MR. ELLIS: Yes, sir. And I have the same question in mind.

BY MR. ELLIS:

Q Professor Sarsten, which then is the corrected number for taking into account the measured front end amplitude, the 7,096 or the 7,060?

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A (Witness Sarsten) The 7,096.

If you'll look, the difference between them is the ratio of 693, which is the measured value, to .690, roughly, which was the calculated front end displacement.

Q Professor Sarsten, you say on page 12 that the 12 orders that Dr. Chen summed include the most significant ones. How did you make that determination?

A I did not look at the orders individually. I would assume that -- an assumption again -- that Dr. Chen would take the most significant orders if he had only 12 available orders on his computer program. He would, of course, choose the most significant ones.

Q What do you mean by the most significant ones, the largest?

A I would assume he chose the largest orders, yes. I do not know that. It's purely an assumption.

Q Were you here when Dr. Chen testified and identified the orders which he summed?

A I heard his testimony. I perhaps would have to have that re-read if I were to try to identify his orders. But again, it would be purely an assumption.

Q Did you make any calculations of the third 12 orders. In other words, you computed the first 24, did you make any calculations for 36?

A Not in this case. I have done, in previous

cases, just to test the accuracy of the computer program.

Q Do you know to what extent the second 12 -- strike that.

Can you name for me today the first 12, in terms of contribution, for the Shoreham 13 x 12-inch crankshaft. In other words, the 12 largest.

A You would have to define this. I can looking at my computer program printout, find those which give the 12 -- the largest stresses in a certain shaft. But however, when you add these vectorially, you do not know if these 12 will, indeed, give a larger vector summation and another choice from the menu of 24 orders.

Q Well, my point is, can you tell me today, which one -- which of the 24, which 12 of the first 24, would give you the greatest contribution vectorially to the 7,000 allowable?

A Not without performing a large number of calculations to make that choice.

Q And, I take it it follows that you cannot tell me what contribution is made by the second 12, in terms of the magnitude of vectorial contribution to the allowable?

A Not without calculating.

Q So when you say that the 24 orders are necessary for the accuracy of the analysis, you cannot tell me today whether the contribution of the second 12, in terms of

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of vector magnitude amount to 1 percent, 2 percent, 3 percent, or any percent, can you? And I'm referring to the Shoreham 13 x 12-inch crankshaft.

A My answer would be urely a guess without making the calculation.

Q So your answer would be, no, you cannot tell me?

A Not exactly, no. I would guess, without knowing, that it would be less than 10 percent. That's just a guess. That's just off the top of my head, if that's what you want. I don't think anyone can say that without calculating.

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Q Professor Sarsten, would you agree with me that the standards such as DEMA are established on the basis of the methodologies that exist at the time the standards are adopted?

A I have not sat on the panel. It would be pure conjecture on my part.

Q You mentioned the CIMAC standard. That -- I think you testified today that is still a draft, is that correct?

A That's still a draft and probably liable to be for the next several years.

Q I take it that is because agreement has not been reached among various manufacturers and suppliers and users, is that right?

A Agreement has not been reached, but the agreement is between the classification societies. The manufacturers and users enter only indirectly into this consultation through their respective classification societies.

Q Does the CIMAC that you mentioned, does that refer to "major orders," or does it specify the specific number of orders to be summed?

A As the rules are not finished yet, we do not know what they will specify. But in a 1979 overview of the proposed draft rules, they specifically mentioned 24 orders as the standard used to achieve the accuracy they supposed

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when using the rules.

Q Do you know whether -- Do you know what terms the ABS standard uses to define the number or category of orders for ABS purposes?

A I have read their rules but I do not remember them specifically, no.

MR. ELLIS: Judge Brenner, in the interest of saving time -- I may come back to that but I have to Xerox something to make it easier for the parties.

JUDGE BRENNER: Did you want to add something, Professor Sarsten?

WITNESS SARSTEN: No, I did not.

BY MR. ELLIS:

Q On page 10 of your testimony, your direct testimony, Professor Sarsten, you indicated the rules of a society may change with time as new design techniques, materials and fabrication methods are developed.

Can you give me some examples of what you mean by new design techniques?

A (Witness Sarsten) One thing that has come into use sometimes, of course, is the finite element method which has given a means of closer calculating the stresses in a crankshaft.

Q Finite element analysis then has become generally accepted as providing an accurate analytical means of stress

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analysis, is that correct?

A There are finite element calculations and finite element calculations. It depends upon the depth of the analysis.

In the case of crankshafts, it requires a very complex model with very, very many node points to achieve sufficient accuracy.

Q Well have you — Are you familiar with a book written by Dr. Johnston on finite element analysis?

A No, not Dr. Johnston's book, no. I usually use Zienkiewicz.

Q Is that a European author?

A That's a European author. He's in the University of Swonsea, Wales.

Q When I said Dr. Johnston, did you know that I intended Dr. Paul Johnston of FaAA at Stamford?

Did you know who I meant?

A No, there are two Johnstons.

JUDGE BRENNER: There is at least one other Dr. Johnston but I guess he doesn't count.

MR. ELLIS: The only one I had ever heard before was Sam Johnston and he wisely kept out of all this kind of stuff.

JUDGE BRENNER: Yes, but I know you're fond of quoting him so I mentioned him.

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BY MR. ELLIS:

Q I meant Dr. Paul Johnston, who is sitting to my right here.

Are you familiar with his book?

A (Witness Sarsten) No, I'm not familiar with his book.

Q Did you familiarize yourself with the finite element analysis that FaAA conducted in this case with respect to the crankshaft?

A I have read through it, yes.

Q Well have you made an analysis of it or an evaluation of it?

A It was given only as an outline. I formed my opinions, perhaps, if that's what you're lookeing for.

Q You have not stated your opinions in your testimony, have you?

A No.

Q Professor Sarsten, would a new design technique -- as you have used that term of page 10 of your testimony -- also include the ability to sum 24 orders rather than one order or two orders or three orders?

A No, the rules.... No, that would not be what I was thinking of.

Q Well is the ability to sum all orders and to write these programs nonetheless a new technique to use in

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connection with assessing the torsional stress of a crankshaft?

A I don't know if you want to call it a new technique. It has been around quite a while. I was not referring to that when I made the statement.

Q Professor Sarsten, did you do any calculations on the old 13 by 11 inch crankshafts?

A I did not.

Q On pages 16 and 17 of your testimony you state in the bottom answer there that you would prefer to assess the adequacy of the crankshaft based upon the large amount of data represented by the appropriate classification societies' rule and their experience in the interpretation of these rules.

What are your reasons for thinking that a classification society -- societies' experience in the interpretation of its own rules is important?

A Because they have a very, very large basis of data base with failed crankshafts and a very large amount of information. It is not easy -- in fact it is sometimes almost impossible for an engine manufacturer to read the rules on his own. Some interpretation is usually required from the classification society at hand.

The rules are different. Some classification societies' rules are rather regular and straightforward.

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Some depend upon the interpretation by the classification society in order to be able to use them.

Q If the classification society does not tell you the number of orders to be summed specifically in their rules, that's a matter of interpretation, isn't it?

