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NUCLEAR REGULATORY COMMISSION

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ATOMIC SAFETY AND LICENSING BOARD

HEARING

In the Matter of:

ENTERGY NUCLEAR VERMONT YANKEE, LLC

and

ENTERGY NUCLEAR OPERATIONS, INC. (Vermont Yankee Nuclear Power Station)

Docket No. 50-271-LR

ASLB No. 06-849-03-LR

Tuesday, July 22, 2008

Windham County Superior Court

7 Court Street

Newfane, Vermont

BEFORE:

ALEX S. KARLIN, Chair, Administrative Judge

RICHARD E. WARDWELL, Administrative Judge

WILLIAM REED, Administrative Judge

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P R O C E E D I N G S

8:30 A.M.

JUDGE KARLIN: Good morning and welcome to the second day of hearings of the Atomic Safety and Licensing Board proceeding in the Vermont Yankee application for license renewal. I'm not going to go through the long introduction of yesterday and hopefully that will suffice, but I did want to mention a couple of things before we get started.

First is a housekeeping matter. Just please remember to turn off your cell phones and those sort of things so they don't interrupt as we're going along.

Second, I would hope that we all try to speak clearly and loudly for the audience, for the public to hear and that the witnesses will also speak clearly and loudly and slowly. We're going to try to ask clear questions and hopefully elicit pretty direct and short answers, except where we ask for a little bit longer explanation and we'll ask for that when the time comes.

We were looking -- Dr. Hopenfeld, I don't know if you can move down a little bit further. The reason we wanted you over there is for the line of sight so the Judges could see you more clearly.

That's helpful. Thank you.

One thing we might also mention is we asked the press and some of the parties might not have been aware of this and I'm not sure how much it will be an issue today, to try to conduct or to conduct any interviews they want to do outside of the hearing room, outside of the courtroom here, the idea being if we have a 10-minute break and come back in at 10 minutes and the media are doing an interview with somebody in the back of the room it kind of messes things up. So if you could encourage them and if they're asking you some questions, maybe you could step outside for that. That will help. So we're not going to have any interviews in the courtroom as it were.

The one other thing to mention this morning is I want to -- we're going to continue on asking questions about the metal fatigue contention of the witness panel. And we might get done today on that. I don't know. But when we do at the juncture when the Board is finished asking questions, we're going to take a break, 15 minutes or so and to think about it ourselves, if we thought we've missed any questions we thought we'd want to ask and also that's the time as we reconvene after the 15-minute break for the parties to suggest if they have any other areas where they think we should have asked questions or it's important that something needs to be brought out. And so while we're going on today, hopefully you'll be taking your notes and think about those things, because you're not going to have much time when we take the break, a 10 or 15-minute break to start scratching your head and think about additional questions.

Once you give us suggestions, if you do, you can either do it in writing which is going to be pretty fast, handwritten or whatever. If you don't want the other side to know about or you can just do it in the open and say we think you ought to ask them about whatever, but then we will either take another quick adjournment or from the bench confer to decide whether we want to ask, we think we need to ask those additional questions or not.

So the main point is as we go along today, be thinking about it if you think we may have missed something important so that when that 15 minutes comes, you can be pretty crisp about it and we can proceed. So anyway we hope we'll get done today on contention 2, but we may not either. We've got a lot of questions today.

With that, I just want to remind the witnesses that you're still under oath and so you acknowledge that you're -- you recognize that. And with that we will proceed with questions.

I believe Dr. Reed was doing the questioning mostly as we ended yesterday.

JUDGE REED: I would like to continue along the lines of trying to understand better exactly how these CUFen calculations were done. I think we made a lot of progress yesterday and I thank you all for helping us to understand that.

But what I would like to do this morning is to understand exactly the sequence of calculations that were done, moving from the original calculations in which the CUFens were calculated and reported to be, some of the CUFens were reported to be over one. And then you did a series of refined calculations in which all the CUFens were less than one for the nine components. And then you did a confirmatory calculation of a single component and what I would like to do is to ask, I guess this question should go to Mr. Stevens.

Could you help us understand first how you did the original calculations and then what was the change from that methodology to the refined analyses and why did those numbers go down so substantially?

MR. STEVENS: I am structural integrity and did not perform the first calculations so with respect to that part I think Mr. Fitzpatrick would be best to answer and then I can carry on for the refined and confirmatory calculations.

JUDGE REED: I'd be happy to pose the question to Mr. Fitzpatrick.

MR. FITZPATRICK: The license renewal application existing design reports, the CUFs in the design reports we used --

JUDGE REED: Please speak up. It's hard to hear.

MR. FITZPATRICK: For the original license application, the CUFs in the design reports we used --

JUDGE REED: What are the design reports?

MR. FITZPATRICK: When the plant was designed, an ASME 3 stress analysis was done and --

JUDGE REED: So you're going back 35 years for this?

MR. FITZPATRICK: Some of them. GE did an update on the CUFs for power uprate and those were the CUFs used in Table 431 of the application.

JUDGE WARDWELL: Who did that again?

MR. FITZPATRICK: The GE report assessing the effects of power uprate on the CUFs.

JUDGE WARDWELL: What date was that report?

MR. FITZPATRICK: 2003.

JUDGE KARLIN: General Electric. GE.

MR. FITZPATRICK: General Electric.

JUDGE KARLIN: That's people who built the reactor.

MR. FITZPATRICK: Designed it.

JUDGE KARLIN: Designed it.

JUDGE REED: Were those calculations done specific to Vermont Yankee or were there some generic calculations?

MR. FITZPATRICK: It was specific things in the table for Vermont Yankee and for the locations that were identified in NUREG 6260 we used 6260 values and there's a footnote on each one of those that we didn't have plant specific, specifically the piping, the original plant design, the B31 piping and piping code. That didn't require explicit fatigue analysis. Later plants are designed to ASME 3 and the Class 1 piping has its specific capabilities.

DR. REED: I'm still puzzled by some of these statements. In the design reports the plant was originally designed for 40 years and now we're looking at CUFens for 60 years, so you must have made some adjustments to account for the additional 20 years.

MR. FITZPATRICK: If you look at the application, the number cycles in the original application did not change. Table 421, 431 and 432 has the same number of cycles as the original design and showed the projections that we wouldn't exceed the original design cycles in 60 years.

JUDGE REED: So your original application for the license renewal assumed the same number of cycles as the original design and it was your expectation you would not exceed that?

MR. FITZPATRICK: That's correct.

JUDGE REED: Weren't there many CUFs greater than one in your analysis?

MR. FITZPATRICK: Not CUFs, CUFen with the Fen factors applied.

JUDGE REED: Fine.

MR. FITZPATRICK: And below that table, statements, we have the option to refine those analysis and do an inspection program or repair or replace over time. We knew we would have to do the CUF analysis.

JUDGE WARDWELL: You've confused me more than helped me. During the original design cumulative use factors were calculated?

MR. FITZPATRICK: For some components on the reactor vessel, yes. Not for the piping.

JUDGE WARDWELL: So then you did the additional analyses required for those that hadn't been done during the original design?

MR. FITZPATRICK: We engaged spectral integrity to do the CUF analysis.

JUDGE WARDWELL: So Mr. Stevens, you are able to testify in regards to the Fen analysis associated with the original, the initial calculations in the license renewal application, yes or no?

MR. STEVENS: No.

JUDGE WARDWELL: Mr. Fitzpatrick, please clarify for me.

MR. FITZPATRICK: The CUF used the original design CUFs on NUREG 6260 CUFs in the license renewal application.

JUDGE WARDWELL: Speak up. It's really hard to hear you.

MR. FITZPATRICK: We used the original design CUFs for NUREG 6260 CUfs in the original license renewal application. The Fens were calculated based on the NUREG by Entergy and the results did come over one and it was presented in the application.

JUDGE WARDWELL: Thank you.

JUDGE REED: Okay, so in the FSER which is what exhibit is it, it's Staff Exhibit No. 1, if I'm not mistaken on page 4.32, it's reflected that seven of the nine components evaluated have an environmentally adjusted CUF of greater than one. So your initial -- as I would call it, the initial CUFen analysis with the license application, the reanalysis in 2007 and then the confirmatory analysis in 2008 on one nozzle.

The initial CUFen analysis you did for this license renewal application showed seven of nine locations exceeding the unity or exceeding one.

MR. FITZPATRICK: Yes.

JUDGE REED: Okay, I'm with you so far.

JUDGE WARDWELL: Is there any technical reason you could not at that point have gone on and performed what was later to be called the refine calculations once you obtained your results that they were over one for seven of the nine components?

MR. FITZPATRICK: No, we could have done it at that time. Another group at Entergy was preparing the application and we submitted it that way.

Keep in mind at the time we had six years we spent in operation.

JUDGE REED: Okay, so I guess we rather crudely understand how you came up with your original set of numbers and maybe it would be useful now to turn to Mr. Stevens and ask if -- how the refined numbers came into being.

I'm guessing that you're going to tell us that basically we heard that yesterday, but the refined calculations, tell us briefly how those were calculated.

MR. STEVENS: So part of what Mr. Fitzpatrick said that I can't testify to is now we have a set of results that were initially developed that comes to me with the request to do some refined analysis. I think a couple of things are important to help clarify that initial set. We have, as Mr. Fitzpatrick just testified, we have several of the locations that show unacceptable results that we're now going to be doing refined analysis on. And another key part of that is for the piping locations, they assumed generic values that are not specific to VY. And as Mr. Fitzpatrick testified, that was because of the piping code used which does not require that CUFs be calculated.

So another important thing that we need to do is to come up with some values for those piping locations that are specific to VY. So we really have two objectives. One is to come up with specific CUFs for all locations, CUFens, as well as to do some refined evaluations.

Another important point is the objective of design analyses, those done originally and those done by General Electric for EPU is to show acceptability, not margin. Acceptability, as I discussed yesterday, is a cumulative usage factor of one. So once an analyst has shown the usage factor is less than one, he has demonstrated acceptability and he can stop his analysis.

So a lot of these analyses are done with simplifications and conservatisms put in and if the answer comes out acceptable, that's an acceptable result and an acceptable method. It does not indicate that the usage factor could not be lowered.

JUDGE REED: Let me take a small amount of time here to ask you some questions about the number one.

You said just now that if you come up with a number that's one or less that that's acceptable. So in your opinion calculating a CUFen of .99 would be acceptable. Is that correct?

MR. STEVENS: That's correct.

JUDGE REED: So you feel that there's no margin required to this failure point of one?

MR. STEVENS: I wouldn't characterize it that way. I would say that the 1.0 has margin in and of itself because of the methodology and the criteria that are being applied. We talked about safety factors --

JUDGE REED: Let me contest that point. Now the number 1.0 has no margin associated with it at all, but that omission of CUFen, if you literally read those definitions it's the number of cycles that you expect to occur divided by the number of cycles it would produce failure. Isn't that the definition of CUFen?

MR. STEVENS: That's the definition, but I guess I would ask you to clarify --

JUDGE REED: Let me continue. If that's the definition, doesn't it imply that if you made your best calculation of CUFen that if you calculated a CUFen equal to one you would expect failure to occur?

MR. STEVENS: No, sir.

JUDGE REED: If you do your best job of calculating what happens -- statistically, I realize there's some variation here, but wouldn't you expect failure to occur when a CUFen equals one?

MR. STEVENS: No, sir.

JUDGE REED: Isn't that the definition of CUFen?

MR. STEVENS: No, the definition is it's a criteria. It's an allowable value. It does not indicate failure. Failure of test data in the laboratory with factor -- adjustment factors applied to it is a criteria. It is not failure.

JUDGE REED: Well, I put it to you that we just discussed the definition of accumulative use factor and it's a ratio of number of cycles that you expect to occur divided by the number of cycles that are required to produce failure of the component. But if that number is one by the definition you would expect failure to occur.

MR. STEVENS: Let me see if I can state it another way. If the failure curve we used was in fact a failure curve without adjustment factors, then I would agree with your statement.

JUDGE REED: But that's what I asked you to postulate, that you were not taking into account any conservatisms in the calculation.

MR. STEVENS: I'm sorry, I misunderstood. I interpreted conservatisms and calculations as I don't have the option of changing that curve, therefore it's not a part of my calculations. But if that's what you allow me to do, then I agree with your statement.

JUDGE REED: Okay, so you're saying that the failure curve and this is an ASME number or -- is that right? This is coming from some report, has conservatisms built into it?

MR. STEVENS: That's correct.

JUDGE WARDWELL: And these curves are in the NUREG 6260 and 5783, is that correct?

MR. STEVENS: No, sir. The curves that we're using are in ASME code.

JUDGE WARDWELL: Thank you.

JUDGE KARLIN: These are what we refer to as the air curves. They're not environmentally adjusted. They're just what ASME calculated as how much stress this particular component would endure, how many times, and there is a scattering of data across the chart and you have to draw a curve that tries to capture what that data reflects.

MR. STEVENS: Yes, sir. We call it the design curve. It's an air curve through the data with adjustment factors applied to account for certain things and the resulting curve that's been adjusted is a design curve. That's the one in the ASME code that we use.

JUDGE KARLIN: Okay.

JUDGE REED: Can you speak to how conservative it is? Is it at the 95 percent limit? Are there some data points on the other side of the curve or is it -- does it completely bound all of the data? Am I making sense in my question to you?

MR. STEVENS: It's a good question. I think Mr. Fair is a better one to answer that.

MR. FAIR: Yes, if I can try to answer that question. I agree with the statement that the fatigue curve --

JUDGE REED: What curve?

MR. FAIR: The ASME design fatigue curve.

JUDGE REED: Fatigue.

MR. FAIR: Is based on test data on small specimens that have been adjusted to account for the difference between small specimens and actual components and for the scatter of the data.

In the NUREG report in 6583, there is assessment of the probability of fatigue crack initiation giving a CUF of 1 and in that it estimates that the probability of initiating a fatigue crack is somewhere between 1 and 5 percent which is logical given that you adjusted the data down to try to bound the test data.

So the second aspect of it --

JUDGE REED: I'm sorry, you said adjusted the data down --

MR. FAIR: I'm sorry, I misspoke. Adjusted the curve down to bound the test data.

JUDGE REED: Okay, so with the curve bounds the test data. There is no data on the other side of the curve. It's that conservative. Is that what you're saying?

MR. FAIR: The original design curve bounded the data as it existed at that time. And based on the data scatter from the test data, Argonne developed a model with a standard deviation and used that model to estimate the probability of initiating fatigue crack at the ASME code limit of 1.0. And that data is discussed, that evaluation is discussed in the NUREG 6583. It's also discussed a little bit in the 6909, the latest NUREG which used the 95/5 basis for developing a new air design fatigue curve. If you go back and look at this new air design fatigue curve, it's slightly above the original ASME fatigue curve for carbon and low-alloy steels which shows that original adjustment was somewhat conservative compared to this criterion 6909.

The other aspect --

JUDGE KARLIN: And with regard to stainless steel?

MR. FAIR: With regard to stainless steel, it's mixed.

JUDGE KARLIN: The NUREG 6909 curve as compared to the ASME curve is mixed. Sometimes it's above and sometimes it's below.

MR. FAIR: Sometimes it's below.

JUDGE KARLIN: Sometimes it's more conservative. Sometimes it's less.

MR. FAIR: That's correct.

JUDGE KARLIN: And 6909 and Reg. Guide 1.207 combined to basically say the NRC should be using, the staff should be using these new air curves from 6909 for new reactors?

MR. FAIR: That's correct.

JUDGE KARLIN: Okay.

MR. FAIR: The other aspect I wanted to point out in -- that's discussed in these NUREGs is that when you do initiate a fatigue crack what you're initiating is a crack that's three millimeters deep. It's not failure of the component, but it's a three millimeter deep fatigue crack based on the size of the test data that was used in the fatigue testing.

JUDGE KARLIN: So if I understand what you're saying on the ASME has a CUF --

MR. FAIR: That's correct.

JUDGE KARLIN: Cumulative use factor and first they start with a bunch of tests and that's data on a chart, right? Please speak, they don't capture a nod on the recording.

MR. FAIR: Yes.

JUDGE KARLIN: So there's data on a chart and then they draw a curve through that chart to -- and as I understand what you're saying that curve showed that 95 percent of the dots are above the curve and only 5 percent are below the curve. Is that right?

MR. FAIR: For the new curve in 6909, that's the estimate.

JUDGE KARLIN: Okay, for the ASME curve are they all dots above the line or --

MR. FAIR: For the ASME curve, the estimate was about a 1 to 5 percent probability of crack initiation which would mean 1 to 5 percent could fall below the line.