A The classification society only — for example, Det Norske Veritas, referring to that, for the crankshafts which are the matter of contention here.

Q Why don't you talk about ABS, which is one of the ones that's in issue here —

A All right.

Q — and not the other.

A I have not had.... Wait, that might not be true. I may have way back reviewed some crankshafts for ABS, but I did not remember using their rules and I cannot — at least I have not used their present rules and I do not know how they would interpret the data submitted to them as regards torsional vibration calculations, for example, or crankshafts.

Maybe we're on different wavelengths.

MR. GODDARD: Mr. Ellis asked a question which dealt with classification societies in general and I believe Dr. Sarsten was going to answer that question in light of the rules of Det Norske Veritas, a Norwegian classification society with whose rules he is very familiar and I would

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like to hear him be allowed to provide that answer.

JUDGE BRENNER: All right. We'll allow it.

Did you want to go back to the answer you had started with respect to Det Norske Veritas?

WITNESS SARSTEN: All right.

MR. ELLIS: May I hear as well his answer that he gave with regard to ABS before it gets too far off the record?

JUDGE BRENNER: You want the whole answer again?

MR. ELLIS: Yes, sir, that's the one I'm interested in.

JUDGE BRENNER: Let me give you the gist of it and then he can tell you if it's right or not, because he repeated himself a lot of times while thinking out loud and I don't think we have to hear it all, unless you really think it's crucial at this point.

MR. ELLIS: Well I'm certainly going to ask him further questions about the ABS.

JUDGE BRENNER: He doesn't remember if he ever evaluated a crankshaft for the ABS using their rules and, in any event, has no present recollection to offer as to how it would be done under ABS.

Am I right, Professor Sarsten?

WITNESS SARSTEN: That's correct.

JUDGE BRENNER: He said some other things but

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that's the gist of it. If you want it all, I will allow it reread back.

MR. ELLIS: No, that's fine, Judge Brenner.

JUDGE BRENNER: Okay. I did not want to prevent you from getting something you thought you needed

MR. ELLIS: No, I'm going to pursue that in a minute, if I may.

May I do that now?

JUDGE BRENNER: No, let him back up to the answer you interrupted, which is the cause of all this problem now.

WITNESS SARSTEN: We were speaking, I think, about classification societies' rules and I mentioned Det Norske Veritas. I have now either forgotten which tack I was on when this interruption was made. Could I get the question back which I was trying to answer?

MR. ELLIS: I will withdraw the question.

JUDGE BRENNER: No, because you have an objection from the witness' counsel. He wants the witness to be allowed to give the answer and in that light you have withdrawn it after acceptance, if you will.

MR. ELLIS: All right. He can also ask him on redirect. But I don't remember -- I think I was keying off his general testimony on page 17 involving -- 16 and 17 involving the experience and interpretation of the rules by the societies.

JUDGE BRENNER: Why don't we go back to Mr. Ellis' question? Can you do that?

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

JUDGE BRENNER: Back on the record.

Do you recall what you started to say before you were interrupted with respect to Det Norske Veritas?

WITNESS SARSTEN: Yes. I said with respect to Det Norske Veritas the torsional vibration level for the crankshaft is not specified as such, however it does enter into the rules for the crankshaft together with the bending stresses.

The classification society, if they found the stress levels to be very high, would presumably check into the amount, the number of orders used and may, if they were below 24, request the submission of a full 24 orders of calculation.

Speaking about Det Norske Veritas, in this case I have submitted a crankshaft to them and had their views on this matter. And they find --

MR. ELLIS: Your Honor, I object to this. This goes well beyond any question I asked. He is now giving an opinion about what Det Norske Veritas may have opined and I think the Board has already ruled on that.

JUDGE BRENNER: That objection is sustained.

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BY MR. ELLIS:

Q Professor Sarsten, with respect to ABS, do you know whether ABS -- or have you checked with ABS to ascertain how many orders ABS would consider adequate for summation of the orders for the ABS allowable?

A (Witness Sarsten) I have not checked with ABS on this matter, no.

Q And do you know what the ABS allowable is?

A For summing the orders?

Q Yes.

A I have the figure somewhere. I think in this specific case the figure was four thousand six hundred and something. It is in the testimony.

Q I refer you to page 15.

A Yes.

Yes, I'm sorry, it's 5035 psi.

Q And in those ABS rules, as I think I recall your testimony, you do not know whether those rules -- how those rules define how many orders are to be summed for that allowable, do you?

A No, I have not had the rules interpreted.

Q You have not had the rules interpreted and you testified you don't know how many they accept for being summed.

How then, Professor Sarsten, do you reach the

conclusion on page 17? — Strike that.

Professor Sarsten, on pages 16 and 17 the statement about the appropriate classification societies' rule and experience in the interpretation of these rules being important, does that in your opinion apply to ABS as well as to other classification societies?

A The ABS crankshaft rules which we're speaking about here are more specific than the other classification societies' rules.

Q Are they specific as to the numbers of orders to be summed for the torsional stress?

A That I do not know. I was speaking of crankshaft dimensions.

Q Well with respect to the summation of orders for ABS allowable, are the ABS rules and their experience in the interpretation of these rules important in your view, given your statement on pages 16 and 17 of your testimony?

A Yes.

MR. ELLIS: Judge Brenner, what time did you plan to take a break? I wanted to Xerox a couple of things.

JUDGE BRENNER: Soon. I was thinking of around 3:30. We can break now if you're at a point where you want to or you can ask some more questions for about 10 minutes and we can break then. I'll leave it up to you.

MR. ELLIS: I would rather break now and Xerox

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that and close that issue out.

JUDGE BRENNER: All right. Fine. Let's break now and come back at 3:40 using that clock.

(Recess.)

JUDGE BRENNER: Back on the record.

Mr. Ellis, do you have a time estimate as to how much more you have?

MR. ELLIS: Yes, sir, I do. I think that I will have approximately three more hours. No more than that. That's an extravagant estimate. That's for both Mr. Henriksen, whom I had not counted on, and Dr. Sarsten.

JUDGE BRENNER: It's certainly a lot different than the estimate this morning when I suggested I thought all parties could complete their examination of the Staff's witnesses on crankshafts and I heard no dissent.

MR. ELLIS: Well it's the old story of finding more than -- but I will do my utmost to expedite it and I may be incorrect but I would rather give you an estimate that is too long rather than one that was too short.

JUDGE BRENNER: Right. You're not going to exceed three more hours, that's what you're telling me.

MR. ELLIS: Yes, sir. I'm pretty clear that I can finish in three hours.

JUDGE BRENNER: All right.

MR. ELLIS: I say that without having -- I

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focused chiefly on Professor Sarsten, but I —

JUDGE BRENNER: I think it may be inefficient to have done that and I was going to ask you — and this is as good a time — when are you going to open up these questions to the entire panel?

MR. ELLIS: In the not too distant future. It may be inefficient but I think it is more effective.

JUDGE BRENNER: Okay. Maybe you're right. Why don't you proceed?

BY MR. ELLIS:

Q Professor Sarsten, does it refresh your recollection with regard to the ABS standard if I tell you that the ABS standard refers to significant non-resonant harmonics that are to be summed. They use the word "significant." Does that refresh your recollection?

A (Witness Sarsten) Yes.

Q All right.

With respect then to the use of the term "significant," would you say that the third order which contributes less than 1 percent, is that a significant non-resonant harmonic or an insignificant one?

A In this specific case, the contribution would not be significant. But without going through all the orders and all the contributions, I don't think anyone can a priori determine which orders are significant or not.

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Q All right. Let's assume that you go through and you calculate all 24 orders.

What is the benchmark or at what level would you say that the orders are significant and below which they are insignificant in terms of contribution?

A If I first have all the 24, I would add them in. Why speculate on which is more important than the other? There's no point in that. You go through all the 24 orders when you first have your program.

Q Well accept the assumption, Professor Sarsten:

You calculate 24 orders, you are now going to sum them vectorially. And I want to know from you at what point or at what level in terms of percentage contribution does an order become significant?

A If we have 24 orders and we are close or above the limit, I would not exclude any order as being insignificant. Because even a small contribution can bring the vector summation over the top. We do not know how it will phase in -- phase-in, phase-out, I was about to say -- and add or subtract from the total. We're playing games here, really, and making an exercise which one would never do in practice.

Q When you testified just now that one would never do this in practice, you in fact do not know what was done in practice in connection with the American Diesel Engine

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Manufacturers' Association, do you?

A If you are speaking of specific calculations submitted, I would have no way of knowing what the individual manufacturers were doing. But I hope that the individual manufacturer would not sit down and choose and wheedle and remove certain orders in order to get a desired result. The most efficient, as far as time and effort goes and also the most straightforward method would be to include all the orders once you have a computer program that is capable of doing this.

Q Well my question to you was that at what point does an order, when summed vectorially, become insignificant in terms of its contribution?

MR. GODDARD: Objection. I believe this has been asked and answered repeatedly.

MR. ELLIS: I don't believe he's ever answered that question, Judge.

JUDGE BRENNER: I'm going to give Mr. Ellis leeway on cross-examination. I won't know until the answer if it has been answered repeatedly. It certainly has been asked a number of different ways and there has been some confusion in language between the questions and the answers and that's another reason to give Mr. Ellis leeway on cross. So the objection is overruled for those reaons.

WITNESS SARSTEN: I would not like to consider

any order insignificant. If we are -- well strike that.

In general I would not like to consider any order insignificant because we do not a priori know if it will add or subtract to a perhaps already large number and we do not know a priori perhaps if the sum of these orders will lie exactly on or just below or just above the limiting value. That's about all I can say, I'm sorry.

BY MR. ELLIS:

Q Well Professor Sarsten, I don't think you. Let me try again.

I think you've testified that you agree that the fourth order does not make a significant contribution.

A (Witness Sarsten) Third order.

Q Third order, I'm sorry.

Now you've also testified that the third order contributes less than 1 percent.

Now what I'm asking you is at what percentage contribution level does an order cease to make a significant -- an insignificant contribution and begin to make a significant one?

A Personally I would not like to weed out any orders. And again it depends upon where the sum, the vector sum lies. A very small value can be the straw that breaks the camel's back, so to speak, when you're at the limit.

Q So is it your testimony then that no matter how

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small the contribution of any order, you would require that it be summed?

A No. If you do that you would go beyond the 24 to infinity of orders. We have to set a limit to the number of orders somewhere. Below 24 I would add them all, no matter how large or how small they would be.

Q But you have already testified that less than 1 percent contribution is not significant.

What percentage contribution is significant?

A Less than 1 percent. Are we speaking of 70,000 psi? There may be some misunderstanding here.

That would be 70 psi. That could make or break the sum of orders if you are close to the limit.

Q Where did you get the figure 70,000?

A 7,000, I'm sorry, psi.

Q All right.

Now didn't you tell me earlier that the third order contribution is less — substantially less than 1 percent?

A To the front end amplitude, yes.

Q All right.

So when you get ready to sum its contribution to determine 7,000, you're going to get a very small number, isn't that right?

A The number will be small, but I would not

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neglect it.

Q Well would you neglect the contribution of 1 psi to the 7,000 allowable?

A All right. That does not amount to much. But I'm speaking of more than 10 psi. It really contributes to the answer.

Q Well going up from 1 psi, at what point would you say it becomes significant?

A Remember we are summing a large number of orders and even though the individual contribution may be small, the sum of a number of small contributions, when in phase, can add up to a figure which is not negligible. So it is difficult to give a fixed value. It must be less than 1 percent at least.

Q Is that only when you are at a point that is close to the allowable?

A The same rule should apply no matter what, no matter where we are. We don't know beforehand where we will wind up.

Q Professor Sarsten, let me -- I think I asked you earlier and you testified that you do not know whether ABS summed any order of its own and, if so, how many orders.

Based on your testimony concerning classification societies, you will agree with me, won't you, that the number of orders that ABS summed, if they summed orders,

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would be significant in terms of the interpretation and application of the ABS standard?

A According to the ABS standards they can approve the crankshaft also on other premises than the torsional vibration levels.

Q Yes, but that wasn't my question, Professor Sarston. Do you want me to repeat it or have it repeated again?

A Yes, please do.

MR. ELLIS: Repeat the question, please.

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

WITNESS SARSTEN: There are many if's and but's in that long question. It's a little perhaps hard to answer it.

Could you rephrase it and break it down into simpler parts which I can retain in my somewhat porous memory?

MR. ELLIS: Sure, Professor Sarsten, I would be glad to.

BY MR. ELLIS:

Q Professor Sarsten, on pages 16 and 17 you said you already testified that ABS "...was among the societies that you had in mind when you gave that testimony and there you said that you prefer to assess the adequacy of

the crankshaft based upon the large amount of data represented by the appropriate classification societies' rules and their experience in the interpretation of these rules."

ABS' experience in the interpretation of its rules is important, isn't it?

A Yes. But I was not referring to the ABS specifically here because the ABS has not perhaps the widest experience in diesel engine crankshafts that some of the other major classification societies have. Their rules are not very — their rules do not take into consideration the torsional vibratory stresses when dimensioning the crankshafts, for example.

Q Is it your testimony that the American Bureau of Shipping is not content to issue standards relating to torsional stresses for crankshafts for medium-speed diesels such as the one at Shoreham?

A No. I only said that the torsional vibratory stresses do not enter specifically into their scantling rules or dimensioning rules for the crankshaft.

Q But they do take into account the dimensions in approving a crankshaft, don't they?

I'm sorry. They do take into account the torsional vibratory stresses in deciding whether to approve a crankshaft or not?

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A Deciding whether to approve it, yes, but not as far as the approving the dimensions of the crankshaft goes, the horsepower rating enters but not the vibratory torsional stresses.

Q Professor Sarston, look if you would, please, at Exhibit -- County Exhibit 43.

MR. ELLIS: Judge Brenner, this is the one I thought I would have to Xerox but the tendency of all to put in all seems to have taken care of that.

BY MR. ELLIS:

Q Do you have that in front of you?

A (Witness Sarsten) No, I do not.

Q Maybe your Counsel can furnish you with it.

(Document handed to witness panel.)