JUDGE KARLIN: One to 5 percent?

MR. FAIR: Right, depending on the stress level.

JUDGE KARLIN: So there's 95 percent chance they're going to be above, and 5 percent they're going to be below?

MR. FAIR: That's correct.

JUDGE KARLIN: And when we say below the line or the line -- what they're calibrating or what they're testing is whether there will be a three millimeter crack.

MR. FAIR: Initiated, that's correct.

JUDGE KARLIN: In the metal.

MR. FAIR: That's correct.

JUDGE KARLIN: Not necessarily the whole thing breaks in half or something.

MR. FAIR: Correct.

JUDGE KARLIN: So that failure or whatever the criterion is is a three millimeter crack?

MR. FAIR: That's correct.

JUDGE KARLIN: And there's a 95 percent chance that there will be no 3 millimeter cracks?

MR. FAIR: That's correct.

JUDGE KARLIN: And that's when you get a 1 to 1, 100 percent?

MR. FAIR: Right.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: So at a CUF of 1 for your initial analysis that meant there is a 1 to 5 percent chance that a small crack could have formed?

MR. FAIR: That's correct.

JUDGE WARDWELL: What is the CFU value was -- what are some of your higher values? Do you remember, Mr. Fitzpatrick?

MR. FITZPATRICK: CUF?

JUDGE WARDWELL: The environmentally corrective ones, what were those --

MR. FITZPATRICK: On the initial --

JUDGE WARDWELL: Initial analysis, the highest one.

MR. FITZPATRICK: Highest one. I think around 10, 11.

JUDGE WARDWELL: If you had a CUFen -- how are we going to call that?

MR. FITZPATRICK: We usually call it C-U-F-E-N.

JUDGE WARDWELL: It can't be simpler than that. CUFen of 10, is there any indication of what the probability of that crack being formed is?

MR. FITZPATRICK: It would be pretty high. There are some plots in NUREG 6583 that essentially for a given stress and it's dependent upon the level of stress, and that's an artifact of the statistical evaluation that Argonne did. It will give you a probability of initiation versus CUF. There are some tables.

JUDGE WARDWELL: If NUREG 6260 and 5783 are used which I believe they were used for all your analysis, both the initial refined and the confirmatory, this same 1 to 5 percent chance probability with a CUFen at 1.0 would exist for all those analyses, is that correct or not?

MR. FAIR: That would not be correct because the original evaluations in 6260 used some interim fatigue curves developed by Argonne prior to the development of the NUREG 6583 and 5704. I don't believe there was a statistical evaluation done to estimate the probabilities using those preliminary curves.

JUDGE WARDWELL: And the subsequent analysis used which NUREGs now?

MR. FAIR: The subsequent analysis has 6583 and 5704.

JUDGE WARDWELL: Thank you.

JUDGE KARLIN: By subsequent analysis you mean the 2007 re-analysis?

MR. FAIR: I was talking about the

subsequent evaluation of the data.

JUDGE KARLIN: Okay, I'm sorry.

JUDGE REED: Okay, so I think I understand the points that you've made. So basically what I'm understanding is that there's considerable conservatism built into these fatigue curves. Now my idea of a fatigue curve, correct me if I'm wrong, is a series of data points where you're plotting frequency on one axis and a strain -- stress or strain on another axis and the point is the failure point. Is that correct? Do I have that mentally wrong?

MR. FAIR: That would be the curve if you used the actual data unadjusted, yes.

JUDGE REED: Yes. And so there's -- is there a lot of statistical variation in these failure points?

MR. FAIR: The estimated variation between the mean and the lower bound is about 2 to 2.5, factor of 2 to 2.5.

JUDGE REED: Okay.

MR. FAIR: I believe that's also reported in the NUREGs.

JUDGE REED: So since you have this conservatism built into the actual fatigue curves that you're using to calculate the CUFens, you again feel that a limit of 1.0 is an appropriate limit, that you don't need to set a limit of .5 or some lesser number?

MR. FAIR: That's correct.

JUDGE REED: Basically, you're accounting for all of the conservatisms in your - -in the methodology by which you calculate the CUFens. You don't need any conservatism on the limit of 1.0?

MR. FAIR: That's correct.

JUDGE WARDWELL: Has anyone tried to quantify that in regards to how much error there is in the resulting CUFen calculation? That being we calculate a CUFen of 1.0, what is the error bar around that calculation? It is calculated within .001 or is it calculated within .5?

MR. FAIR: I'm not aware of any attempt to estimate the uncertainty in the calculation. Generally, the calculations are done with conservative inputs and no attempt to quantify the exact level of conservatism , but to try to use a conservative input when you're doing the calculation itself.

JUDGE WARDWELL: But as you go ahead and then refine the calculation, isn't part of that sharpening the pencil in regards to applying it to site-specific things and in essence you are also in the process reducing some of that conservatism. Isn't that correct?

MR. FAIR: That is correct.

JUDGE WARDWELL: How do you know how far you can go before you've gone too far without this uncertainty analysis performed on the CUFen calculation itself?

MR. FAIR: Well, it's up to the analyst to maintain the input parameters as conservative values, not to use a nonconservative input.

JUDGE WARDWELL: Mr. Stevens, would you like to comment on that question on how you, as a company, do your analyses and comfort yourself that you're not broaching on the conservatism too much to make it too close to being the actual creation perhaps as opposed to having these inherent conservatisms built in?

MR. STEVENS: Yes, sir. I agree with what Mr. Fair just said and it's important that -- and we pointed to four items in my testimony or our testimony yesterday about four conservatisms inherent to the analysis. There's other subtleties as far as heat transfer coefficients that we calculate as a function of flow rate that we bound the flow rates of these transients and all that. But it's important that in the transient definitions, the number or cycles, the temperatures and pressures and flow rates used, and all those definitions that we are able to demonstrate they are conservative.

In addition, we maintain the methodology and guidance of the ASME code which from a consensus body has been defined as a proper and conservative methodology for us to use and much of our work we attest to the fact that we have maintained that methodology.

JUDGE KARLIN: Let me focus on that. Isn't it -- I thought there was something in the record that reflected that the ASME was having a problem with regard to recalculating its air curves and that the NRC has asked them to do that and they had not been able to reach a consensus.

Mr. Fair, do you recall something like that in the record?

MR. FAIR: Yes, there was. I don't recall where it was in our record, but the fact is correct. There was a discussion, a long discussion on the air curve for stainless steel and there was a concern by some individuals that the adjustment on the stainless steel in the high frequency range which was supposed to be a factor of two was somewhat less than a factor of two.

So that was one of the changes we made in the 6909 NUREG was we put the adjustment in with the factor of two which results in the lowering of the stainless steel repeat curve in the high frequency range.

JUDGE KARLIN: Right -- go ahead.

MR. FAIR: And there's a number of individuals within the ASME that don't agree with what we did on the stainless steel curves. They think we're too conservative.

JUDGE KARLIN: And I think -- tell me about Reg. Guide 1.207? Was it -- that was at the context where the staff decided to recommend as guidance to use the air curves from 6909, correct?

MR. FAIR: That is correct.

JUDGE KARLIN: In lieu of using the ASME air curves?

MR. FAIR: That's correct. Well, we would accept the use of the carbon and low-alloy steel air curves which would be conservative, but we requested them to use the new air curve in 6909.

JUDGE KARLIN: And are you familiar with the draft guidance, was it 1144 that preceded Reg. Guide 1.207?

MR. FAIR: Yes.

JUDGE KARLIN: In that context, did they not discuss the difficulties that ASME was having or there was question and doubt about ASME's curves?

MR. FAIR: Yes. There was a discussion of -- if you're talking about within the NUREG, yes.

JUDGE KARLIN: And so the staff decided, had several options. One was to continue to use the ASME air curve.

MR. FAIR: That's correct.

JUDGE KARLIN: And the other was to come up with its own air curve for new reactors.

MR. FAIR: That's correct.

JUDGE KARLIN: And the staff decided because of the debate within ASME about its air curves that it would -- the staff decided to use the new air curve of 6909 for new reactors?

MR. FAIR: That's correct.

JUDGE KARLIN: Right. And still it's the staff's position that none of that applies to existing reactors because essentially they're grandfathered or you're not going to impose that and there are other conservatisms that offset this problem?

MR. FAIR: That's correct. That's the staff's position.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: After the analysis that was performed for this license renewal application or any of the applications like this, it seems to me it would make better engineering sense and more consistent with engineering practice for an attempt to be made to quantify the various conservatisms in some fashion and then come up with an error bar that could be useful to people performing these calculations so that they are guided on how much conservatism there is for any given calculations and the inputs that they do put into it. Do either of you, Mr. Fair or Mr. Stevens, know the reason why that hasn't been done for analyses such as this performed for a license renewal application?

(Pause.)

No is an answer.

MR. FAIR: No.

JUDGE WARDWELL: Fair enough.

MR. STEVENS: From our perspective, ours being structural integrity, we think that such an evaluation is at some level a little bit meaningless if you can demonstrate that all your inputs are bounding. Then you know that the result you get is a conservative maximum. Any such errors would give you a less number. When your criteria is acceptability, that kind of information is generally not viewed as meaningful to the folks in the industry.

JUDGE WARDWELL: But yet we know that they aren't all bounding. I mean just to start with the curves have a 1 to 5 percent chance of not being bounding.

MR. STEVENS: I was going to clarify Dr. Reed's question too on margin earlier which is now getting at your question. In addition to what's in the curve there are margins in the way we calculate stresses to use that curve.

And those margins can be very significant and based on the writing in the Reg. Guide 1.207 and my interpretation of that and Mr. Fair, I think, can clarify further, but those conservatisms are a key reason why those curves were not backfit to existing plants.

Those conservatisms through many analyses and many studies by many different organizations over the course of the industry's history have demonstrated that those analyses and results are very conservative.

JUDGE WARDWELL: Is another way of saying what you've said, as I listen to you speak, that one of the reasons you don't try to quantify the conservatism is that the error in trying to estimate that conservatism may be as much or more than the actual amount that's there so that the number that you've generated somewhat meaningless as you say because it's so difficult to quantify the conservatisms for some of these behaviors that you know you inherently have, but can't actually put a number on how conservative it is?

MR. STEVENS: I think that's a fair way to say it. I might clarify it or say it a little bit differently.

JUDGE WARDWELL: I hope you can say it simpler than I did as I was struggling through that.

MR. STEVENS: If I can demonstrate that my number is very, very conservative and I have an error of two orders of magnitude in the lower direction, then I think just my answer being bounding and conservative with respect to criteria is all that generally satisfies folks.

JUDGE REED: Okay, let's come back to the earlier point and that is we were trying to understand this progression of CUFen numbers starting from the original numbers in the application and we move to the refined calculations.

Do you have anything further to add to us about how those refined numbers were calculated? I think I understand that and I think I understand why the refined numbers are so much less than the original numbers.

JUDGE WARDWELL: Could you say that again then, exactly why they are less, the components that contributed to the fact that they are less?

MR. STEVENS: Yes. Again, there was -- remember, we have some locations that did not have Vermont Yankee specific analyses performed so that was a key to starting some of the refined analyses. We wanted to replace those generic 6260 CUFens with plant-specific values. So that was one key.

Another thing, if I may, take you back to Judge Karlin's paper clip example yesterday which is really an excellent example of how to help explain some of this. And you recall I was talking about how we might for one component have 20 transients to evaluate. One simplification, conservatism an analyst may do to make his analysis lie simpler is he may choose the worst of those 20 transients, analyze that one and pretend all the other transients look just like it. It's a very bounding assumption.

So if the analyst did that and he analyzed one transient that was the worst one in a quantity that is the sum of all 20, and he showed acceptable results, that's an acceptable analysis, a lot of conservatism, and he's completed his evaluation.

In that sense, the result he achieved in terms of CUFen, it might be .99 as you suggested, Dr. Reed, which is acceptable. But obviously, if I were to take the time to analyze all 20 of those transients, I would get a much lower result. So my point here is that the usage factor from an analyst that analyzed all 20 transients as one very conservatively and had he done that and achieved a usage factor like 11 as Mr. Fitzpatrick said was in the original license renewal application, there's clearly other things I can do to show acceptability which is what we call refined analysis.

Remember that his objective was to -- the analyst's objective was to demonstrate acceptability, not margin. So that gives me some leeway as an analyst to go back and refine that calculation further to show acceptability before I give up and say the result is unacceptable.

And that, I think, what I'm trying to characterize is the input given to structural integrity with unacceptable CUFen results and now what I can do as a first step to try and demonstrate acceptability. I can go refine those calculations by removing some of the excess conservatisms that were put into the analysis originally by another analyst. And that's, in fact, what we did.

JUDGE WARDWELL: Do you remember when you were tasked to do this and when you finished this analysis?

MR. STEVENS: Yes, sir.

JUDGE WARDWELL: Would you care to share that with us?

MR. STEVENS: We -- my recollection is we started discussions with Entergy in late, very late as in November, December 2006 to understand a scope and we began calculations in the spring of 2007, approximately May time frame and that initial set was completed in July of 2007, drafted for review.

JUDGE WARDWELL: I think yesterday you testified that it took somewhere in the neighborhood of three persons, a set amount of time that you quoted yesterday, that related to this refined analysis, those numbers that you gave yesterday. Is that correct?

MR. STEVENS: That referred to the confirmatory evaluation of the feedwater nozzle we did in January of this year.

JUDGE WARDWELL: About how much labor

effort was required in your refined analysis, roughly? Can you estimate?

MR. STEVENS: What I said yesterday was three weeks, three people, about nine man weeks. That's a reasonable estimate for doing these analyses refined. Refined took a little bit longer because some of the inputs into the confirmatory analysis were identical and we did not regenerate those.

Reasonable estimate for doing one of these refined analyses which didn't have an initial starting point to work from, 12, 13, 14 man weeks. The lapsed time would depend on our workload on other activities at the time.

JUDGE REED: Clarification, please. Is that per component or was that for all nine components?

MR. STEVENS: That would be per component.

JUDGE REED: Per component, 12 man weeks per component.

MR. STEVENS: And that would be more for the - -like the nozzle analyses that we did, piping, some of the analyses we were able to do in a more simplistic fashion. They took less time, but on the average for the more involved analyses, yes, you're correct.

JUDGE WARDWELL: And which more involved analyses, confirmatory or the refined or both?

MR. STEVENS: Both. The refined, the 12, 13, 14 week estimate refers to the refined calculation. The confirmatory would be a little bit less because some of the analyses I did for the refined like building a finite element model, I could make use of without dedicating time whereas in the refined analysis I had to create that model.

JUDGE WARDWELL: And so just to be sure I understand, those numbers you quoted now and quoted yesterday refer to per component average?

MR. STEVENS: That's correct.

JUDGE WARDWELL: Mr. Fitzpatrick, why did you task them to do that if, in fact, your plan in your license renewal application was to do that in the future?

MR. FITZPATRICK: It's part of the -- it's part of the contention.

JUDGE REED: I'm having trouble hearing you.

MR. FITZPATRICK: I'm sorry, to resolve the issue in the contention.

JUDGE REED: To resolve?

MR. FITZPATRICK: Try to resolve.

JUDGE REED: To resolve. Thank you.

JUDGE KARLIN: I want to ask, if I may, about -- as I understand what you're saying, Mr. Stevens, that to calculate and we're talking about not just CUF but the fen values also, the CUFens for the reanalysis which occurred I guess from November of '06 to July of '07. You estimate 12 to 14 person weeks per location. Is that right?

MR. STEVENS: That's correct.

JUDGE KARLIN: Why does it take so long? Isn't it just sort of a straight-forward calculation?

MR. STEVENS: No, sir. It's -- there's quite a bit involved. It takes -- building a finite element model is on the order of a week in and of itself. Running 20 transients through that finite element model are whatever means are used, takes time. We have the quality assurance process that all of our work must be documented and verified and checked by an independent reviewer as well as the project manager himself.

JUDGE KARLIN: Okay, so --

MR. STEVENS: All that together is extensive time.

JUDGE KARLIN: But is it pretty much mechanical or does it involve judgment, technical analyst's judgment also.

MR. STEVENS: It does involve judgment.

JUDGE KARLIN: Okay, and with regard to the single confirmatory CUFen analysis you did on the feedwater nozzle, that was yesterday you said three people, three weeks of work, nine person work week?

MR. STEVENS: Correct.

JUDGE KARLIN: For that. Did that also involve judgment and time and effort?

MR. STEVENS: Yes, sir.