JUDGE BRENNER: I guess I only heard half of your last comment about the tendency... Were you criticizing the County for including something you want to use?

MR. ELLIS: No, I said all the parties.

JUDGE BRENNER: I have already given you my somewhat veiled and perhaps uncharacteristically subtle opinion that the parties have not met their responsibilities in screening which portions of these exhibits are appropriate for evidence and in the discussion we had last week with the Staff's Exhibits 7 and 8 on a minor scale reinforced that point and I still heard nothing further from

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the parties in that regard.

MR. ELLIS: I understand, Judge Brenner.

BY MR. ELLIS:

Q Exhibit 43 is the deposition of three witnesses from the American Bureau of Shipping. This is a transcript I think you testified you had reviewed, is that right, Professor Sarsten?

A (Witness Sarsten) That's correct.

Q You see attached are the exhibits to that deposition transcript. Do you see that, Professor Sarsten?

A Yes.

Q Okay. And you see the calculations that are attached to that?

A The computer printouts here?

Q No, the calculations that are attached to it, handwritten calculations.

A Yes.

Q Okay.

Do you recall the reference to those when you reviewed the transcript as being the calculations of ABS?

A I have seen the transcript. I have not seen these calculations.

JUDGE BRENNER: At least one page is almost totally illegible, obliterated is more to the point. That is, it's blank in my copy.

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MR. ELLIS: Yes, I have the same problem.

If you will find that page, that's a good benchmark since they are not numbered; it's the one just prior to that. I think in fact what that is, Judge Brenner, is it is not a blank page but I think it is merely the remainder — if you look at the right-hand side and I'm speaking not for one of my own exhibits but only for — in the hope that I might clarify, I think that second page is nothing more than the remainder of what was cut off from the page right before it.

Do you see what I mean?

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MR. SCHEIDT: This is the way it was provided to the parties by the ABS when it was copied at the time of the deposition. And the second page to which Mr. Ellis is referring is the runoff or the extra section of the righthand margin of the page that precedes it.

JUDGE BRENNER: Particularly since we are dealing with numbers, I'm not going to speculate on whether there are any digits missing in between the two pages.

MR. ELLIS: Well, let me just ask a short question and may end this.

BY MR. ELLIS:

Q Professor Sarsten, can you tell how many orders summed from looking at the page that I referred you to, which is the page immediately prior to the one that is largely blank?

A (Witness Sarsten) I have not seen this before so it's a little difficult. My testimony ends on page 173. I have not seen this before.

Q I understand you haven't seen -- you have seen the transcript before?

A The main transcript, not the attachments.

Q Right.

Now, can you tell, from looking at that calculation how many orders were summed?

A I would have to go through it in detail, the

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specific page you're referring to here?

Q That's right -- well --

Look at the handwritten calculations. Do you see those?

A Yes.

Q Okay. Let me direct you to the fifth page, do you see those?

A What's at the top of the page, just as a check?

Q Critical speed for five and a half order.

A Correct. I have that page here.

Q Can you determine, from that page, how many orders were summed?

A I would not like to do so without going through all the calculations and finding what's going on.

Q I beg your pardon?

A I would not like to guess here without going through all the pre-calculations and seeing what's going on. But being a handwritten calculation, I would be surprised if it were more than one order. That's all I can say.

Q Can't you tell where you see the square root of 25/37ths squared plus the square root of 35 39/58ths squared?

A It looks like two figures are being summed. That's all I can say. What they are, I don't know here.

JUDGE BRENNER: Presumably, by the square root, the sum of the squares method?

BY MR. ELLIS:

Q Professor Sarsten, on page 17 of your testimony, you conclude that, in your opinion, the 13 x 12-inch crankshafts do not meet the ABS requirements regarding torsional vibration stresses. In light of your testimony that you do not know how many orders ABS sums, or accepts as being adequate or summing, and in light of the fact that you have not contacted ABS concerning the interpretation of their rules or reviewed their calculations, is it unfair to say that you don't have a basis for reaching a firm conclusion that the ABS requirements are not met?

A (Witness Sarsten) The figure set forth here of a little over 5,000 psi is way below the calculated figure.

Q What figure are you referring to?

A If we are now speaking of the sum of the orders.

Q I thought you couldn't tell what that figure was?

A I, again, was speaking on different --

Q Oh, I see. You're talking about the 5,035 on pages 15 of your testimony?

A That is correct.

Q And you arrived at that by summing 24 orders, is that correct?

A No. I arrived at that from the calculations

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submitted to ABS. That is not a calculation of mine. That is the ABS limit, and the TDI calculations submitted to ABS. If we're speaking of the same thing, now.

Q Did you compare the 7,096 to 5,035?

A I'll have to get the figures correct. There's 5,000-something, yes, I'm sorry. 5,035, you say. That sounds, a little over 5,000, that sounds correct.

JUDGE BRENNER: Look at page 15 of your testimony, Professor Sarsten.

WITNESS SARSTEN: Yes.

JUDGE BRENNER: We don't need to think out loud.

WITNESS SARSTEN: Here we are, 5,035. That is TDI's figure for allowable vibratory stresses.

JUDGE BRENNER: Okay, now, ask your question.

WITNESS SARSTEN: -- as they interpret the ABS rules.

JUDGE BRENNER: Now, ask your question again, Mr. Ellis.

BY MR. ELLIS:

Q Didn't you just take the sum of 24 orders as 7,096 and compare it to the 5,035 psi ABS figure?

A (Witness Sarsten) I did. That would be standard practice, in such cases.

Q You don't think it is at all significant what ABS itself did in this case, in light of your testimony that the

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ABS's interpretation of its own rules is important?

A The ABS's interpretation of its own rules is, of course, important. And, of course, they're the only ones who can move upon this if the crankshaft meets the rules or not. I can only say that the stress I have calculated is above that which the rules allow using 24 orders. It's clear that ABS can accept any stress level they want to, do it in any fashion they wish to. They can approve the crankshaft on any other basis than torsional vibration if they so wish. I've only stated the calculated stresses, and the allowable stress levels.

Q And your testimony, then, is based on the use of 24 orders which, you say, is standard practice in Europe these days to some orders to torsional stress?

A That is true. I'm here also that ABS is one of the classification societies sponsoring the so-called CIMAC rules. The matter of 24 orders is not under contention as far as, you understand, an accepted practice for all these classification societies.

Q Do you know why ABS did not use 24 orders in the promulgation of its standard that sets 5,035 as the allowable?

A Did not use 24 orders in the -- could you --

Q Why didn't ABS specify 24 orders when it established its allowable for summation at 5,035 psi.

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MR. SCHEIDT: Objection. There's no foundation that ABS did, in fact, do as Mr. Ellis states.

JUDGE BRENNER: The objection is sustained. It anticipates a question I wanted to interrupt and ask. Because, Professor Sarsten, and I'm going to ask the question now: In passing, you refer to the 5,035 psi figure as the ABS allowed figure. Did I hear you correctly?

WITNESS SARSTEN: That's correct. That's taking from the TDI calculation submitted to ABS.

JUDGE BRENNER: You don't know what ABS's allowed figure is according to ABS, do you?