JUDGE KARLIN: So analyst's judgment was involved in doing that?

MR. STEVENS: Yes, sir.

JUDGE KARLIN: Now I'm going to ask some questions a little later, but maybe this gets into it. On commitment number 27, it calls for Entergy to conduct two additional what I'll call confirmatory CUFen analyses on the core spray nozzle and the reactor recirculation outlet.

Is that right?

MR. FITZPATRICK: I don't think it's in commitment 27. That's in license condition in the SER.

JUDGE KARLIN: Right, okay. Thank you. I'll take that correction. Mr. Stevens, how long is it going to take those two confirmatory analyses on the core spray and the reactor recirculation outlets I guess it is.

MR. STEVENS: It would be timing consistent with that on the feedwater nozzles, so approximately nine man weeks.

JUDGE KARLIN: And it would involve judgment calls by various technical and scientific people?

MR. STEVENS: That's correct.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: Mr. Fitzpatrick, why didn't you apply the same criteria you did in regards to the refined analysis to the confirmatory analysis and just perform those additional two at this point in order to resolve this contention, help resolve this contention?

MR. FITZPATRICK: Repeat the question, I don't understand that.

JUDGE WARDWELL: When I asked you why did you task Mr. Stevens to do the refined calculations you stated you did that to help resole this contention.

MR. FITZPATRICK: The initial assessment we took the existing fatigue analysis, applied the FEN factors of NUREG 6583 and 5704 and came up with higher CUFens for a number of components.

We knew we would have to redo the analysis for the VY components that weren't plant specific and listed those in NUREG 6260 combined. Such integrity has the expertise to do it. We engaged them to do it.

JUDGE WARDWELL: That's fine. That wasn't my question, but that's a good answer for another question, so I'm glad you stated that.

My question now is why haven't you gone ahead and tasked them to compete the confirmatory analysis for the other two nozzles that the staff is requiring you to do at some point in the future, but do it now to again help resolve this contention, using the same approach or philosophy that you did when you tasked them to do the refined calculation?

MR. FITZPATRICK: At this point, we believe the refined analyses are conservative. The confirmatory analysis demonstrates that. The results show that there's no need to do that. We're going to get similar results.

JUDGE WARDWELL: So with the refined analysis because the CUFens were greater than one, you felt the need at that point when -- at the time you're deciding whether to task Mr. Stevens to perform a refined analysis, you had CUF values greater than one that inspired you to now task them to do at this point to help resolve this contention. You don't have that same situation is what you're saying with the additional two nozzles that need confirmatory analysis because you feel they're conservative enough and below one at this point and that that confirmatory analysis can wait for the future consistent with what the staff is requiring of you?

MR. FITZPATRICK: Yes, that's exactly right.

JUDGE WARDWELL: Mr. Stevens, did you want to add something to that?

MR. STEVENS: Just one other item I think is important is we in the confirmatory evaluation that everyone has accepted and reviewed it, we evaluated the bounding nozzle, so technically going into this we would say there's no reason to evaluate the other two nozzles, given that we one, evaluated the bounding nozzle; and two, we still believe these refined analyses are conservative.

JUDGE WARDWELL: But didn't your value, resulting value in your confirmative analysis for the feedwater nozzle increase over what it was before?

MR. STEVENS: No, sir. CUFen went down in the confirmatory evaluation which was our objective in those evaluations. It is lower.

JUDGE KARLIN: What went up? Something went up 40 percent. What went up?

MR. STEVENS: The CUF went up.

JUDGE KARLIN: By?

MR. STEVENS: Approximately 40 percent.

JUDGE REED: I'd like to ask Mr. Fair to state his opinion of what we just heard in light of the fact that the staff is requiring that two additional calculations be done. Is it the staff's view that this calculation was bounding, this feedwater?

MR. FAIR: Yes, it is. It was the highest CUF going into the analysis. The reason that the staff requested the other confirmatory analysis was that the CUF analysis was not bounding, although the CUFen analysis was bounding.

The staff couldn't make a judgment. The reason that the CUFen analysis went down was there was some refinements that were made in the confirmatory calculation on the Fens for each transient which instead of using a bounding Fen that covered all the transients, they had a specific Fen for each transient.

The staff was unable to make a judgment that the same level of reduction would apply to these other two nozzles and that's why they requested that they do the additional confirmatory analyses.

JUDGE REED: I thought I read in some of your testimony or somewhere here that the staff made a pretty clear statement that they did not believe that this was bounding. I thought you used that word. Am I mistaken?

MR. FAIR: I think the staff and the SE did say they thought the feedwater nozzle was bounding.

JUDGE REED: It's not so much that the feedwater nozzle was bounding, but that the confirmatory calculations were not bounding. I would have to study here for a few minutes --

JUDGE WARDWELL: Let me help you here. In a February 14 OA audit, the staff concluded that the use of Green's function could under estimate the cumulative use factor and therefore cannot be the analysis of record. Isn't that correct?

MR. FAIR: That's correct.

JUDGE WARDWELL: And so that's the motivation for why you're requiring the other nozzles to also be analyzed. Is that correct?

MR. FAIR: That's correct.

JUDGE WARDWELL: Why doesn't that also apply to the other locations?

MR. FAIR: Because the other locations weren't based on the Green's function evaluation.

JUDGE KARLIN: I thought we heard yesterday that it was. Mr. Stevens maybe can answer that.

MR. STEVENS: Just the three nozzles, core spray nozzle recirculation nozzle, feedwater nozzle. The other six locations of the nine were not evaluated with that methodology with the Green's function that you referred to.

JUDGE WARDWELL: Why weren't they?

MR. STEVENS: They were done with other more conservative methods.

JUDGE WARDWELL: Do those methods, those conservative methods all relate to how the stresses are analyzed and the number of stress component tensers that are used in the field?

MR. STEVENS: Yes.

JUDGE WARDWELL: And are those other locations such that they are more one dimensional if you will that allow you -- or the flow is one dimensional so that you ignore any of the small shear stresses that might develop that would require more than one stress tenser to be analyzed?

MR. STEVENS: No, sir. For example, the piping locations, feedwater piping recirc RHR piping were evaluated with ASME code NV3600 formula methodology for piping which accounts for all of that in a conservative fashion.

JUDGE WARDWELL: When is the Green's function used, let me ask you that?

MR. STEVENS: I'm sorry, did you say when?

JUDGE WARDWELL: Yes, when -- let me back up quickly on that. There's the simplified Green's function and I assume there's a complex or a normal Green's function. Is that correct?

MR. STEVENS: No, there's really -- I would say there's just one Green's function.

JUDGE WARDWELL: It's been called the simplified Green's function in much of the testimony.

MR. STEVENS: Right, and this has been the source of a lot of confusion in the discussion on this topic. It's not really the Green's function that parties have - -are again disagreeing over. The Green's function is a well-documented mathematical technique that's understood and is very accurate. What's - -where the single stress term idea comes in and taking the results from using the Green's function and what you do with that result.

JUDGE WARDWELL: And when you did that, what did you do? How did you apply that?

What did you do to the results of the Green's function to simplify that or however you want to word it?

MR. STEVENS: We took a single stress term result from the Green's function, if you will, a stress difference and utilized that to generate stress different histories for all transients.

JUDGE WARDWELL: And that's what made the analysis for all those other components besides the three nozzles a quicker analysis or less complex analysis or --

MR. STEVENS: Well, again, this Green's function technique we're talking about was only used for the three nozzles in the refined analysis. So it was a simplification made for just those three nozzles and what I call the second tier of the refined analyses that were performed.

JUDGE WARDWELL: Say again then why were the other locations able to be analyzed without the Green's function?

MR. STEVENS: It really goes back to my

discussion of what an analyst may do once he shows acceptability. He's finished. The other evaluations for the other components lended themselves to not having to make those simplifications or refinements to the analysis to show acceptability.

Some of the locations we use stresses that were generated in the original stress report, for example, that did not use Green's function, that were done consistent with using six stresses and we used those and were able to show acceptability. There was no need to go to a Green's function approach or a more refined approach.

JUDGE KARLIN: If I may, while we're on the Green's function, it references you to the FSER page 4.38. Could you all pull that out? That's where the discussion -- there's a four-page, I think, three or four page discussion of the Green's function in the staff's final safety evaluation report.

Page 4-38 of the FSER.

MS. BATY: Your Honor, I just wanted to supply our witness a copy.

JUDGE KARLIN: Yes.

MS. TYLER: Judge Karlin, will you state the exhibit number again, please?

JUDGE KARLIN: The exhibit number is Staff

Exhibit No. 1, I believe. Staff Exhibit No. 1. I believe that's the FSER. Let me double check.

(Pause.)

Is that right, Ms. Baty?

MS. BATY: Yes.

JUDGE KARLIN: Yes, Staff Exhibit No. 1, final safety evaluation report, page 4-38. It's a discussion of Green's function.

Perhaps this would go to Mr. Stevens. Help me here. As I understand it, are you all saying there's nothing wrong with the Green's function per se. The problem in how it occurred here was that there was simplified input into doing the Green's function calculation. Is that right?

MR. STEVENS: Simplified input as well as simplified use of the output.

JUDGE KARLIN: Yes, okay.

JUDGE WARDWELL: For only the three nozzles.

MR. STEVENS: That's correct.

JUDGE KARLIN: So on the last paragraph on page 4.38, there's a discussion of the staff's review and the second sentence says "the applicant's implementation of the Green's function input to the software assumes that shear stress analyses are negligible."

And then it goes on, "this implementation may not be valid for those locations with geometric discontinuity or non-axis symmetric load cases. So therefore the applicant's implementation for calculating a stress intensity cannot be validated, page 2.39, therefore the staff could not conclude the refined fatigue analysis is valid."

As I understand what they're saying, there's nothing wrong with the Green's function per se, but you've got -- the input has got to be done right and there was a simplified input. Only one input as opposed to six inputs. Is that right?

MR. STEVENS: Yes, sir.

JUDGE KARLIN: And you all corrected for that at the staff's request in doing the confirmatory analysis for the feedwater nozzle?

MR. STEVENS: Yes, sir.

JUDGE KARLIN: Right. And as I understand what you're saying when you ran through this analysis the confirmatory analysis showed a CUF that was 40 percent higher than what it had been before, but with the addition of the Fen the CUFen was lower than what it had been before.

MR. STEVENS: That's correct.

JUDGE KARLIN: Okay. Now in your proposal the license condition, Mr. Fair, that's being proposed by the staff is that they do that same analysis for these two other locations.

MR. FAIR: That's correct.

JUDGE KARLIN: And the proposed license condition or commitment 27 would say that Entergy would do this within two years prior to the start of the period of extended operations, right?

MR. FAIR: I believe that's correct.

JUDGE KARLIN: Okay, and the period of extended operations begins in 2012, right?

MR. FAIR: Again, I do not know the exact dates.

JUDGE KARLIN: March 2012, the current license would expire, so the period of extended operation would be March 2012, so the commitment or the license condition as proposed, the recalculation of those two CUFens would have to be done by and completed and submitted to staff by March of 2010. Are you with me, Mr. Fitzpatrick, is that right?

MR. FITZPATRICK: Yes, sir.

JUDGE KARLIN: Have you started doing it now?

MR. FITZPATRICK: No, sir.

JUDGE KARLIN: You haven't asked Mr. Stevens' firm to start working on it yet?

MR. FITZPATRICK: No, sir.

JUDGE KARLIN: Okay. Let me ask another angle on this. Under the recalculation under 6909, Mr. Stevens, perhaps, you said you did that in four hours over the weekend, right?

MR. STEVENS: Two of us, so I guess that would be eight hours.

JUDGE KARLIN: Okay. And does that involve judgment and -- why was that so much quicker and the rest of it was you know, many, many weeks and man hours?

MR. STEVENS: Again, we -- from my description yesterday, the finite element analysis, stress analysis of all these transients and accounting, how they pair with each other and all that doesn't factor into the calculation you're asking about now. So we did not have to do all that. We did the very, very tail end of the analysis which is given the stresses and the number of occurrences, we can use the 6909 fatigue curve to give allowable cycles, recompute cumulative usage factor and Fens. That's a relative short process.

JUDGE KARLIN: Okay. Maybe I'll ask Dr.

Hopenfeld at this point.

With regard to the confirmatory analysis, I understand part of the reason that was done to correct for this Green's function simplified input problem. Are you satisfied that the confirmatory analysis at least deals with the and eliminates the Green's function simplification problem that was perceived?

MR. HOPENFELD: Well, the two nozzles stated on the record are still subject to the Green's function analysis.

JUDGE KARLIN: Let me ask this with regard to the feedwater nozzle, the one that they did it for, are you okay --

MR. HOPENFELD: With respect to that aspect, yes, because they took the Green's function out.

JUDGE KARLIN: Okay.

MR. HOPENFELD: But important, we constantly hear these words conservatism. I mean to say conservatism without quantifying it is not very conservative.

My point is in the two items here, one -- go back to the different issue --

JUDGE KARLIN: Dr. Hopenfeld, we

understand. You have testified and we probably will ask some questions about how you don't agree with some of these conservatisms, particularly --

MR. HOPENFELD: It's not the question -- at this point, it's not the question of the mindset that something is conservative.

I make a certain assumption that may have no justification whatsoever. Now the results become conservative. I convince myself it's conservative. That's the problem. Because now we -- and the same thing with the definition that you ask, is something going to fail? And I can answer that question very quickly. You see, it goes to the definition and how people run tests prior to 30 or 40 years ago --

JUDGE KARLIN: Okay, well -- one of the things I think we might want to get back to is there was a discussion and Mr. Stevens, Mr. Fair was talking particularly about well, why don't you calculate the range of uncertainty associated with these calculations? They're saying it doesn't need to be done because it's conservative. And I understand that your testimony is and you've submitted that you think those uncertainties should be calculated and determined. I know you disagree with what they've said and we've got your testimony.

MR. HOPENFELD: I said the mindset and Mr. Stevens kept saying conservatism and you'll be convinced it's conservative.

JUDGE KARLIN: Right. Right, okay. But you are happy with the way they fixed the Green's function for the feedwater nozzle --

MR. HOPENFELD: I have no problem with the CUF with the exception of the bounding conditions to how to calculate it. The bounding condition for the Green's function and the bounding condition for the Fen under NV .32, they're considered the same. The consequences are different. I think they are under misconceptual of what the consequences are, but the bounding conditions for the Fens as far as how they use that is a contention, yes. But as far as getting rid of the simple aspects of the Green's function as a simplified method of reducing the amount of work, yes, I'm satisfied with that.

JUDGE KARLIN: Okay. One thing at a time and I just wanted to see if you were satisfied with that.

MR. STEVENS: May I add one piece of clarification?

JUDGE KARLIN: Okay.

MR. STEVENS: And I know we didn't say

this explicitly in this discussion, but the discussion up to now about the 40 percent increase in CUF, we focused on Green's function and the use of these inputs, single stress term. Yet, we need to keep in mind that our objective in the confirmatory analysis was not to reproduce the refined analysis. It was to address several items that had been brought up as potential issues with the analyses and to redo that analysis independently, completely with satisfactory compromises on all of those that would satisfy all parties and we agreed to do that with the staff to help them with their review process.

There are many factors that could have led to the 40 percent increase and I think some of the documented responses to the staff last fall from Entergy indicated that the Green's function and the single stress term was not the cause of that increase, the bulk of that increase or a significant portion of that increase. And that's why we still believe those refined analyses are bounding for --

JUDGE KARLIN: What was the cause of the 40 percent increase or the major factors?

MR. STEVENS: There was approximately 20 -- what we characterized as 20 differences in the analyses, processing of the inputs. An example would be there were a few transients, the way they were estimated with the Green's function, the inputs were changed in the confirmatory analysis because we did not have to make those assumptions.

We changed material properties in the sense -- we used the same material properties, but the Green's function assumes the properties are constant because that's a condition of a linear integration. In the confirmatory evaluation, we -- material properties varied with temperature. There were many differences that were put into the confirmatory analysis any one of which could have contributed to the 40 percent increase.

JUDGE KARLIN: Well, okay. Let me refer you to the Staff Exhibit 1, the SER, again on page 4-42. We're talking about this 40 percent increase and I'm trying to find it referenced, if it is, in the FSER and on page 4-42 at the bottom of the page, there is a sentence that goes "with the maximum Fen value used, the new EAF-CUFen is 0.893 which is greater than the previous value of 0.639 reported by using the Vermont Yankee Green's function application. Is that the 40 percent difference? What is that?

JUDGE REED: If I may make a correction, the numbers I have is not zero point, but .089 and

.064.

JUDGE WARDWELL: That's not what's in the SER.

JUDGE KARLIN: What are those numbers? I know what the numbers are in the FSER. They are 0.839 which is the EAF-CUF and the previous value of 0.639. Is that a 40 percent increase?

JUDGE REED: And my numbers come from paragraphs 20 and 21 of your initial statement position.

JUDGE KARLIN: Well, let me stick with this one first. What do these numbers in the FSER mean? Maybe Mr. Fair can help us?

MR. FAIR: Yes. I wasn't the reviewer.

JUDGE KARLIN: I understand.

MR. FAIR: I believe that the .893 is the application of the confirmatory analysis with the constant FEN, that same FEN that was used in the original analysis.

Then the Applicant further refined that analysis, that confirmatory analysis, developing an Fen for each transient which then lowered it below the original --

JUDGE KARLIN: No, I don't think so. Look at the sentence. It says with the maximum Fen value used, the new EAF-CUFen is 0.893 which is greater than the previous value of 0.639. So the previous value -- the first earlier one in time was the .6 and the new one is the .8, so something is going up.

Mr. Stevens?

MR. STEVENS: The numbers that Dr. Reed was referring to are CUF values prior to FEN evaluation and are the values that reflect the 40 percent.

JUDGE KARLIN: Okay, now where do they derive from, where are they found if I wanted to find them?

JUDGE WARDWELL: If you tried 40, page 21 they may be on that of his testimony.

JUDGE REED: That's 20 and 21 of Entergy's initial statement of position.

JUDGE KARLIN: Okay, so are they in the FSER? Mr. Fair, Mr. Stevens?

MR. STEVENS: I don't recall.

JUDGE KARLIN: I mean don't you think the FSER should say that this the CUF went up 40 percent?

JUDGE WARDWELL: That's just the CUF, not the CUFen, correct?

JUDGE KARLIN: Right, right.

JUDGE WARDWELL: The CUFs are .064 and

0.89 as you change from the refined to the confirmatory. Is that correct?

MR. STEVENS: Yes, the values in the FSER are taking the values that Dr. Reed identified, I believe it was you stated in the NRC initial statement of position which are the CUF values. And that these are the CUFens applying the same Fen value that was determined in a refined analysis to both of those results.

JUDGE KARLIN: Okay, all right. stop right there. So the Fen is a constant value in this calculation and the CUF is a differential value. And it's going up. It went up from .6 to .8 and Fen is a constant, right? Isn't that a 40 percent increase?

I thought you said -- if you use a constant Fen, the CUFen would have gone up 40 percent by fixing the Green's function?

MR. STEVENS: Yes.

JUDGE KARLIN: But you didn't use a constant Fen.

MR. STEVENS: No.

JUDGE KARLIN: You used a more specific or particularized Fen.

JUDGE WARDWELL: And that came up to a .3 of CUFen, is that correct?

MR. STEVENS: That's correct.

JUDGE KARLIN: So the CUF went up and Fen went down and the total result you conclude went lower than the prior one.

MR. STEVENS: That's correct.

JUDGE WARDWELL: And your constant Fen is either 10 or .1. I don't know which why it applies.

JUDGE KARLIN: So and in fact this would be directly, I guess, well, Dr. Hopenfeld?

MR. HOPENFELD: I would like to help them to give you -- I'll tell you where the reference where we can find the CUF and it's -- the last one. I can go back and find it.

If you look at NEC JH-21 and I think page 7 of 7. There's a table there where you can see how they've done that.

JUDGE WARDWELL: Wait, bear with us while we find those first.

JUDGE KARLIN: NEC JH-21. And that is structural integrity?

MR. HOPENFELD: Correct, and I think it's page 7 of 7. And you'll see a table there. I think it's dated -- it's a revision. I think it was given to us at the beginning of January. And you'll see there they have the user factor for all the transients and then you see how they corrected it. I think this was done for the exact analysis and they have similar like that for other tables, but you asked about where to see the user factors before the correction and that's where it is.

JUDGE WARDWELL: This is page 7 of --

MR. HOPENFELD: Page 7 of 7.

JUDGE WARDWELL: And you can read that thing?

MR. HOPENFELD: I need a magnifying glass.

JUDGE KARLIN: Do you agree with that, Mr. Stevens?

MR. STEVENS: No, I'm not finding -- I'm a little cross wired on the commonality of the exhibits.

I had JH-21 as being the equivalent of Entergy Exhibit E-227. Is that correct?

JUDGE KARLIN: I do not know. Maybe Ms. Carpentier, do you have that?

(Off the record.)

JUDGE KARLIN: E-227.

MR. STEVENS: E-227 specifically is Entergy calculation VY19Q303. That would be the fatigue results for the confirmatory evaluation of the feedwater nozzle. It reports one value. I'm not seeing a comparison to any others.

JUDGE KARLIN: Dr. Hopenfeld?

MR. HOPENFELD: Yes, the table that I was referring to gives you the usage factor without the correction and with the correction. It's unfortunate --

JUDGE KARLIN: It's just one of the values.

MR. HOPENFELD: It's the latest one. It's the latest one. It's the one that you get the final answer to form .897, but you can see what the differences are between. Before correction and after correction and all the usage factors.

JUDGE KARLIN: Mr. Fair, Mr. Stevens, I'll go back to the FSER on page 4-42. The new EAF-CUFen is 0.893. The previous value is 0.639. Unquote from the FSER. You're saying that's the revised CUF and a constant Fen value, is that right?

MR. FAIR: That's correct.

JUDGE KARLIN: Okay, perhaps you can then show me -- let's go on in the FSER and tell me where the ultimate CUFen value which with the Fen changed is reflected in the SER, is it?

(Pause.)

Well, I didn't understand. I was confused by that. Is the final CUFen value that Entergy has presented by the confirmatory analysis reflected in the FSER, the number put in the FSER?

MR. FAIR: Give me a moment. I thought it was in there. I'm looking for it.

JUDGE KARLIN: Okay.

(Pause.)

JUDGE KARLIN: Well, let's read the next sentence. "This indicates the results of the Green's function application using the specific software could under estimate the CUF and therefore cannot be the analysis of record."

Then the next sentence says "however, the updated analysis, whether using the maximum Fen or appropriate Fen yields CUFs lower than the code allowable. The staff concludes that this updated analysis is the analysis of record for the feedwater nozzle. When it says "this updated analysis" what is that? Is that the analysis with the revised Fen?

MR. FAIR: Yes, that's what is referred to.

JUDGE KARLIN: But that value is not --

MR. FAIR: Yes, appears not to be in --

JUDGE KARLIN: And what is that value, Mr. Stevens?

MR. STEVENS: It's .3531.

JUDGE KARLIN: Point 3531 and where does that come from? I mean is there an exhibit that tells us that? Is that this exhibit that Dr. Hopenfeld has pointed us to?

MR. STEVENS: Yes, sir.

MS. BATY: Your Honor, it's Entergy Exhibit E-228 also has a table with just these critical numbers in it on page 6.

JUDGE KARLIN: E-228. All right. Let's focus on the exhibit NEC JH-21, page 7. It's also Entergy Exhibit E-227, as I understand it. Where is this new value on this tiny little chart? Where -- where can I find it?

MR. STEVENS: If you go to Table 1 on page 7 of 7.

JUDGE KARLIN: Yes, sir.

MR. STEVENS: And upper half, far right.

JUDGE KARLIN: All right.

MR. STEVENS: With my glasses on, I can see that it reads "total U60-ENV equals .35306."

JUDGE KARLIN: Okay. There it is. There it is. I see it. Which equates to .3531.

I wish the FSER had had that in there.

JUDGE WARDWELL: Mr. Fair, can I ask why

did you ask -- it appears based on the statements in the FSER that this was asked of them to calculate later on because it has parentheses, "this value was verbally provided during the audit."

Why did you ask for that calculation when in fact what they considered to be the appropriate calculation included the variation in the Fen value for each of the different transients?

MR. FAIR: I would have preface this that I'm not the reviewer, but my understanding of why it was asked at that time was the intent was feedwater analysis confirmatory analysis was going to be used to show that all three nozzles were appropriately conservative.

When Dr. Chang reviewed this confirmatory analysis and noticed that there were different Fen factors used in the confirmatory analysis, it couldn't make a conclusion that this same level of conservatism would exist in the other two nozzles that would allow you to drop that CUF down and that's why they were asked to do the analysis of the other two nozzles.

So although the feedwater nozzle analysis is acceptable, they couldn't make a judgment that the other two nozzles had the same level of conservatism in them that would come out and give a lower result.

JUDGE KARLIN: You could or could not?

MR. FAIR: Could not.

JUDGE KARLIN: Could not, and therefore --

MR. FAIR: Requested the other two nozzles be evaluated.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: In the pause, I'll ask again, Mr. Stevens, to refresh my memory on earlier testimony this morning on why does not the same approach need to be applied to the other components besides the nozzles?

MR. STEVENS: Because the other components were demonstrated to be acceptable using other analytical techniques that don't have these issues included in them, Green's function issues. So we were able to use existing conservative analysis that did not rely on Green's functions that estimate stresses, conservatively demonstrate the CUFens were less than one. We met criteria and our evaluation is complete.

(Pause.)

JUDGE WARDWELL: Saying it another way, for the refined analysis, when you analyzed the nozzles, you had to or chose to use the Green's functions to analyze the stress conditions on it that ultimately resulted in demonstration of meeting the criteria?

MR. STEVENS: Yes, sir.

JUDGE WARDWELL: Okay, I understand.

JUDGE KARLIN: It's been going about an hour and a half now and you all have been very good in trying to answer our questions. I think it's probably good to try to take a break. I have 10 o'clock. Why don't we reconvene at 10:15. So we'll stand adjourned until 10:15.

(Off the record.)

JUDGE KARLIN: We'll go back on the record, Mr. Reporter.

And let me remind the witnesses that you're still under oath.

We are continuing with questioning related to metal fatigue contention, and I believe Dr. Reed can start us off again.

JUDGE REED: Okay. Just a quick follow-up on a statement Mr. Fair made. I'd like to ask you to please open up your initial statement of position, the staff's initial statement of position, and look on page 17.

MR. FAIR: Now, what do you mean by the initial statement of position?

JUDGE REED: I don't have the exhibit

number.

JUDGE KARLIN: It's not an exhibit. It would be the pleading presumably.

JUDGE WARDWELL: Dated May 13th.

MR. FAIR: I think I have it.

JUDGE REED: Okay. If you would look at the bottom and read that paragraph on the bottom, please, starting "although the confirmatory analysis."

MR. FAIR: Well, maybe I'm not on the right -- did you say page 13?

JUDGE REED: No, 17. Sorry.

MR. FAIR: Oh, I'm sorry. And again, which?

JUDGE REED: The bottom paragraph. It starts with the word "although."

MR. FAIR: All right. Somehow I don't seem to have the -- oh, I'm sorry. I'm turning to the wrong (pause) -- thank you so much.

I have it. Sorry about the delay.

JUDGE REED: No problem.

MR. FAIR: "Although the confirmatory analysis was acceptable to the staff and the CUF with feedwater nozzle was less than 1.0. The CUF produced by the confirmatory analysis was greater than that produced by the September 2007 analysis and thus not bounding. SER (Staff Exhibit 1 at 442 to 443, Staff Exhibit 2 at 820). Therefore, the staff requested that Entergy make the confirmatory analysis, the analysis of record for the feedwater nozzle. SER (Staff Exhibit) --

JUDGE REED: You can skip those references. And then the final sentence is?

MR. FAIR: "Also, because the September 2007 analysis was not bounding for the feedwater analysis, the staff proposed a license condition requiring that Entergy preform ASME code analysis for the core spray in the reactor recirculation outlet nozzle at least two years prior to the period of extended operation and make those analyses the analyses of record for the core spray in the reactor recirculation outlet nozzle.

JUDGE REED: Thank you.

So earlier I asked you if the staff's position was that this confirmatory analysis was bounding or not, and it was my understanding that you said that you believed that it was bounding, and so in light of this testimony that you just read or this initial statement of position, were we simply confused or --

MR. FAIR: Well, I may have been confused as to what the intent of your questions are. What I meant when I said it was bounding, I meant it was bounding for the other two nozzles. The reactor feedwater nozzle had a bounding CUF.

JUDGE REED: Okay, but again, in the sense of this, the staff's position is that that analysis is not bounding and that is hence why you are asking for these two additional analyses to be performed; is that not correct?

MR. FAIR: That's correct.

JUDGE REED: Okay. I just wanted to clear that up.

Okay. I would like to change gears slightly, and I'd like to talk now more particularly about the Fen values. I observed earlier that there seems to be quite a large variation in Fen values ranging from one to I think I've seen numbers as high as 70 or 90. So clearly fatigue cracking can be very sensitive to environmental factors; is that correct, Mr. Stevens?

MR. STEVENS: Yes.

JUDGE REED: So could you state for me what environmental factors you believe fatigue cracking is most sensitive to?

I know there are a large number of these factors, but if we could pick out the five or six that you think are important.

MR. STEVENS: The laboratory data that Argonne evaluated would indicate that strain rate, dissolved oxygen, temperature, and where appropriate it --

JUDGE REED: Temperature of what?

MR. STEVENS: Fluid temperature.

JUDGE REED: Fluid, not steel temperature?

MR. STEVENS: Correct. They're assumed to be the same.

JUDGE REED: Okay.

MR. STEVENS: And where appropriate, material sulfur content.

JUDGE REED: And is that sulfur content in the water?

MR. STEVENS: That would be in the material itself.

JUDGE REED: In the material. Anything else?

MR. STEVENS: Those are the dominant ones in the relations. There are other effects like strain amplitude, how much you -- what level you stress a component to that could indicate a threshold below which you would not have to consider the other variables, but those are the dominant ones.

JUDGE REED: Well, let's talk for a minute about one of these. Let's pick oxygen concentration and talk about that for a moment. So can you tell us a little about how you've accounted for oxygen concentration in your calculations?

MR. STEVENS: Yes, sir. Entergy provided structural integrity with oxygen values that are representative of plant operations, and we looked at those values and took a bounding value that would have been seen in plant operation and used those in the formulas to estimate the Fen appropriately.

JUDGE REED: Now, this is a single constant number you used for all transients for all time?

MR. STEVENS: No, sir. We took bounding values, but with the implementation of hydrogen water chemistry, I don't recall exactly the year that was implemented, but it was well after plant start-up. It has a significant impact in some areas of the reactor on dissolved oxygen levels.

JUDGE REED: Exactly what is meant by hydrogen water chemistry? I don't know that.

MR. STEVENS: Hydrogen water chemistry is a method to bring under control water chemistry in the reactor and reduce dissolved oxygen and other things that could be detrimental to materials in terms -- mainly stress corrosion cracks.

JUDGE REED: So this reduces the dissolved oxygen.

MR. STEVENS: It reduces the dissolved oxygen in some areas of the reactor, yes.

JUDGE REED: So a higher concentration of dissolved oxygen is detrimental to fatigue cracking or it tends to worsen fatigue cracking?

MR. STEVENS: Generally speaking it's dominant for carbon and low alloy steels, that the higher the oxygen the more detrimental on fatigue. In a case of stainless steels, at least the relationships that we use for austenitic from the NUREG CR-5704 that indicates that lower oxygen is a bit more detrimental than higher oxygen levels, forced austenitics.

JUDGE REED: What type of steel are we talking about for the feedwater nozzle?

MR. STEVENS: The feedwater nozzle calculations are based on ferritic, carbon low alloy.

JUDGE REED: Carbon low alloy. There was some mention of a -- you'll have to forgive me. Maybe I should ask you to describe the feedwater nozzle very briefly. Geometrically what does it look like?

And I know there are two locations that you're concerned about. So you might help us understand a little bit about what it looks like and why you're analyzing two different locations on that nozzle.

MR. STEVENS: The feedwater nozzle is basically a component where the feedwater piping which brings back condensed fluid to the reactor, joins the reactor pressure vessel. Very simplisticly, that's two intersecting cylinders, an incoming pipe into a larger cylindrical reactor pressure vessel.

The nozzle itself is a very large forging that transitions in thickness from the thick reactor pressure vessel to the thinner feedwater pipe. There is a component called a safe end in between the nozzle forging end of pipe that is another transition piece to transition from the pipe to the nozzle.

JUDGE REED: Okay. There was some mention of the installation of a thermal shield. I believe I have the terminology correct.

MR. STEVENS: Thermal shield or thermal sleeve is the more commonly referred term.