WITNESS SARSTEN: No, they would have to move upon that. They would have to judge that for themselves, of course.

JUDGE BRENNER: In other words, ABS, if I'm understanding your testimony in the first answer on page 15 correctly, doesn't have a precise figure. Rather, they have a means -- well, let me ask you:

How does one arrive at the allowable figure for total vibratory stresses under the ABS?

WITNESS SARSTEN: It's in the ABS rules and this figure was increased to take the added ultimate tensile strength of the crankshaft into consideration. And that was submitted by TDI to ABS.

JUDGE BRENNER: Well, what's in the ABS rules?

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The figure?

WITNESS SARSTEN: The ABS rules has a certain figure for a certain grade of steel. If you have a higher grade of steel you're allowed to escalate that limiting value according to the steel grade.

JUDGE BRENNER: Well then, why do you need a TDI calculation of the values that would be allowed by ABS if it's as simple as going to the ABS rules with some adjustments in getting the allowable figure from the rules?

WITNESS SARSTEN: Because it had been done there.

JUDGE BRENNER: I'm sorry. What had been done where?

WITNESS SARSTEN: I'm sorry. Because these calculations had already been performed by TDI.

It is our purpose, I have understood, to review the calculation, not to repeat and re-do all calculations on our own. I've only performed calculations in cases where the accuracy, perhaps, of stress or where the figures were very critical. I've not repeated all calculations in all things I have reviewd.

JUDGE BRENNER: Well, that doesn't clarify very much for me. But I'm going to bow out and allow you to have your up to three hours to the extent that I can and if somebody does some clearing up before it gets back to me,

I'll try again.

Go ahead.

MR. ELLIS: Judge, I think I'm doing my best. I hope I'm moving it along as quickly a I can.

JUDGE BRENNER: I was criticizing myself for interrupting you and not you.

Go ahead.

BY MR. ELLIS:

Q Professor Sarsten, turn to Exhibit 2, to your direct testmony, if you would, please?

A (Witness Sarsten) I have it.

Q This exhibit shows stresses at 450 rpm and then at higher and lower rpm's as well, for a number of orders, is that correct?

A That is correct. But it refers to a number of different shafts. Shaft 6 is the most critical shaft.

Q Thank you.

The point in the middle at 450 rpm is the point at the continuous speed of the engine isn't it?

A That's correct.

Q And tnat's the point that appears on 7,096, is that correct?

A That was plotted at the -- let me see -- that is plotted at the calculated value of almost 7,100 -- 7,096, yes, I think that was the figure.

3 WRBpp

Q All right.

Then you calculated other stresses at over speed and under speed conditions. Are those steadystate or transient conditions?

A Those are steady state conditions.

Q What do you mean by steady state conditions?

A I mean a steady state condition is such that when you start the calculation at, for example, top dead center of crankshaft one, everyone of the masses after .7720 degrees of rotation will have the identical amplitude and identical velocity.

May I add identical to the initial value that was implied. The values will be identical to the start values. When you start the calculations that is termed as a steady state solution.

Q Do you know what the governor response of the Shoreham engines is for underspeed and overspeed conditions?

A It has been stated at roughly 2 to 3 percent, I believe. Somewhere in the transcript.

Q Okay.

Let me refer you to Exhibit C-17, page 2-5.

A I will need some help here.

We have it.

Q All right.

You will see referred there, that the largest

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variations in speed were minus 3 percent, 2 plus 2 percent, do you see that?

A I see that.

Q And that the time lag associated with the unit's ability to return the 450 rpm was likewise found to be less than 3 seconds?

A I see that.

Q Given that, wouldn't you agree that it is not unrealistic to accept that there will be under speeds and over speeds stresses of any significance actually experienced by the engine?

A I would not because those are requested by the DEMA standard practices which are invoked in this case. But the range covered by the governor is not addressed here. Or it's only addressed in the DEMA standards.

Q So you're saying that a rigid application of the DEMA standard required you to make those calculations?

A Rigid or not. That's not the question. The application of them, I would delete the word, rigid.

Q Just the application?

A Yes.

Q Then stated 105 percent and 95 percent?

A It's stated plus or minus 5 percent, which is the same as 95 to 105.

Q There is no ambiguity there as there was with

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respect to the summation of major orders, is that right?

MR. GODDARD: I object to the form of the question.

MR. SCHEIDT: I object.

JUDGE BRENNER: I'm going to allow it if he's asking it as a serious question. A cross examiner is entitled to probe. I think it arguably redundant, but let's see what happens.

WITNESS SARSTEN: Again, there were two simultaneous objections which drowned out the question. Could you repeat it?

MR. ELLIS: Yes. I'll repeat it, Professor Sarsten.

BY MR. ELLIS:

Q I would say there was no ambiguity with respect to the under speed and over speed situations contrary to the ambiguity that exists on the summation of major orders, isn't that right?

MR. SCHEIDT: Objection.

JUDGE BRENNER: I overrule the same objection. You can't object twice on two different times to the same question. It's overruled.

WITNESS SARSTEN: I personally do not consider there is much ambiguity in the other case, either. But here it is not even a matter for discussion.

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BY MR. ELLIS:

Q in the other case, it's a matter for some discussion.

A (Witness Sarsten) Well, you can -- I've heard Professor Chen has had other views on this matter in his testimony.

Q Are you also saying that you realistically, as an engineer, expect that with the response times given for this engine as they are, that the underspeed and overspeed conditions reflect something realistic that the engine will experience?

A It is not for me to decide. I only have to look in the DEMA regulations. Secondly, I must remind you that, under recent applications, one of the Shoreham engines indeed did exceed these limits for a considerable period of time under load.

JUDGE BRENNER: Is that the so-called excursion of the 103 engine, Professor Sarsten, that you have in mind?

WITNESS SARSTEN: Exactly.

JUDGE BRENNER: Do you know how far over 100 percent that engine operated at?

WITNESS SARSTEN: I heard that it went below 390 rpm. And enormous excursion in terms of rpm.

JUDGE BRENNER: Do you know, though?

WITNESS SARSTEN: Beg pardon?

JUDGE BRENNER: I did not measure one myself. I read some testimony to that effect. I'm sure we will hear more about that in at least one other context.

MR. ELLIS: Judge Brenner, I would move to strike that, since he doesn't have any basis for that testimony as to how low it went, 300 and whatever it was rpm.j

JUDGE BRENNER: I'll tell you what. I won't rely on his figure for it and you remind me to ask somebody that you think knows on behalf of LILCO at the appropriate point.

MR. ELLIS: Yes, sir. I think we can do that. That panel has already testified, I believe. But --

JUDGE BRENNER: Well, somebody who knows a bit about blocks might know about it.

MR. ELLIS: They do. Mr. Youngling will know, Judge Brenner.

JUDGE BRENNER: That's one of the major reasons ascribed for why there are problems with the 103 cylinder block, is that correct?

MR. ELLIS: That's right. I'm just telling you who would know, Youngling.

BY MR. ELLIS:

Q Dr. Sarsten, another question about ABS. I take is it fair to say since you have not reviewed the ABS calculations, and don't know how many orders they use in summing, that you have no opinion regarding the adequacy or

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the accuracy of the ABS calculation and evaluation of the Shoreham crankshafts?