JUDGE REED: Thermal sleeve.

MR. STEVENS: Thermal sleeve is inside the -- it connects or it touches to the safe end and channels the flow through the nozzle into the reactor vessel and is connected to what's called a sparger. The sparger distributes the feedwater flow evenly into the inside of the reactor vessel. The thermal sleeve acts as a shield to the feedwater nozzle forging and connection to the reactor pressure vessel to help channel the flow and also minimize thermal cycling on the nozzle itself.

JUDGE REED: So the thermal sleeve is helpful with regard to fatigue in that it reduces the stress on the feedwater nozzle due to temperature changes; is that correct?

MR. STEVENS: Yes, it's very beneficial in that it protects or greatly reduces the severity of transience on the nozzle itself.

JUDGE REED: And did you account for the presence of this sleeve in your analyses?

MR. STEVENS: Yes, sir.

JUDGE REED: But that sleeve was a recent addition; is that correct?

MR. STEVENS: Can you clarify your question?

JUDGE REED: It was my understanding that the sleeve -- has the sleeve been in position sine the plant was --

MR. FITZPATRICK: The feedwater nozzle has always had a thermal sleeve in it.

JUDGE REED: Yes.

MR. FITZPATRICK: The design was changed in 1976 with a sleeve that had a tighter seal than the original.

JUDGE REED: In '76?

MR. FITZPATRICK: '76.

JUDGE REED: So I had misread some document actually. So these analyses have always assumed the presence of a thermal sleeve.

MR. FITZPATRICK: Yes.

JUDGE REED: So let's go back to the question of dissolved oxygen. So there is an allegation by NEC that, in fact, fatigue is not really sensitive to dissolved oxygen, but is sensitive to something else called the electrochemical potential. Could you respond to that?

And maybe you're not the right witness to do that, but --

MR. STEVENS: I think Mr. Fair would have a better answer to that than I would.

JUDGE REED: Mr. Fair.

MR. FAIR: Yes. There has been some recent data that's indicated that electrochemical potential is a significant contributor to the environmental fatigue. Argonne looked at that data and determined that based on some of the testing that they had done, it took a certain amount of time to get a proper soak, heat soak in the material so that that was not a concern. It would stabilize.

JUDGE REED: I didn't understand what you said. A proper heat?

MR. FAIR: Yes. Well, I'm sorry. I'd like -- I used bad terminology.

JUDGE REED: It's just I can't hear you from across the room.

JUDGE WARDWELL: Could you explain what electrochemical potential is in these situations that is of concern?

MR. FAIR: Well, it's just the potential electrical field that's set up that could have an impact on the fatigue -- on the environmental effect, and the data that we have for environmental is basically measured oxygen content, and we do not have measurements on ECP.

When Argonne took a look at this issue, they determined it took a while for the ECP to stabilize at a given oxygen content so that there may be some period of time, a short period of time where the ECP could have an effect.

JUDGE REED: So let's cut to the bottom here. Is it dissolved oxygen or electrochemical potential that should be the controlling factor?

MR. FAIR: That issue has not been totally settled in the industry. Again, the data that we have for the environmental effect is all based on dissolved oxygen with very small amount of data that actually has ECP measures.

JUDGE REED: Let me turn to Dr. Hopenfeld. This is your issue. Could you please state what your concerns is regarding dissolved oxygen?

DR. HOPENFELD: First of all, I would like to comment that this is not a major concern.

JUDGE REED: This is not what?

DR. HOPENFELD: This is not a major concern, but it is an item that is important to understand.

JUDGE WARDWELL: Don't you testify that it's a controlling parameter?

DR. HOPENFELD: Yeah, I'm saying, but a major -- a major factor compared to all the others, why that is an important factor. I mean, you should use ECP or you should use the electrochemical potential instead of concentration. It comes through the uncertainties of calculating the Fen and looking elaborately on that.

But like I said, compared to others this is not high on the priority, but let me explain.

JUDGE REED: Let me just observe that when I asked Mr. Stevens for a list of controlling parameters, the most significant parameters that affect fatigue, environmental parameters that affect fatigue, dissolved oxygen --

DR. HOPENFELD: Yes, that's correct.

JUDGE REED: -- was number two.

DR. HOPENFELD: Well, oxygen is important.

JUDGE REED: So are you saying that you've been down around number ten?

DR. HOPENFELD: Let me explain what I come from on this. The basic mechanism of a crack propagator is not 100 percent understood, but oxygen creates an important part of it, but the driving force is ionic dissolution. In the case of anodic dissolution you have an anode and you have a cathode and you have electrochemical potential to drive the reaction.

The reason behind the electrochemistry, and you write the equation for an electrochemical potential, it's the activity that comes as a basic coreometer, not the concentration. But dilute concentrations you can sometimes say, yes, the activity coefficient is not very important and you can just go directly and right to potential in terms of concentration.

Now, why is that important? It was one item in the table that I provide you, and the reason it comes in, because it is an electrochemical parameter, and you're going to basic mass transfer between electrodes. You'll find out the conductivity. The ionic conductivity of the water also plays a part in the anodic dissolution, and I think Argonne discussions this and goes into the one parameter that is important.

In that context I was saying it's more important to use the -- I just want to make sure that the science is correct. As you understand, the basic parameter, if you look in every textbook you'll see what defines electrochemical potential in your battery, in your anywhere in certain terms of activity. That's the basic thermodynamic parameter, not concentration.

However, it's difficult to measure absolutely. it should be measured by the potential, but that's why people are talking concentration, but you have to understand that was the purpose of it. When you have an uncertainty, and Argonne alludes to the fact that different conductivity affects the fatigue produced. And that's where I was trying to explain.

JUDGE WARDWELL: Did you not state at your Exhibit 64, page 427 and 28 that EPRI also believes that this --

DR. HOPENFELD: Oh, yes, yes, they did. They did.

JUDGE WARDWELL: -- chemical naturally is a controlling parameter?

DR. HOPENFELD: Yes, yes, sir, and if you wish, if you go to -- let me see if I can find the exact page where it's stated.

JUDGE WARDWELL: Four, twenty-seven.

DR. HOPENFELD: It should be -- to be considered is the electrochemical potential. They stated that very clearly.

Now, I did see some of the testing that they've been talking about, but I haven't seen -- I haven't analyzed the work. It's hard to get because this is not the number one priority on the uncertainties here.

JUDGE WARDWELL: Well, that's why I want

to focus on why it isn't the number one priority. Are you saying that representing this electrical-chemical potential or at least the effects of it can be approximated by just having the concentrations of dissolved oxygen represented at the --

DR. HOPENFELD: That is --

JUDGE WARDWELL: Let me finish. Okay? Because then I can hear you if you would let me finish my question.

DR. HOPENFELD: Right.

JUDGE WARDWELL: Let me start it again. Are you saying that this electrical-chemical potential can be represented by a dissolved oxygen concentration in regards to its effect on fatigue we're trying to analyze?

DR. HOPENFELD: That is correct, except --

JUDGE WARDWELL: Now I'll let you explain. Elaborate more if you wish.

DR. HOPENFELD: Yes, it is correct, but --

JUDGE WARDWELL: Okay, but it's your position that a more accurate way to do it would be to measure the electrical potential precisely.

DR. HOPENFELD: -- not from immediately -- any electrochemist will tell you that.

JUDGE WARDWELL: How could that be done?

DR. HOPENFELD: Well, you measure the electrochemical potential.

JUDGE WARDWELL: How?

DR. HOPENFELD: I don't know practically, but in the plant you probably don't do it, but in the laboratory they do.

JUDGE WARDWELL: Well, practically how can you do it in a plant?

DR. HOPENFELD: You can't.

JUDGE WARDWELL: So why are you bringing this -- so isn't the only alternative available is to use dissolved oxygen?

DR. HOPENFELD: In the plant, yes, but the point is --

JUDGE WARDWELL: Thank you.

DR. HOPENFELD: -- sir, what I'm trying to say when you hear that everything is conserved, what I'm trying to tell you, that there are parameters in here that come into play. I think Dr. -- persons at Argonne -- I can mention about the factor of one to two conductivity in the plant. That's where it comes in.

JUDGE WARDWELL: And did Argonne show that the measurement of dissolved oxygen always underestimated the potential that might --

DR. HOPENFELD: No, I don't --

JUDGE WARDWELL: -- the potential impact associated with the electrochemical potential?

DR. HOPENFELD: No, I don't think they got into that detail, except that, you know, the whole --

JUDGE WARDWELL: So, in fact, the dissolved oxygen may over estimate the impact associated with this parameter.

DR. HOPENFELD: It could be. I don't know the exact kinetics. I mean, I don't think anybody knows what they are, but kinetics is going on in that when the crack propagates. These are theories, which is not exact science. The basic parameters and, therefore, the people at EPRI said -- a lot of people believe, and they're really talking from the perspective of the scientist or the perspective of the people who do tests in the laboratory, who can do that. They're not talking in terms of scientists at the plant. I never meant to.

JUDGE WARDWELL: In Entergy --

DR. HOPENFELD: All I was just trying to tell you is there's an uncertainty, and I don't want to tell you the uncertainty comes from nowhere. I'm just trying to say where it comes from, and that uncertainty very well might --

JUDGE WARDWELL: And it could be on either side of the estimation of its impact.

DR. HOPENFELD: Yes.

JUDGE WARDWELL: Entergy's statement of position, Answer 33 on page 16 said it considered oxygen values and water chemistry excursions in its CUF analysis. Doesn't that resolve this issue?

DR. HOPENFELD: Absolutely not.

JUDGE WARDWELL: Why not? It's also using not only oxygen but also water chemistry.

DR. HOPENFELD: Could I refer you, sir to NUREG 6583 and NUREG 6909?

JUDGE WARDWELL: And what's the --

DR. HOPENFELD: Well, in Entergy's documentation it's just called NUREG 69 -- 6583.

JUDGE WARDWELL: What's the exhibit? We need the exhibit number to find it.

JUDGE KARLIN: The exhibit number for NUREG 6909 is, among others, Entergy 2-30. That's 6909, and the other one you referred is NUREG 6583, is Entergy Exhibit E-206, as I have it.

DR. HOPENFELD: This is extremely important, and I would like to read it because this is --

JUDGE WARDWELL: Where are you at?

DR. HOPENFELD: I'm sorry?

JUDGE KARLIN: What page of which exhibit?

DR. HOPENFELD: NUREG 6583.

JUDGE WARDWELL: Wait, wait. Got to find it. You have to bear with us. Sixty-five, eighty-three?

DR. HOPENFELD: At 78.

JUDGE WARDWELL: At 78.

JUDGE REED: Page 78?

DR. HOPENFELD: Correct.

JUDGE WARDWELL: And did you say 6583?

DR. HOPENFELD: Sixty-five, eighty-three. I have this Exhibit 204. I need 204.

JUDGE KARLIN: Here it is. Okay. Sixty-five, eighty-three. On what page, sir?

DR. HOPENFELD: On page 78.

JUDGE KARLIN: Seventy-eight.

DR. HOPENFELD: Can I read it?

JUDGE WARDWELL: Yeah. Is everyone set?

DR. HOPENFELD: The value of the temperature --

JUDGE WARDWELL: Now, where are you reading? I'm sorry.

DR. HOPENFELD: End is -- oh, can I read?

JUDGE KARLIN: What part of the page? The first paragraph, second --

DR. HOPENFELD: I don't have paragraph.

JUDGE KARLIN: All right.

DR. HOPENFELD: I didn't -- I don't have the thing.

JUDGE KARLIN: It's a long page.

DR. HOPENFELD: Yeah. Let me read it to you. It's only one sentence.

JUDGE KARLIN: Please read it, yeah.

DR. HOPENFELD: The value of the temperature and dissolved oxygen may be conservatively taken as the maximum value for the -- the same wording were given to us this week by Entergy when they passed out, and I don't know if you have it in evidence, when they passed out in slides that they wanted to talk about it.

This is the instruction. These are the specifications in NUREG 6583 as to how to use that equation. What you heard from Mr. Stevens before, he was talking about steady state operation. These equations when you look at the equation itself, in the exponent you have temperatures, oxygen, sulfur. You have strain weight. These are to be determined during the transient at the surface during that time.

These are not the parameters for oxygen in your sample somewhere in the plant once a week. This is not the value, the intention you formulate in dividing these equations. That's not the purpose of Argonne to specify that you can use the steady state.

Now, let me go and take another document --

JUDGE WARDWELL: Wait a minute.

DR. HOPENFELD: -- what's extremely important.

JUDGE WARDWELL: I've got to slow you down.

DR. HOPENFELD: Sure.

JUDGE WARDWELL: This seems to me a different discussion than the electrical-chemical discussion. You are now saying if I am hearing you correctly that you're arguing that they're using dissolved oxygen values from a steady state operational condition and not for the transients, and that's what you're objecting to; is that correct?

DR. HOPENFELD: That's correct, but I was trying to answer your question. Why is oxygen important? The oxygen concentration, that's what the question is about. That was my response.

JUDGE WARDWELL: I'm sorry. I did not mean to ask that question.

DR. HOPENFELD: Well, that's what I was responding, sir. I wasn't responding in the context of electrochemical potential. There is more than a tutorial kind of thing. Look. This is the --

JUDGE WARDWELL: Just to make sure we're not wasting time --

DR. HOPENFELD: Right.

JUDGE WARDWELL: -- I'm sorry if I interrupt you, but if hear that I haven't made myself clear, I don't want to waste everyone's time --

DR. HOPENFELD: Absolutely.

JUDGE WARDWELL: -- nor your efforts associated with this.

I think the last question and what I intended to try to resolve was whether or not Entergy's fact that they or testimony I should say that they consider oxygen values and water chemistry excursions in a CUF analyses does not resolve this issue of best representing anything associated with these parameters and their impacts on this phenomenon we're trying to address.

And what is your response to that?

DR. HOPENFELD: My response is that's incorrect, and that's what I started reading this. Because you see, they're talking about excursion. If

I understand correctly, they probably talk about excursion through the crane, okay, or after heat-up some time because maybe the system was opened up.

But what the excursion --

JUDGE WARDWELL: I'll ask them what they meant.

DR. HOPENFELD: Right. If you tell me what they mean by "excursion" --

JUDGE WARDWELL: So Mr. Fitzpatrick and Mr. Stevens --

DR. HOPENFELD: -- I've got to make sure and I tell you what I understand.

JUDGE WARDWELL: Right. So what did you mean by "excursions"? The oxygen values in law of chemistry excursions in your analysis.

MR. FITZPATRICK: Could you point to where you're speaking?

JUDGE WARDWELL: I was looking at your statement of position, Answer 33 on page 16.

MR. FITZPATRICK: Thirty-three.

JUDGE WARDWELL: I haven't typed it.

MR. LEWIS: Point of clarification. Are you referring to the testimony, the post -- statement of position? Because if it's A-33, it's our testimony.

JUDGE WARDWELL: It could be the testimony.

JUDGE KARLIN: Yeah, it's Answer 33 on page 16. Is that where we are?

(Pause in proceedings.)

MR. FITZPATRICK: Is that Question 56 on page 33?

JUDGE WARDWELL: I have Answer 57 on page 33, and I think it's also on 56, page 32. I was trying to look at the other one also. And both of those answers, 56 and 57.

JUDGE KARLIN: And now we're referring to what was formerly Entergy Exhibit 2.82.01 on pages 32 and 33, which is now no longer an exhibit.

JUDGE WARDWELL: But as I interpret what you were saying there, the oxygen values in the water chemistry excursions were included in your CUF analysis. Is that correct or is it not?

MR. FITZPATRICK: Yes. We get the single value for oxygen, all the transients. That value represented 13 years of measurement data including start-ups and shutdowns, and that was an average plus one standard deviation.

JUDGE WARDWELL: Okay. So you took the average of a transient DO levels -- say that again.

MR. FITZPATRICK: The oxygen measurements I used to take at least twice a day. It's either daily or twice a day. I always took it more during this time when I tried to get this system down. That data, we took a statistical average of it, and we added the standard deviation. So the expressions in the planning office are based on 50 ppp feedwater oxygen, will typically run 36 to 40, in there.

JUDGE WARDWELL: How much does it vary during the transience?

MR. FITZPATRICK: During the transient, I don't think it varies that at all during a transient. During a transient, that would be an injection.

Were the vessels hot? Once the hydrochloric chemistry and the oxygen injection system is stable, that doesn't change unless the system goes off line. But there is no direct correlation between the transient -- the oxygen injection, the hydrogen injection system, and a transient.

JUDGE WARDWELL: Dr. Hopenfeld, do you agree with that?

DR. HOPENFELD: No, absolutely not. If you look, please, at JH-65.

JUDGE KARLIN: Give us a moment to find it. That's okay.

DR. HOPENFELD: I think the pages are there. Do you see there --

JUDGE WARDWELL: What are you referring to?

DR. HOPENFELD: JH-65.

JUDGE WARDWELL: I know, but where in that?

DR. HOPENFELD: It's on the -- there are two pages in there. One pages shows you the date on -- the second page showing the oxygen.

JUDGE WARDWELL: So Figure 1?

DR. HOPENFELD: Yeah, it's only one.

JUDGE WARDWELL: Page 53.

DR. HOPENFELD: Right. Two, fifty-three, is that what it is?

JUDGE WARDWELL: I'm looking at the exhibit. You tell me what you're looking at.

DR. HOPENFELD: Yeah. Well, I thought I did. It's 10ECJ865. There are only two pages in that exhibit. I'm talking about the graph, the graph that gives you oxygen concentration in ppm versus temperature in degrees C. Only two pages, unless you're looking at a different --

JUDGE WARDWELL: I have three pages.

DR. HOPENFELD: Okay.

JUDGE WARDWELL: But you're referring to Figure 1 --

DR. HOPENFELD: Correct, correct, right. Correct. It's only one figure.

You can see in that oxygen concentration either hydrogen chemistry or normal state chemistry goes up by an order of magnitude during that trend, up and down. Another word I'd like to say is counting on that gases have a negative solubility coefficient. So as the temperature goes down, the oxygen concentration goes up an order of magnitude.

Furthermore, if you will now permit me to finish my line of thought, if you're going out to NUREG 6909, and again, this is a very important -- it's important you understand it, and this kind of misunderstanding about what we're talking about was excursion because you can have excursion and do steady state, too.

JUDGE KARLIN: What page? Sixty-nine, oh, nine?

DR. HOPENFELD: A-5.

JUDGE KARLIN: A?

DR. HOPENFELD: A-5.

JUDGE KARLIN: A-5.

DR. HOPENFELD: NUREG 6909.

JUDGE KARLIN: A-5. This is the Appendix 5.

DR. HOPENFELD: A-5, right. Sir, you asked what is the difference between these two NUREGs, and you didn't get the answer.

JUDGE KARLIN: Okay. It's NUREG 6909, page A-5.

DR. HOPENFELD: Can I read it?

JUDGE KARLIN: Yes, sir.

DR. HOPENFELD: The dissolved oxygen value is obtained from each transient constituting the stress cycle. For carbon and low alloy steel the dissolved oxygen content, DO, associated with stress cycle is the highest, highest oxygen content level in the transient. And for us ferritic steel is the lowest.

A value of .4 ppm. It's ..4 ppm. It's 400 parts per billion is recommended. This is the instruction with the package. What was passed to us the other day was the same wording that said you should value the oxygen at the highest concentration, the highest concentration due to the transient, both in NUREG 6583, but they didn't say that their recommendation, that specification is 400 parts per million.

Now, if you take this together with what you see, the EPRI data, then your next step is to make the calculation, and I would like to make the same calculation to show you the result of my calculation, about the same time that Mr. Stevens did, and I'd like to read you those numbers so we can compare what those Fen values are for only that one uncertainty, which is the oxygen content.

Can I do that?

JUDGE KARLIN: Well, didn't you put that in your testimony?

DR. HOPENFELD: No, I did not. I just calculated it about the same time he did.

JUDGE KARLIN: Well --

DR. HOPENFELD: I did put some of the testimony -- I gave you the order of magnitude, yes.

In the table, I think it was Item 10, I said use --

JUDGE WARDWELL: Item 10 of what?

DR. HOPENFELD: The table, the table that I provided.

JUDGE KARLIN: Ah, your table in your rebuttal testimony?

DR. HOPENFELD: Yes. I'll give you the number of the table.

JUDGE KARLIN: Table 13 --

DR. HOPENFELD: Just a second and I'll give you the table number.

JUDGE WARDWELL: Table 1.

DR. HOPENFELD: JH-63, there's a table there.

JUDGE WARDWELL: Page 4?

DR. HOPENFELD: Yes, I believe it is page 4, yes. On Item 10 there, I told you the oxygen count, and if you put a factor of five in there it increases the Fen by -- I don't know -- a factor of 50 or something, a factor of 55.

Do you see down there?

JUDGE WARDWELL: And that's with a factor --

DR. HOPENFELD: Right.

JUDGE WARDWELL: That's with a factor of four in the oxygen.

DR. HOPENFELD: Correct, correct. Because you see, it's an exponential which is being amplified by the -- you take the exponential and you see how sensitive it is to the oxygen. You know, if you take DF, DO to give you the sensitivity, the derivative will give you sensitivity, the parameter.

You see how -- what it is, it makes a big difference because now you have it back here, and that's why I gave you an order of magnitude. I told you what the problem is, and all I'm trying to tell you, I went through the same thing and I tried it by pencil over the weekend, and I'd like to give you those numbers.

JUDGE KARLIN: Sure, all right.

DR. HOPENFELD: Okay.

JUDGE KARLIN: Tell us what they are.

DR. HOPENFELD: You'll have something to compare one to one. It's number one; it's component number one, between .6, .8. This is the CUFen, that only due to the interest of the oxygen. There are other parameters. I'm just talking about 01, which hopefully we'll get to others.

JUDGE WARDWELL: We understand.

DR. HOPENFELD: But 01, the oxygen, okay?

One, I can repeat the number, .6 to .8.

Two, 4.5 to 6.

Three, 6.7 to 8.9.

Four, which is stainless steel, they're doing the right thing. They used the lowest oxygen. That's NUREG 6909, but you cannot use -- you see, the accident is because the mechanism of crack propagation. The theory is that the oxygen operates differently through the --

JUDGE KARLIN: Keep giving us the values. What are the values?

DR. HOPENFELD: Yeah. I was just going to tell you I didn't calculate it.

JUDGE KARLIN: Oh.

DR. HOPENFELD: I didn't calculate it because their numbers I agree with it.

JUDGE KARLIN: Oh, okay.

DR. HOPENFELD: I agree with it with respect to that aspect alone, not others.

JUDGE KARLIN: Okay, fine.

DR. HOPENFELD: But I keep qualifying myself. Just remember I'm talking about the effect of oxygen only. They did it correctly.

Five, I couldn't find some data. So I just skipped that one. I couldn't find it over the weekend, but it's more than one definitely, but I just couldn't do it exactly.

Seven is one and 1.2.

Eight is 1.2 to 1.6.

Nine is 7.2 to 10.3.

And ten is 2.5 to 3.5.

JUDGE WARDWELL: To clarify --

DR. HOPENFELD: Yes.

JUDGE WARDWELL: -- what was the value of oxygen that they used or what was the value that you used?

DR. HOPENFELD: Okay. That's what -- the reason that you had two numbers here --

JUDGE WARDWELL: What was the value that they used and what was the value that you used?

DR. HOPENFELD: They -- okay. Very good. Let me just tell you what I got. I took their equation, the numbers that they used. They used between, depending on the component, between 50 to 100 on the average.

JUDGE WARDWELL: Parts per million.

DR. HOPENFELD: I couldn't go to that exact because --

JUDGE WARDWELL: Parts per million.

DR. HOPENFELD: -- they average. They had 96 on one side, your normal operation. The hydrogen is 150. I just didn't want to do --

JUDGE WARDWELL: Is that ppb or ppm?

DR. HOPENFELD: I did it over the weekend -- I'm sorry?

JUDGE WARDWELL: Was that ppm or ppb?

DR. HOPENFELD: Ppb.

JUDGE WARDWELL: Okay. B.

DR. HOPENFELD: So I just took their numbers, plugged the thing back into the equation, pulled out the appropriate factor, and plugged my number. Now, you have to realize the equation is written in such a way that if you go about 500 parts per billion, it doesn't make any difference because that's constant. It's a number. It's a log of 12.5. If you look at the -- you see it doesn't make any difference. So once you get out of the 12.5, it doesn't matter.

JUDGE WARDWELL: So for carbon steel and low alloy steel --

DR. HOPENFELD: Correct.

JUDGE WARDWELL: -- the higher the concentration of dissolved oxygen, the higher the Fen value.

DR. HOPENFELD: Absolutely. Now, let me tell you one more thing if I may. I gave you three reasons why that's so. I'd like to give you another one, and the only reason I'm doing it, well, I'm probably getting excited here, but the problem is when I do this conservative and everything is conservative, and we get to this mind --

JUDGE WARDWELL: We understand that. Curb your enthusiasm and let's go --

DR. HOPENFELD: But what -- but let--

JUDGE WARDWELL: Is that all you wanted to say?

DR. HOPENFELD: No, no, no, no. What I want to say, you certainly can check on what I'm saying, what I'm telling you here. And the incentive check, you take a look at EPRI. Okay? Take a look at what EPRI does about that. They realize; they realize that this whole concept of Fen is work in progress. They say these work. It's a work in progress. I can quote you the number where they say that.

Now, many uncertainty, many loose ends. The bottom line is you define the people who are the analysts. You make sure they understand what's behind that. That's what it is. The whole thing is not ready for the market yet. That doesn't mean you go home and don't do anything. What you do is in the back of your mind you say, "Well, I'm going to do this. I'm going to use a conservative number. I'm going to use the upper bound, but I want to make sure I run it, I check it by somebody that these are real numbers, not just because I decided it's a conservative number."

JUDGE WARDWELL: We are --

DR. HOPENFELD: Let me just give you the

figure that I was going to provide you because that figure is NEC JH-84.

JUDGE KARLIN: It must be in the rebuttal.

DR. HOPENFELD: Yeah, it is in the rebuttal, right, and you see that --

JUDGE KARLIN: Oh, no, we don't see anything yet.

DR. HOPENFELD: Oh, okay. I have to go and get it myself. I could say the time table is the result if you want to, but --

JUDGE KARLIN: Hold on a second.

MS. TYLER: Tell me the title of the document. He doesn't have an Exhibit 84. What's the title of the document?

DR. HOPENFELD: Yeah, it's NEC JH-64.

MS. TYLER: Sixty-four.

JUDGE KARLIN: Yeah.

DR. HOPENFELD: Sixty-four, and it's page 418. Oh, did I say --

JUDGE KARLIN: You said 84.

DR. HOPENFELD: I'm sorry. I'm sorry. It's 64. I apologize.

JUDGE WARDWELL: Well, I'm glad I have never made a mistake either.

(Laughter.)

JUDGE WARDWELL: I'm with you. I know how this is when you know where you are. Okay. What page are you on?

DR. HOPENFELD: Page 418. See at the bottom carbon steel, Fen?

JUDGE WARDWELL: Yes. Is everyone with you? Yeah.

DR. HOPENFELD: Are we on the same page now?

JUDGE WARDWELL: Yeah.

DR. HOPENFELD: Okay. You see that my numbers, according to the numbers, I didn't give you the Fens, but roughly they're on the order of magnitude -- I can give them to you, but they are between 80 to 100. That's the final CUFens.

If you look here you see what EPRI has is they have F 550. I think that's about the temperature we're talking about. Do you see the upper bound is 80? And this is not my calculation. It's sort of an independent checking. So you see my number is consistent with EPRI. EPRI numbers show that the numbers in this area are something on the order of 80.

Now, the slides that were given to us by Entergy were titled maximum Fen. I think they should revise this and call it minimum.

MR. STEVENS: May I clarify?

JUDGE WARDWELL: In a second. I just want to ask a couple more fixing points and then I'll get back to you. I'll get back to Entergy to respond.

So in conclusion, it's your position that, in fact, they are not conservative in regards to the value they selected for dissolved oxygen for carbon steel and low alloy steel.

DR. HOPENFELD: (Unintelligible.)

JUDGE WARDWELL: It's your position that their analysis for stainless steel in regard to dissolved oxygen alone is adequate.

DR. HOPENFELD: Yes.

JUDGE WARDWELL: Thank you.

What is your response to everything he has just said, Mr. Stevens.

MR. STEVENS: Where do I start? Let's start with the NEC JH-64 document, otherwise known as MRP-47, Rev. 1. I think I can comment on that because I was the primary author of that document.

JUDGE WARDWELL: So this is the EPRI document.

MR. STEVENS: This is the EPRI document. Let's start with the figure on page 418. What that figure is showing is Fen is a function of temperature under various oxygen and strain rate loads. The top curve, the range of these are trying to show to individuals, given the range of the parameters defined by these equations, how Fen can vary.

There's several variables. So you have to take several graphs to show people the variance on any of these variables. This one here is trying to show as a function of temperature when you apply the different oxygen levels how the Fen would apply. It doesn't indicate in any way that those indications are valid for Vermont Yankee or any other plant. It's just merely demonstrating to you the variation in Fen as a function of temperature under those variations.

The top curve, I think I even said this yesterday in response to one of Dr. Reed's questions. The Fen can be as high as 140 as indicated by that figure, but that's under oxygen levels greater than 500 ppb and very low strain rate.

Those conditions don't exist at Vermont Yankee, and whereas I would agree that that would be a very conservative assessment, it's also very unrealistic.

JUDGE WARDWELL: But have you not characterized all of your analyses as being very conservative and very bounding? Is it fair to say then that, in fact, your dissolved oxygen -- your selection of dissolved oxygen in your analysis is more realistic than it is bounding?

MR. STEVENS: I would characterize it, sir, as being bounding for the conditions we have as info, which are for the Vermont Yankee plant. They were labeled as maximum Fens as applied to Vermont Yankee, not as applied to the maximum you could possibly achieve through these relationships.

JUDGE WARDWELL: How would -- and if I'm wrong in remembering this -- if I understand it correctly, you selected a value that is an average plus one standard deviation, and that average included all operational conditions with the transients included in it, but wouldn't that value, in fact, be very biased towards normal operational conditions?

MR. FITZPATRICK: Yes.

JUDGE WARDWELL: Is that an appropriate conservative value or would the transients dominate the potential failures that we're trying to evaluate in this contention?

MR. FITZPATRICK: In relation to the oxygen levels in the transients, your higher oxygen during start-up, which is a very slow, and sometimes a cycle which is a gradual cool heat-up with a gradual cool down. The contribution to the CUF from the start-up is very small compared to the contribution from an injection from HIPSI or the feedwater.

JUDGE KARLIN: Could you speak up, Mr. Fitzpatrick?

MR. FITZPATRICK: The contribution to the CUF from a start-up or a shutdown transient when the oxygen data shows that status for the system, you're going to higher oxygen when you're starting up the plant as the systems come on line. That fatigue contribution from that start-up is a very small contribution to the total CUF.

The primarily contributors are when the plant is running and something happens, when you get the injection of the plants, when you're getting a steady state. Also there's no direct correlation of a higher oxygen content from any measurement we've seen over there. The oxygen went up for this transient. It just the transients occur very quickly. There's nothing to change the oxygen.

JUDGE WARDWELL: But wouldn't it be more appropriate to use just the oxygen levels that were observed at the 20-some transients, or whatever it was, that we were talking about yesterday -- I forgot

-- that we're --

MR. FITZPATRICK: Those are design transients.

JUDGE WARDWELL: -- analyzing as the cumulative effects on this bending of the paper clip?

MR. FITZPATRICK: Those are the design transients. There is no measured -- the measured data that we've taken over time, we will shut the plant down, show that there is no real change. Say that on plant trips -- I have to look it up. For an example, if a plant trips, the O2 data is carried, still measured the same frequency, and you don't see any change until later on. You don't see any change to the transient.

MR. STEVENS: May I clarify? The oxygen measurements that Mr. Fitzpatrick is referring to are indicative of what they would be during transients that cause dominant fatigue.

The other response I was going to make with Exhibit NEC JH-65, which was this paper from --

JUDGE WARDWELL: Before you go to that -- I'm sorry to interrupt, but I just want to make sure I understood what you just said. Would you repeat that? I don't know what you're referring to -- the comment.

MR. STEVENS: Mr. Fitzpatrick said that the oxygen levels are monitored once or twice daily on a continuous basis.

JUDGE WARDWELL: Right.

MR. STEVENS: And those oxygen levels -- because of the water chemistry control and all of that during plant operation are indicative of what they would be if a transient occurred during that period, in between reads if you will --

JUDGE WARDWELL: Can I stop you right there with a promise I'll get back to you?

MR. STEVENS: Yes.