A (Witness Sarsten) Are you referring to the attachment to the testimony, the handwritten calculations?

Q Yes.

A I have no opinion, of course, not having seen them before or reviewed them.

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Q Dr. Sarsten, is DEMA applicable to a specific design and manufacturer of crankshafts or to a range of crankshafts?

A DEMA is an engine manufacturer organization. I would like to believe that it is applicable to a range of low- and medium-speed stationary diesels engines, the range we refer to.

MR. ELLIS: Judge Brenner, I am on page 5, Roman III-A and B, in that area.

BY MR. ELLIS:

Q Professor Sarsten, so the 5,000 psi for a single order and the 7,000 psi for a summation of the major orders are general figures meant to apply to a range of crankshafts. Isn't that right?

A (Witness Sarsten) If by "range" you mean a certain number of makes and rotational speeds, yes.

Q And also different materials, different geometries for fillets?

A None of this is mentioned in the DEMA standards, so I would assume that it is applicable to also these different crankshaft configurations.

Q Do you know how DEMA defines the range of crankshafts to which it is applicable?

A They name low- and medium-speed engines for stationary purposes. They also have another recommendation

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for marine applications which covers a larger speed range.

Q Well, do they make any assumptions or statements about the kinds of materials that crankshafts should be made of to fall within the application of the DEMA standard of 5,000 and 7,000 psi?

A Yes, they mention on page 53 shafting information such as physical characteristics and materials, lengths, diameters, et cetera, and they have a number of other data.

Q This is page 53 of the handout that I gave you earlier today?

A Correct.

JUDGE BRENNER: C-14.

MR. ELLIS: C-14.

BY MR. ELLIS:

Q My question though was does DEMA say anything about the kind of materials, the kind of steel that the crankshaft should be made of in order to fall within the scope of the DEMA standard?

A (Witness Sarsten) I would have to read it again and check that. I cannot remember any specific reference to steel.

Q Would it refresh your recollection if I tell you that DEMA refers to "conventional materials"?

A All right.

Q Well, "all right." If it does refresh your

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recollection you can tell me it does. And if it doesn't--

A It does, yes.

Q Okay. I see.

What does "conventional materials" mean?

A Well, that is a rather broad phrase. It can mean really a lot of things. It is not very specific.

Q Well, do you know what assumptions, if any, Professor Sarsten, are made by DEMA with respect to ultimate tensile strength or forging process, surface finish, clearance limits, or matters of that sort?

A No. They may have a reference to conventional manufacturing procedures. I do not know.

Q Do you know what material the original crankshafts at Shoreham were made of?

A Yes. I think it had-- At least one of the shafts had a UTS of 93,000, and it varied somewhat.

I have also seen a test figure of 88,000 for another of the shafts.

JUDGE BRENNER: I didn't get the first figure. I don't know if the Reporter did.

WITNESS SARSTEN: 93,000 psi.

JUDGE BRENNER: Ultimate tensile strength?

WITNESS SARSTEN: Correct.

BY MR. ELLIS:

Q Do you know what the figures are for the new

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13 by 12 inch crankshafts?

A (Witness Sarsten) They are somewhat higher, roughly 100,000 psi. I remember a figure of one hundred thousand, seven hundred, and I think it was seventy-seven psi for the lowest of these.

Q Do you know what range DEMA assumes as being pertinent for their 5000 and 7000 allowable limits for torsional stresses?

A DEMA does not refer to any steel specification, as far as I'm aware, except that the material be as stated earlier.

Q It would be relevant, though, wouldn't it, Professor Sarsten—

Did I interrupt you? I'm sorry.

A No; you're correct. Go ahead.

Q It would be relevant, though, wouldn't it, Professor Sarsten, to an assessment of whether a crankshaft was adequate?

A The material specifications of course would be relevant to an assessment of the adequacy of the crankshaft if it were done under a classification society rule. But, however, the DEMA rules do not take the material into consideration whatsoever anyway.

Q Except insofar as, I think, you have conceded that I refreshed your recollection that it calls for

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conventional materials.

A Right.

Q But in terms of assessing whether the crankshaft is adequate or not, you would agree with me that if the tensile strength were very high, then it the summation of the orders were close to the allowable, that would be less significant than if the tensile strength were substantially lower?

A As there is nothing in the DEMA rules about this, we cannot speculate on what we would like to do. The rules are straightforward. As far as I am concerned, there is a limit of 7,000 psi for the summation off the orders, irrespective of the material employed.

Q Well, let me just give you a hypothetical.

If the steel used in the crankshaft in issue had an ultimate tensile strength of -- instead of 100 or 102 ksi, if it had 100,000 ksi, would you be concerned that the summation of the orders then was 7096?

A It is not my prerogative to be concerned or not. It is to judge if the vibratory torsional stresses are above or below this limit.

I concede, if we were looking at the adequacy of the crankshaft in another context, that would be something we could discuss, but not here.

Q What do you mean by the "adequacy of the

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crankshaft in another context"?

A If we were looking at the adequacy of a crankshaft with very high tensile strength, it would of course influence the results we came to if we reviewed that crankshaft under Lloyd's rules or Veritas rules or whatever. But here we are looking at just a limit on the torsional vibratory stresses in which the material does not enter into the picture, the way the rules are formulated today.

Q But the rules assume some range of materials, don't they?

A The rules only assume that the materials must be as good or better than the conventional.

Q The quality of materials you say has improved, Professor Sarsten, since the late '50s to today for use in crankshafts.

A The quality of materials has, in the cases where I have been more intimately concerned, improved over the years. This is due to the intense competition, the rise in break mean effective pressures, and maximum firing pressures, and the wish to remain competitive without building enormous engines and crankshafts which would be too costly. Yes.

Q You said that the materials for DEMA had to be -- I think you said conventional or better. Can you show me

anywhere in DEMA where it says conventional or better?

A No. You asked me perhaps to interpret the rules. We can get the reading exactly from the DEMA standards if we can find the page.

Q In the interests of time I will point you to the place —

A Please do.

Q — at the next opportunity. Let me go on now in the interests of time.

You testified that the tensile strength of the replacement shafts was better than the original shafts. Do you know whether the surface finish on the replacement shafts is better than in the original shafts?

A I do not know that, no.

Q Well, based on your testimony that you are aware that the tensile strength, the ultimate tensile strength of the replacement shafts is better, would you then conclude that the replacement crankshafts are of better material than the conventional — or that the material used in the original crankshafts?

A Yes. I know also that they have been thoroughly inspected for flaws which might arise as a result of the slab forging process. Assuming that there are no hidden flaws, I would say that the material was better, yes.

Q Well, you will agree with me, won't you, that the

surface finish in the fillet regions is a significant factors in crankshaft performance?

A Yes.

Q And DEMA also encompasses, I think you testified, Professor Sarsten, a range of crankshafts. Would that include a range of journal pin web configuration and fillet geometries?

A Yes.

Q Do you know how wide or how this range would be defined, how broad it is?

A No. You would have to make an extensive survey of the various engines. I have not done that.