JUDGE WARDWELL: Dr. Hopenfeld, what indication do you have, or evidence do you have, that the oxygen levels could be as high as what you use in your analysis at Vermont Yankee?

DR. HOPENFELD: Well, for one thing, it's plain physics. If I didn't know anything else, I would tell you that the temperature goes -- as the temperature goes down, the oxygen concentration goes up, you saw the --

JUDGE WARDWELL: Sorry. Say that again. It's hard to --

DR. HOPENFELD: As the temperature -- the solubility of gases is inversely proportional to the temperature, which is by Henry's Law, whatever. When the temperature goes down, the oxygen concentration goes up. The equation that you have to resolve here, or solve, are -- those require you to find out what the oxygen concentration is during the transient at the surface, not somewhere else.

And EPRI makes the point very, very clear in their writeup. I can't -- I don't know if I can find the page. Maybe someone can find it for me. They say that oxygen is unknown in the transient. It's completely opposite, so Mr. Stevens said. He says he knows it.

I'd say I don't understand the issue. I think maybe they weren't that careful or maybe they didn't understand it to that degree, or for whatever reason, when they wrote 6583 they told you to calculate the oxygen at its maximum boundary to the transient. In 6909 they specified 400, not only the shutdown -- not only during the startup/shutdown, but let me answer about the shutdown, and let me --

JUDGE KARLIN: Dr. Hopenfeld, may I just interrupt? This is strange, if we go -- you're citing at the EPRI document, NEC Exhibit JH-64, right?

DR. HOPENFELD: Yes.

JUDGE KARLIN: And it's EPRI materials

reliability guidelines for addressing fatigue environmental effects in a license renewal application, MRP-47. This is the -- EPRI's guidance on this issue. And if we go to page iii of the matter, it says that the author of that document is Gary Stevens, who is sitting right there next to you. And so I'm very -- I have a difficult time with Dr. -- when Mr. Stevens tells me that -- what they say, and you're saying that it's directly opposite. I mean, he wrote the report.

DR. HOPENFELD: What I'm saying is the numbers that I have calculated, according to their equation, their values --

JUDGE KARLIN: Yes.

DR. HOPENFELD: -- substituting their oxygen content, which was 50 to 100 -- whatever it was -- with my numbers, which are -- which were prescribed by NUREG-6909, which says all transients use 400 parts per billion. That's what they recommend to use with those equations during transient.

JUDGE KARLIN: And let me ask, in this case as I understand it, the dissolved oxygen value that was used was 50 parts per billion, is that right?

DR. HOPENFELD: 50 to 100, depending on the component.

JUDGE KARLIN: Okay. Let me ask Mr. Fitzpatrick on that. What dissolved oxygen value was used in calculating these Fens?

MR. FITZPATRICK: So let me ask --

JUDGE KARLIN: I read somewhere that it was 50 parts per billion based on this 13 years and all that other stuff.

MR. FITZPATRICK: That's the feedwater line on the feedwater safe end, dissolved oxygen concentration.

JUDGE KARLIN: Okay.

MR. FITZPATRICK: Inside the reactor, the oxygen concentration varies due to radioelectrolysis with chemistry going on inside the core. Most of the -- when the water goes through the core, it creates steam. A lot of the oxygen goes out.

Throughout the circuit, EPRI has a program that determines oxygen levels around the circuit. So each section of the lesson there are values for dissolved action.

JUDGE KARLIN: So do you agree with what Dr. Hopenfeld just said, that you -- that Entergy used values from 50 to 100 parts per billion ---

MR. FITZPATRICK: Even higher than that.

JUDGE KARLIN: -- oxygen.

MR. FITZPATRICK: Even higher than that.

DR. HOPENFELD: On the average.

JUDGE KARLIN: Okay. On the average.

DR. HOPENFELD: We really --

JUDGE KARLIN: Well, what size did you use? I mean --

MR. FITZPATRICK: Exactly?

JUDGE KARLIN: Well, if you can --

JUDGE WARDWELL: If you've got them handy, yes.

JUDGE KARLIN: Yes.

MR. FITZPATRICK: It's E-212.

JUDGE KARLIN: E?

MR. FITZPATRICK: E-212. Table 1.

JUDGE KARLIN: E-212. What was the page?

MR. FITZPATRICK: Page 14.

JUDGE KARLIN: E-212 is? Could you identify that?

MR. FITZPATRICK: It's the EPRI calculation for VY 16Q-303.

JUDGE KARLIN: Okay. Dated?

MR. FITZPATRICK: It's dated 7/5/07.

JUDGE KARLIN: Okay. We're with you. And what page?

MR. FITZPATRICK: Page 14.

JUDGE KARLIN: Page 14. All right. And what is that we're looking at?

MR. FITZPATRICK: All right. Those are inputs --

JUDGE KARLIN: Are those your dissolved oxygen levels that you used?

MR. FITZPATRICK: Dissolved oxygen levels from each of the components evaluated in the analysis.

JUDGE WARDWELL: How do you reconcile that with the recommendation in 6909 that we should be using 400 parts per billion?

MR. FITZPATRICK: He misquoted the last sentence in the appendix on 6909, on page A-5.

JUDGE KARLIN: All right. Hold on.

MR. FITZPATRICK: It's the bottom sentence.

JUDGE KARLIN: We're at Exhibit --

MR. FITZPATRICK: 6909, Exhibit --

JUDGE KARLIN: A-230 at page A-5, is that right?

MR. FITZPATRICK: That's correct.

JUDGE KARLIN: Okay. The last sentence on that page?

MR. FITZPATRICK: The sentence says, "A value of .4 ppm for carbon and low-alloy steels and

0.05 ppm for austenitic steels can be used to perform a conservative evaluation."

JUDGE KARLIN: Okay.

MR. FITZPATRICK: It's not prescriptive.

JUDGE KARLIN: Not prescriptive, all right.

MR. FITZPATRICK: It says "can."

JUDGE KARLIN: And since you wrote it, Mr. Stevens, what did you mean by "can"? No, I'm sorry, you didn't write this one. This is 6909. I'll withdraw the question.

Is there any place -- well, that seems to be -- is there any other indication in 6909 that some other value can be used? I mean, are they just sort of throwing that out there?

MR. FAIR: If I could help?

JUDGE KARLIN: Yes, Mr. Fair.

MR. FAIR: This was put in there in case somebody that's using this procedure does not have dissolved oxygen to input.

JUDGE KARLIN: Doesn't have the actual values.

MR. FAIR: That's right.

JUDGE WARDWELL: That it would be permissible to use this --

MR. FAIR: For a --

JUDGE WARDWELL: -- and still meet the reg guide, if that's what -- I mean --

MR. FAIR: That's correct.

JUDGE WARDWELL: -- the NUREG, if that was of interest --

MR. FAIR: I --

JUDGE KARLIN: Dr. Hopenfeld, would you agree with that?

DR. HOPENFELD: I would. I would agree with that, to the extent they had a -- they had a instrument sitting at the surface of each of those components measuring the oxygen. During their training they don't have anything like that.

JUDGE KARLIN: All right. So let me stop you there. So --

DR. HOPENFELD: And that is what is recognized. I think this -- what Mr. Fair said, he reads what Argonne could have thought about it, and then the definition is, you know, what chem is? I don't know what --

JUDGE REED: Do you believe that the oxygen concentration at the surface of these components is larger than the bulk oxygen?

DR. HOPENFELD: Simply use applied

physics. There is about --

JUDGE REED: Applied physics.

DR. HOPENFELD: It increases by an order of magnitude going from 50 to 100.

JUDGE REED: But is that -- first of all, I don't understand the physics, and I'm not sure we should take the time to delve into it. But is that the assumption in which these curves were generated?

MR. FAIR: Yes, it was the --

JUDGE REED: Was it the local right next to the --

DR. HOPENFELD: Yes.

JUDGE REED: How did you measure that, then? I don't believe that.

DR. HOPENFELD: The assumption, that those things were generated in a laboratory, temperature uniform, oxygen uniform, measured -- everything was measured accurately. Then, I am taking this and trying to apply it to --

JUDGE REED: If the curves are correlated against the bulk oxygen content, that's what you have to use, not the content adjacent to the surface of the metal, because that's not how the curve is run.

DR. HOPENFELD: They're the same. The two --

JUDGE REED: Pardon me?

DR. HOPENFELD: In a case of -- where the curves were used, they are the same.

JUDGE REED: They're the same in the lower -- they're the same in the lab, but not in the reactor.

DR. HOPENFELD: They were not writing the train. They were writing the steady-state.

JUDGE WARDWELL: Let me see if I can help clarify, at least for me. It may not for you, Mr. Reed, but -- Mr. Fitzpatrick, do you dispute the fact that solubility changes dramatically with temperature?

MR. FITZPATRICK: No. That's physics.

JUDGE WARDWELL: During transients, how does the temperature vary in these components?

MR. FITZPATRICK: Measure each transient, which will go from operating down to 100 degrees Fahrenheit for a certain transient.

JUDGE WARDWELL: That's a pretty drastic temperature change, isn't it, for that component.

MR. FITZPATRICK: Yes.

JUDGE WARDWELL: Would you not expect the dissolved oxygen to increase by several factors, if not orders of magnitude?

MR. FITZPATRICK: It depends on the

timing. If the transient is very rapid, I don't think it could -- in order for the chemistry to happen, to occur, I --

JUDGE WARDWELL: What was --

MR. FITZPATRICK: I didn't get to that level of chemistry, but the phenomenon is there.

JUDGE WARDWELL: Mr. Stevens, what was the basis for your selection of those values we were looking at in the previous exhibit? E-212 VY, page 14. We look at DO values, as you said, between 50 and 100.

MR. STEVENS: Those values were provided to us by Entergy, consistent with what Mr. Fitzpatrick had testified earlier.

JUDGE WARDWELL: And, Mr. Fitzpatrick, which of those -- what is the basis for those in regards to how you incorporated the change in dissolved oxygen associated with a change in temperature for each of those components and the resulting change in solubility of dissolved oxygen?

MR. FITZPATRICK: It wasn't evaluated to that specific level. The oxygen levels given were based on an EPRI model reactor with different operating conditions -- normal water chemistry and for hydrogen water chemistry at different power levels.

And there is representative steady-state at those power levels.

JUDGE WARDWELL: It's only during the transients that these cumulative use factors are evaluated, correct?

MR. FITZPATRICK: If you don't have a transient, you don't have any usage, yes.

JUDGE WARDWELL: And as I'm hearing now, that change in temperature of that component is very influential in determining the dissolved oxygen that's available at that transient.

MR. FITZPATRICK: Yes. And it -- that's one part of the Fen expression. If the transient occurs very fast, you have a strain rate component, which cancels out that content.

MR. STEVENS: May I add some clarification for you?

JUDGE KARLIN: Sure, go ahead, sir.

MR. STEVENS: I'm going to try and clarify where -- your oxygen questions. We have talked about a variety of inputs here. We have talked about an old EPRI paper from 1983. We have talked about temperature. I'm going to go back to NEC JH-64, which is the --

JUDGE WARDWELL: Is this back to the last time I promised I'd get back to you and I haven't gotten back to you?

MR. STEVENS: That's kind of where we are, yes.

JUDGE WARDWELL: I'm off the hook for that.

MR. STEVENS: This is the MRP guidance for license renewal that I authored. And we -- in the last 45 minutes or so, we have talked about ECP, we have talked about oxygen, we have talked about temperature. And this document identified that these are some issues. And as Mr. Fair testified, there have been some other observations and data taken on these.

But what this document basically says is what we have is the best -- the best method based on what we know today. And this identifies things like ECP and how some of the experts have said maybe that's a better parameter. It talks about time history, variation of things during transients, and then it makes a recommendation that's based on all of these best practices and knowledge of the industry on what to do.

That discussion, for example, on analysis issues on oxygen is contained on page 4-27 of that document. And at the bottom it makes a recommendation on what to do, and it points at a section in this document -- 425 -- and says, "This is what you should do." And what it says you should do for oxygen is exactly what we did for the Entergy evaluation.

And what this document says is, given all of these inputs and issues that have been identified, that is the best way to evaluate this particular issue. And what it would say is to take the measurements in the plants, the bulk levels, and it would say to take those and time-average them, and use those inputs into your analysis. And that's what we did.

And, in addition, we -- to the average we took a one sigma deviation on those to make sure we bounded some of these variations that occurred over the time in the plant. So we are following the guidance and the methodology that has been defined to us based on all of the information we have at this point.

On the 1983 EPRI paper that shows very high oxygen content, the Figure 1 of NEC JH-65, we don't know where these measurements were taken. We don't know what plant they were taken. We have no reason to know whether they're applicable at all to

Vermont Yankee.

What we might be able to infer from some of the wording in here is that these are related to BWR startup events. It does say that in the text, although it does not say specifically that that's where this data was taken.

So there's a couple of observations we can make on that. First off, at least half of the data or more is below 150 degrees Centigrade, which is a threshold temperature below which environmental effects don't apply or Fen is one.

And, secondly, we know from our analysis, as well as 40 years of experience with doing these analyses, startup events contribute insignificantly to fatigue. So, and then, the fact that this paper is 25 years old aimed at stress corrosion cracking issues, you know, we have to be careful on how we apply that to environmental fatigue analyses today.

So my point would be how we evaluated oxygen and put it into the relationship is exactly consistent with all of the guidance out there by EPRI and the industry.

JUDGE WARDWELL: Well, I think we've got the picture on DO and ECP as best we can. Would you like to add anything else?

DR. HOPENFELD: I'd like to add a couple of things. For one, with regard to the word "can," I'm not --

JUDGE KARLIN: I'm sorry, I didn't hear that.

DR. HOPENFELD: That the mention of the word "can," I mean, Mr. Fitzpatrick said that you don't really have to do it because it says "you can use it." I don't think the intent behind that -- because they still don't measure the oxygen concentration during the transient at the surface. And the data was looked at under steady-state conditions.

Dr. Chang, when he went to the ACRS, he told them, because the question about oxygen came up, obviously. And he told them, "Yes, well, I'm not sure they're using bounding values for oxygen." But then he said -- well, Mr. Stevens said that the usage is very small.

Well, I went and looked for the transients going up and down for the startup and the 300 -- startup transients and the 300 shutdown transients. And I went to the table that I mentioned to you before -- I think it's NEC JH-21 -- and I looked at those transients, and I edited out under 300 -- for the --

I can give them to you -- and each transient was very -- the usage factor is very, very small. But there are 300 of them, so -- 600 of them, and they add up to 50 percent of the total.

Now, if this is so small, why -- why do you even include shutdown? Why do you -- it's going to cost more money to run more transients if it's nothing.

I was trying -- I was surprised Dr. Chang comes in, and ACRS probably made some decisions based on what -- his testimony. He comes in and he says they used -- there is no usage here at all. And they -- because he --

JUDGE KARLIN: Can I stop you there? Dr. Chang's testimony before the ACRS on what date? Was this February --

DR. HOPENFELD: I have to check. I don't have it in front of me. I can give you his testimony also in this proceeding. I can give you the page where that --

JUDGE KARLIN: Well, let me just ask counsel for NEC if they could find that, and at some later point give us that citation to that testimony you're referring to.

DR. HOPENFELD: On the ACRS. But that

particular ACRS paper I got from Entergy. It was attached to -- it was one of their exhibits.

JUDGE KARLIN: Which exhibit and what's the page?

DR. HOPENFELD: Yes.

JUDGE KARLIN: Ms. Tyler, if you could help us with that, either now or later.

DR. HOPENFELD: But in the same context, I would like to give you that -- the -- Dr. Chang's testimony on page 10 -- for page 12, NRC testimony.

JUDGE KARLIN: Page 12 of --

DR. HOPENFELD: It's page 12 of his testimony.

JUDGE KARLIN: Oh, okay. Hold on a second while we --

JUDGE KARLIN: And then, it was repeated in a different form to the ACRS.

MS. BATY: Let me point out for the record that this exhibit -- that this testimony has not been -- the Board has yet to rule on the admissibility of this testimony, and there is a pending motion to withdraw the testimony before the Board.

JUDGE KARLIN: All right. So noted. What page?

DR. HOPENFELD: Page 12, on the bottom of the page. This was my notes. I don't have -- it's NRC. I don't remember which number -- which exhibit.

JUDGE WARDWELL: It's Dr. Chang's testimony?

DR. HOPENFELD: Yes.

JUDGE WARDWELL: Okay. That's Staff 2.

DR. HOPENFELD: I don't have --

JUDGE WARDWELL: NEC --

DR. HOPENFELD: He said they did not use bounding numbers, with the exception of the -- of the heatup. He used the word "heatup."