Q Well, will you agree with me then that the DEMA standard for the single order and the summation of major orders is a general or rough predictive tool that is not as accurate as actual experimental data?

A We are speaking of two different things now, a limit on torsional stress levels allowable, and the second is measured values, if I understood the question correctly.

Q What is the answer to my question?

A Could you please rephrase or repeat it?

JUDGE MORRIS: I think it would be better, Mr. Ellis, if you would rephrase it. I didn't understand the question myself.

MR. ELLIS: I was afraid you would say that.

I will, Judge.

BY MR. ELLIS:

Q Given that DEMA assumes a range of crankshafts which you have indicated includes a range of materials, fillet geometries, journal pin web configurations, it really is a general predictive tool, isn't it, that is not as accurate as making actual empirical measurements of the stresses in the high stress areas of the crankshaft?

A (Witness Sarsten) We are speaking of two things. One is a torsional vibration calculation that gives a certain value.

Another is the measured stress values on the crankshaft. They are two different things. They both have their uses and their limitations. It is very hard to compare them.

Q Let me add to my question:

I understand your answer with regard to assessing the adequacy of the crankshaft. Isn't it fair to say that if you had actual torsional stresses in the areas of known high stress, you had the actual strength of the material, that that is a more adequate measure or assessment of the adequacy of a crankshaft than plugging figures into the DEMA calculation?

A As I said before, these are two different things, but I personally perhaps would be more happy with a more

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refined approach. But on the other hand, the DEMA requirements are there and they have to be met so let's wait.

Q I don't think you answered my question, Professor Sarsten. Maybe it is still unclear.

MR. ELLIS: May I have it read back? I am trying to get it clear, but perhaps I haven't succeeded yet.

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

WITNESS SARSTEN: All right.

Having heard it again I think that I can say I presently would perhaps be more happy with such an approach.

BY MR. ELLIS:

Q Which is the "such an approach"?

A (Witness Sarsten) "Such an approach" using the measured values.

Q Professor Sarsten, did you make any calculations at load levels of 3300 or 3200 or some level below 3500?

A I did make some very rough approximate calculations at these load levels, yes.

Q What damping factor did you use in connection with those calculations?

A I used a magnification factor of 40, referred to the fourth order.

Q How did you arrive at that damping factor?

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A I arrived at that damping factor through experience with such torsional vibration calculations previously, and I know specifically that that is the range used by Det Norske Veritas.

I know it is a rather high damping relative to the recent results from another diesel engine manufacturer in Norway. I would assume this value to be, as damping goes, slightly on the high side.

Q Is that different from the damping factor that you used in connection with your calculations that are reflected on Exhibit 2 of your testimony?

A Yes, it is. The figure there was one of a number of calculations I made when reviewing the 8, the 12, the 16 and the 20 cylinder crankshafts. I then employed a damping value which happened to be in the data. This is a slightly lower value of damping than I subsequently used.

However, the values referred to at 450 rpm have been corrected to the larger damping value.

Q What then would be the new stresses that you calculated using the new damping at the underspeed and overspeed conditions?

A The stress levels using this rather large damping changes the value slightly near resonance. At the lower end of the speed range I used 428 rpm. The value turned out to be 7,051 psi. At the upper end of the speed range, 473 rpm, the value was 7,851 psi.

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Q And what was the value then at 450 rpm?

A That is the value that's given in the report. I had time to perform one calculation before writing the testimony and the correct values are given there. There is a very slight difference at these values, because the damping does not make too much of a difference.

Q Were the figures you just gave at 3500 Kw?

A They were at 3500 Kw, yes, or, to be more specific at 225 psi. The psi was assumed constant over the speed range.

Q So then by using this different damping factor on your calculations, you went from about 9,000 on your Exhibit 2 down to about 7,021 at the underspeed condition, is that correct?

A 7,051.

Q 7,051.

A Correct.

I also indicated in the testimony that the damping was negligible, that the figures were preliminary and that the stress values at the lower end of the speed range would go down dependent upon the damping.

Q You would consider, wouldn't you, this 30 percent reduction to be fairly significant, wouldn't you?

A Yes, but they still do not meet the DEMA requirements or alter my conclusions at all. They were

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expected.

Q Well is it your testimony that in the application of DEMA there is no room for any engineering judgment?

A I have only the rules to go by. So that is my testimony.

Q Is it true that you do not use an engineering judgment in the application of any standards?

Let's take ABS, do you use engineering judgment in the application of ABS standards?

A The standards are specific. We are not allowed to use engineering judgment. If so, it must be the classification society itself who waivers the rules or uses some engineering judgment.

Q Did you use that new damping factor in connection with your calculations for 3300 Kw?

A Yes, I did.

Q Were the values then -- What were the values that you received or that you obtained then for your stresses?

A They were somewhat lower, of course.

If you will give me a little time, I can try to give you approximate values.

I'm sorry, this may take a little time, if you wish the actual values now.

Q Why don't we do it overnight then and I will pick it up in the morning and go on, if that's all right with

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the Board.

JUDGE BRENNER: It's all right with us.

Are you going to ask him about 3200 also?

MR. ELLIS: If he has done them. I wasn't sure that he had done them at 32.

WITNESS SARSTEN: I have done them at 32 and Det Norske Veritas has done them at 3150.

MR. ELLIS: I'm only interested in what you've done.

BY MR. ELLIS:

Q Professor Sarsten, let me show you a book entitled "Rules for Building and Classing Steel Vessels, 1983, American Bureau of Shipping."

MR. ELLIS: I only have one of these, Judge. I didn't anticipate this was coming up. Shall I hold this as well?

JUDGE BRENNER: You can proceed. I don't know where we'll go.

MR. ELLIS: It's just a short point.

JUDGE BRENNER: I assume you'll ask him some preliminary question about it.

(Document handed to the witness.)

BY MR. ELLIS:

Q Are you familiar with that volume, Professor Sarsten?

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A (Witness Sarsten) If the rules, as applied to diesel engine crankshafts are here, I'm familiar with that. Otherwise not.

Q Have you ever seen that book before?

A This book I have not seen before, no.

MR. ELLIS: That was shorter than I thought.

BY MR. ELLIS:

Q Well Mr. Henriksen, have you seen it before?

A (Witness Henriksen) Not that edition. I have seen earlier editions.

JUDGE BRENNER: Once I hear the questions, I will know whether -- in my own mind whether or not it is reasonable for you not to have expected this to come up.

And also if it focuses in on a particular point the rest of us will have overnight to catch up, so that's another reason for proceeding now a little bit.

MR. ELLIS: Yes, sir. I plan to be very short. I did not anticipate it. That doesn't mean that I shouldn't have.

JUDGE BRENNER: All right.

MR. ELLIS: You may conclude that I should have.

JUDGE BRENNER: I may.

MR. ELLIS: I would just ask that you be charitable.

JUDGE BRENNER: We may need copies overnight.

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Let's see where it goes. We may not.

MR. ELLIS: Yes, sir.

BY MR. ELLIS:

Q Mr. Henriksen, those are the ABS rules -- that includes the ABS rules that we've been talking about today, don't they?

A (Witness Henriksen) Yes.

Q Is it also your testimony, as well as Professor Sarsten's, that the application of ABS standards excludes the exercise of engineering judgment?

MR. SCHEIDT: Objection. I don't believe that was Professor Sarsten's testimony.

JUDGE BRENNER: Why don't you rephrase the question and leave out the reference to Professor Sarsten but ask the same question.

MR. ELLIS: Yes, sir.

BY MR. ELLIS:

Q Mr. Henriksen, does the application of the ABS rules exclude the use of engineering judgment?

A (Witness Henriksen) I have not made any judgment on the ABS rules. I have only been involved with the torsional as it applies to DEMA.

Q You are not then I take it an expert in the application and interpretation of the ABS standard for torsional stresses for crankshafts?

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A No.

Q Thank you.

Professor Sarsten, do you recall -- I know you're going to look tonight, but do you recall whether at 32- or 3300 Kw there is a demonstration of DEMA compliance or not, both at the synchronous speed and at the overspeed and underspeed conditions?

A (Witness Sarsten) As far as I remember, you had to go down to 3200 to get compliance with the DEMA requirements over the whole speed range required by DEMA.

Q So that at 3300 Kw it is above 7000 for the summation of 24 orders, is that right?

A I would have to refresh my memory but I believe that's right, yes.

Q Does the DEMA standard of 7000 have conservatisms built into it, if you know?

A The DEMA standard of 7000 is a relatively high torsional stress and far above what is normally allowed, for example, by Lloyd's Register of Shipping, for example. Their rules, I think, allow for this size of shaft something around a little over 4000 psi. I would nave to calculate that but it's in the range they would allow.

Q So if it were an 11-inch crank pin -- strike that.

Do you know what the calculated summation of

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major orders was by Dr. Chen for the 13 by 11 inch crank pin — crankshaft?

A It's in his testimony. I have not calculated that. I do not remember what it was, no.

Q If I tell you that it was in the range of 9000, does that refresh your recollection?

A Yes. It was far above the DEMA requirements, at least as I remember, according to his testimony.

Q So you would expect certainly a fairly early failure then under those circumstances, wouldn't you?

A That would, of course, depend on the crankshaft configuration and material and so on. But under normal conditions, yes, one would expect an early failure.

Q Do you know how many hours were on the diesel generator 102 at the time that that crankshaft failed?

A The exact number I don't remember, but it was something in the order of 400 hours I believe but full load. It may have run more at lower load levels.

Q Look if you would, please, at Exhibit 35 of the County's exhibits. Exhibit 35 is an NRC Technical Evaluation Report by Franklin Research Center.

Do you have that, Professor Sarsten?

A Yes.

Q Have you reviewed that?

A It is.... Let me see.

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May 9, 1984. I do not remember reviewing it.

JUDGE BRENNER: I think you may have to turn to the third page of the exhibit to see if you recognize it, Professor Sarsten. The first two pages are just a cover letter.

WITNESS SARSTEN: Oh, I'm sorry. April 6, 1984.

I have not reviewed it. I may have seen it and glanced briefly through it. I have not reviewed it, no, in detail.

BY MR. ELLIS:

Q Look at page 15 of that report, if you would.

A (Witness Sarsten) I have it.

Q Do you see there where it indicates the number of hours on each of the three engines at the time that the diesel generator 102 crankshaft failed?

A Yes.

Q Do you see diesel generator 102 had 718 hours at the time of the failure?

A Correct.

Q That's almost ten to the seven, isn't it?

A It is, but it depends on how many of these hours were at the load, the rated load. It is not shown here.

Q Do you know how many hours of the 718 were at the rated load or higher?

A No.

1 WRBagb

Q Do you know whether the Franklin Research Institute concluded that the 13 by 12 inch crankshafts met the DEMA standard or not?

A No.

Q Look if you would, please, at page 69 of that Exhibit 35.

Does that refresh your recollection on whether Franklin Research Center on behalf of the NRC concluded that the 13 by 12 inch crankshaft, the replacement crankshaft, met the DEMA recommended values for single order excitation and for summation of the orders?

A Which part of the page is this on? I'm sorry, I'm not familiar with it.

Q Look at about midpoint on the page.

A Okay. Right. I see that. I have not read this before.

Q Okay.

Do you know how many orders they summed?

A No.

MR. ELLIS: Judge, this might be an appropriate time to break and I will use the time to insure that my estimate was accurate.

JUDGE BRENNER: Okay. We will break in a moment.

Let me make sure I understand something:

This exhibit that you've been examining from on

your last question or two which, as of now, is proposed County Exhibit 35, is the Technical Evaluation Report prepared by Franklin Research Center acting as a Staff consultant?

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

JUDGE BRENNER: Is that right, Mr. Goddard?

MR. GODDARD: That's correct.

JUDGE BRENNER: And your lead witness on the same subject is not familiar with it, is that right?

MR. GODDARD: I am informed this is a report that was used to analyze the old crankshaft, not the 13 by 12 crankshaft.

JUDGE BRENNER: The same question, though.

MR. GODDARD: It also analyzed the shot peening on the 13 by 12 crankshaft.

JUDGE BRENNER: Mr. Henriksen, are you familiar with this report?

WITNESS HENRIKSEN: I have read it, yes.

JUDGE BRENNER: You've read it. That's all you've done, you've read it?

WITNESS HENRIKSEN: Yes.

JUDGE BRENNER: You have not been involved in any analyses of it or anything of that nature?

WITNESS HENRIKSEN: Other than giving my views on it to PNL.

1 WRBagb

JUDGE BRENNER: All right.

MR. ELLIS: Judge Brenner, if you will look at the title, I think it does cover the replacement crankshaft.

JUDGE BRENNER: Well I don't want to go into it just yet.

Keep in mind what I said about the efficiency of directing questions to the entire panel and also what I said about basing findings on reports that are merely buried in exhibits, particularly lengthy reports.

MR. ELLIS: Yes, sir.

JUDGE BRENNER: All right.

We will break at this point and we will resume at 9:00 tomorrow morning and we'll try to finish up by the first break which we usually take around 10:30.

MR. ELLIS: Yes, sir. I think I will try to pick out the portions of this exhibit so that I am clear about it tonight and perhaps we may offer those as our exhibits in cross-examination tomorrow.

JUDGE BRENNER: If you're going to do that you should tell Staff Counsel what portions you are going to use so they can tell their witnesses and be prepared.

MR. ELLIS: Yes, we'll do that and would ask that they do the same thing when our witnesses are up. I'm sure they will.

JUDGE BRENNER: All right.

1 WRBagb

We'll be back at 9:00 tomorrow morning.

(Whereupon, at 5:00 p.m., the hearing in the above-entitled matter was recessed, to reconvene at 9:00 a.m., the following day.)

CERTIFICATE OF OFFICIAL REPORTER

This is to certify that the attached proceedings before the UNITED STATES NUCLEAR REGULATORY COMMISSION in the matter of:

NAME OF PROCEEDING:

LONG ISLAND LIGHTING COMPANY

(Shoreham Nuclear Unit)

DOCKET NO.: 50-322-OL

PLACE: Happauge, New York

DATE: 24 September 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

(TYPED) William R. Bloom

Official Reporter

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