JUDGE WARDWELL: You said you're referring to page 12?

DR. HOPENFELD: Yes, on the bottom there somewhere. That's what my note said, on page 12 on the bottom. Dr. Chang agreed this occurred through heatup of -- usage factor is negligible. He didn't quantify either one of them.

JUDGE WARDWELL: I'm looking at one sentence here that says the DO values used in the Fen calculations are the average DO values plus one standard deviation, which bounds almost all of the data points in normal plant operation.

DR. HOPENFELD: That's what he said, yes. And he also said that this would not -- he also used the word -- he said that the oxygen occurred during heatup.

JUDGE WARDWELL: Yes. The staff noted that --

DR. HOPENFELD: The usage factor is negligible.

JUDGE WARDWELL: And this is one -- the staff noted that excursions where oxygen content increases do occur during heatup. However, no significant thermal transients occur during this period, so that practically no fatigue usage factor is accrued during this period.

DR. HOPENFELD: He didn't quantify it. And I tried to quantify it. My usage factor doing those things comes to about 50 percent of the -- both heatup and cooldown. And he also didn't say -- he just made the statement -- I would like for him to testify, so we can find out.

JUDGE KARLIN: Can I ask a question here? we've spent an hour or something talking about dissolved oxygen and the electrochemical potential. And you have a chart, Dr. Hopenfeld, on page -- the 13 factors --

DR. HOPENFELD: Yes.

JUDGE KARLIN: -- on your rebuttal

testimony.

DR. HOPENFELD: Yes.

JUDGE KARLIN: Is dissolved oxygen one of your major concerns and problems here?

DR. HOPENFELD: It was one of them. It was not -- it was one of them. I basically --

JUDGE KARLIN: Okay. It was one of them.

DR. HOPENFELD: One of them. It is a major input, yes.

JUDGE KARLIN: It's one of the 13.

DR. HOPENFELD: Very important.

JUDGE KARLIN: But of the 13, what are your top three problems with regard -- top three.

DR. HOPENFELD: Top three?

JUDGE KARLIN: The biggest three problems.

DR. HOPENFELD: The one that bothers me the most has to do with -- again, you talk in terms -- you have to put yourself in the mind-set as you have these --

JUDGE KARLIN: Just what they are, just what -- you've got 13.

JUDGE WARDWELL: Just give us three of them.

DR. HOPENFELD: Oh, you mean an example? Okay.

JUDGE KARLIN: You've got 13 factors.

DR. HOPENFELD: I'm sorry. The factor about the cracks in the cladding.

JUDGE KARLIN: Cracks in the cladding.

JUDGE WARDWELL: That's number one?

DR. HOPENFELD: Yes, I would say this is number one. Surface roughness.

JUDGE KARLIN: Okay.

DR. HOPENFELD: And I already said the -- what was that one that I said?

JUDGE KARLIN: Oxygen.

DR. HOPENFELD: Yes, and --

JUDGE KARLIN: You think oxygen is in the top three?

DR. HOPENFELD: Yes. Oh, absolutely.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: It's number 2, surface finish?

DR. HOPENFELD: I would say number --

JUDGE WARDWELL: No, no. I mean, I'm just -- you said surface roughness. I'm saying that your number 2 --

DR. HOPENFELD: Yes.

JUDGE WARDWELL: -- of your table, surface finish is one of them.

DR. HOPENFELD: Yes.

JUDGE WARDWELL: Number 10, oxygen, is the other one of your top three.

DR. HOPENFELD: Right.

JUDGE WARDWELL: And then, number 13, existing surface cracks?

DR. HOPENFELD: Correct.

JUDGE WARDWELL: Is the other --

DR. HOPENFELD: Correct.

JUDGE WARDWELL: -- another one.

DR. HOPENFELD: Now, in terms of importance, I can't say this is higher than that. I'm just saying --

JUDGE WARDWELL: No, that's why --

DR. HOPENFELD: -- those are -- those three are very important. Not that -- there are nine more, and you have to evaluate each one of them. I don't have data -- a lot of them. Nobody does. But what you have to know, which I believe they do not, they believe because the -- it states conservative, conservative, conservative, he believes it. When you look to those -- all of these 13 factors.

JUDGE KARLIN: But, Dr. Hopenfeld, let me ask -- isn't it true that they calculate these CUFens for every nuclear powerplant that -- that's being used in the United States? It's a common thing -- the calculation of CUFens.

DR. HOPENFELD: Well, I don't know. The whole concept of this methodology, and I -- I was going to read to you, when Mr. Stevens said that he was involved in this -- writing this report. I'm sure that many people wrote this report, and I don't know what part he had --

JUDGE KARLIN: Well, but let me ask -- I just want to get back --

DR. HOPENFELD: No, no.

JUDGE KARLIN: -- is calculation of CUFens a normal thing that's done for all nuclear powerplants in the United States?

DR. HOPENFELD: I don't know.

JUDGE KARLIN: You don't know.

DR. HOPENFELD: I really cannot testify to that, because I don't know. And I was trying to get --

JUDGE KARLIN: Is it unique here? Have you ever seen it done before? Are they doing it at Indian Point?

DR. HOPENFELD: I'm sure they do, because as soon as they see the data, the NRC tells them to do that, they would do that. However --

JUDGE WARDWELL: Mr. Fair, is this -- as far as staff experience is concerned, is this a common calculation that is done at various -- at numerous plants?

DR. HOPENFELD: For reactors that have --

JUDGE WARDWELL: I'm asking Mr. Fair.

DR. HOPENFELD: It's only for those that -- if it's fair?

JUDGE WARDWELL: I'm asking Mr. Fair because --

DR. HOPENFELD: Oh, oh.

JUDGE WARDWELL: -- you didn't know. I was asking Mr. Fair whether or not it is a common --

MR. FAIR: It's common for all plants undergoing license renewal.

JUDGE WARDWELL: And it's -- how is it for the other plants that aren't going through license renewal?

MR. FAIR: The staff I know -- I'm afraid to use the terminology, but the staff did a study back in about 1995 to determine whether we should have existing operating plants evaluate their components for environmental effects.

But part of the evaluation involved a risk assessment. As a result of the risk assessment, the staff determined that they could just justify backfitting this to existing operating plants because of the low risk.

JUDGE KARLIN: Well, let me ask you about that, then.

MR. FAIR: Okay.

JUDGE KARLIN: The requirement to do a CUFen analysis is applied to all plants that are looking for a license renewal. Is that what you're saying?

MR. FAIR: That's correct.

JUDGE KARLIN: Okay. And in -- but it's not applied to existing plants that are not looking for a renewal.

MR. FAIR: That's correct.

JUDGE KARLIN: And the CUFen analysis that's imposed upon license renewal applicants is NUREG 5704 and 6583.

MR. FAIR: Correct.

JUDGE KARLIN: And the -- but a totally different CUFen analysis is imposed upon new reactors, which is 6909.

MR. FAIR: That's correct.

JUDGE KARLIN: So neither one of them is a backfit. Nothing is applied to existing plants at all, is that right?

MR. FAIR: Yes.

JUDGE KARLIN: Unless they are looking for renewal or a -- yes, unless they're looking for renewal.

MR. FAIR: That's correct.

JUDGE WARDWELL: And is it fair to say that the low risk came about under the assumption they were going to be closing down also within a short period of time, and knowing that the amount of cumulative use factors are not likely to be exceeded in the future. Is that where the low risk came in?

MR. FAIR: No. The low risk came in from an evaluation of the probability of initiating a fatigue crack if you have a CUF greater than one, coupled with the probability of then running that fatigue crack through the component to get leakage, and the probability of once you ran the crack through the component you would get a failure of the component.

That total risk was determined to be low. So the -- you know, there are several factors that went into the risk assessment. The probability of initiating a crack, the probability that the crack goes through the component, the probability that causes a component to fail, and the consequences if the component failed of what would happen to the plant.

JUDGE WARDWELL: How many metal fatigue failures have occurred nationwide at plants?

MR. FAIR: I don't believe that there is any failures that occurred. I think there has been several cases of leakage due to unanticipated thermal loading.

JUDGE WARDWELL: And are those -- were those leakages detected in readily accessible areas, or were some in areas that could have gone unnoticed for even longer periods of time, such that more drastic failures could have occurred, do you know?

MR. FAIR: That I can't answer.

JUDGE REED: So, Mr. Stevens, I believe I heard you some time ago state that the Fen values for situations with temperatures below 150 degrees C, the Fen values are one in that case. Did I hear that correctly?

MR. STEVENS: Yes, sir.

JUDGE REED: Okay. I also believe that it's NEC's position, or that NEC asserts, that they believe the decrease in light of up to a factor of two is possible in this temperature range. Do I have that correct, Dr. Hopenfeld?

DR. HOPENFELD: That is correct. And that's a direct quotation of Dr. -- the author of that Argonne report, the guy who developed these equations. That's the part between the ACRS -- to the ACRS, and he said -- I mean, the question came up, "What about the temperature?" And he said, "Well, you know, on the average about 150. Most of the data falls apart above that." But if you go below the 150, you could have -- it's not necessarily zero. But when you put the Fen in statistical correlation, it exponentially drops out at zero. That's one.

And they also said, if you look at the data, if you go back to the original raw data, all you see -- what you will see, you will see there is only one point -- one data point at the very low -- at the 50 to 40 -- 50 to 40 parts per billion. In other words, there's a lot of weighing to be put in there on that -- on that very -- one data point.

He said, "Well, even there it's not 100 percent sure when you go to the lower accident that you don't have some" -- so this is a statistical correlation. It's the best correlation you can come up with. I'm not questioning that. But you have to realize that this -- they say that this is -- the data that -- the answer comes to 2.9999, and that's correct.

JUDGE REED: I'm sorry. I'm not following you. Is it your point that statistically the statement that Dr. Stevens made is correct, that the Fen is one below 150, but there is some statistical fluctuation around that, and there is some possibility? I didn't really follow what you said.

DR. HOPENFELD: No. I'm saying that Dr. -- the person who developed these equations -- not me -- he said if you look at his equation it may be when we go to the indication -- below 150, whatever the requirement is -- I think it was 150 -- it's zero. But it really isn't. It's -- it could be as much as a factor of two.

JUDGE REED: I'm sorry. You said it is zero, and I didn't --

DR. HOPENFELD: Well, the exponential term drops out.

JUDGE KARLIN: Well, let me just stop you, Dr. Hopenfeld. Let's pull out the relevant NUREG, and you can point us to where --

DR. HOPENFELD: Okay.

JUDGE KARLIN: -- Mr. or Dr. Chopra, who wrote these NUREGs -- from Argonne wrote --

DR. HOPENFELD: Okay.

JUDGE KARLIN: Cite us to the page that he talks about this matter. I remember seeing something about that, and so --

DR. HOPENFELD: Yes, I think --

JUDGE KARLIN: I just can't find it.

DR. HOPENFELD: It's NUREG --

JUDGE KARLIN: Is it 6909? Is that what we're talking about?

MS. TYLER: If you go to page 26.

JUDGE KARLIN: 26?

MS. TYLER: Yes.

JUDGE KARLIN: Yes, okay. That's it. Yes. And is that also E-230? We're talking about NUREG-6909.

MS. TYLER: Yes, E-230.

DR. HOPENFELD: You can go to any one of those equations and see --

JUDGE KARLIN: On what page?

DR. HOPENFELD: Okay. Okay. That's -- I'm looking at the equations. Let me find the equations where the temperatures were in there. Actually, we probably -- we talked about -- that equation was brought into evidence this morning, the Fen equals T. I'm looking for it, but -- oh. Just a minute. I'll get it in a minute.

JUDGE KARLIN: Take your time. 6909 is a long document.

DR. HOPENFELD: Let me -- while I'm looking at it, let me talk about the equation was brought up -- oh, here I think it is. Yes.

JUDGE WARDWELL: How do you spell his name?

DR. HOPENFELD: The person who wrote this?

JUDGE KARLIN: Chopra, that's C-H-O-P-R-A.

DR. HOPENFELD: Just a minute. I have to spell it out.

JUDGE KARLIN: Okay. Chopra.

DR. HOPENFELD: I think it's Dr. Chopra. Yes, here it is. Chopra and W.J. Shack. I think that Mr. Shack -- Dr. Shack is a member of ACRS.

If you go to -- let me see what -- find the Fen equations here. Okay. If you go to -- on page 38, okay, you'll see there's an equation there, Fen is a fraction of -- is a function of .6 -- the first term says the constant drops out.

The next one -- you see there's a T star there, and that T star is really -- is a normalized T. It's T minus some reference value, which I think is 150 -- I don't remember that calculation. I believe it's 150. And so the whole term at the lower temperature drops out. It becomes -- what you have is constant, because you see the term on the right hand is zero. And what you wind up with is a constant.

JUDGE KARLIN: Well --

DR. HOPENFELD: If T star is zero, the rest is --

JUDGE KARLIN: But, Dr. Reed, could you restate your question? It was about 150 degrees and it --

JUDGE REED: Well, there seems to be a difference of opinion between the two parties as to whether temperatures below 150 degrees -- what the environmental factor is. There's an assertation by Entergy that at below 150 degrees the Fen value is one. Dr. Hopenfeld believes that it may be as large as two.

JUDGE KARLIN: And there's something on this page 38 that supports what you just said?

DR. HOPENFELD: On page 38, I'm explaining where it comes from. When you see the equation there, it says a constant, and then you have an exponential to -- times the --

JUDGE KARLIN: Which equation? 26, 27, or 28?

DR. HOPENFELD: Take any one. Take 28.

JUDGE KARLIN: All right.

DR. HOPENFELD: And you will see it's sulfur times temperature. Notice it is not the real temperature. It is a reduced temperature. It's a T minus T8 -- 28.

JUDGE KARLIN: Where does it say that 150 degrees is not one?

DR. HOPENFELD: Okay.

JUDGE KARLIN: This calculation says it?

DR. HOPENFELD: No, no. The -- where it says it isn't one was in the testimony of Dr. Chopra at the ACRS.

JUDGE KARLIN: Oh, okay.

DR. HOPENFELD: We do have that as an exhibit.

JUDGE KARLIN: All right.

DR. HOPENFELD: I just didn't know the number of that exhibit. It's an ACRS --

JUDGE WARDWELL: It also says it right there in the following paragraph below 28 -- one, two, three, four, five, six, seven -- seven lines down, that within the threshold of this is -- Fen is equal to one.

DR. HOPENFELD: Yes, correct.

JUDGE WARDWELL: Is that not correct? Where does it say the Fen should be two under other circumstances?

DR. HOPENFELD: No, it's not just for -- it was a factor of two higher than the equation would predict.

MR. STEVENS: May I clarify?

JUDGE KARLIN: Well, just -- in a moment, but I agree with what Dr. Wardwell just -- the threshold strain amplitude is also defined, below which lightwater reactor coolant environments have no effect on fatigue life, i.e. a Fen of one. And is that what you're saying, Mr. Stevens, is 150 degrees?

MR. STEVENS: Yes, but I -- I need to clarify, because in all the confusion I might have confused you further. I was -- I thought the discussion was referring to carbon and low-alloy steels. There is a similar effect, although not one, for austenitics. And I --

JUDGE KARLIN: Okay.

JUDGE WARDWELL: Austenitics?

MR. STEVENS: May I clarify now?

JUDGE KARLIN: Yes.

MR. STEVENS: I hesitate to do this, but I'll refer you to NEC JH-64 again. This is the EPRI

MRP report, page 4-18.

JUDGE KARLIN: You're citing yourself again, is this what we're doing?

(Laughter.)

MR. STEVENS: Yes, sir. There's two figures on this page that show Fen as a function of temperature.

JUDGE WARDWELL: I'm sorry. And the page again?

MR. STEVENS: 4-18. Two figures on this page, top one being for stainless steel, bottom one being for carbon steel. My earlier statement of Fen is one below 150 was referring to the carbon steel, and you can see by that graph that the Fen goes down to one at lower temperatures.

The upper graph for austenitics shows that the Fen for stainless steel at lower temperatures is approximately two. So I recognize the adjustment can be a factor of two at lower temperatures for austenitic material. Yes, that's true by these equations.

JUDGE KARLIN: So is that -- do you agree with that, Dr. Hopenfeld?

DR. HOPENFELD: Well, I thought -- if I am wrong, correct me. I was really -- I did check that, but I went by the testimony of Dr. Chopra before the ACRS, and I don't remember him saying -- making a distinction between stainless steel and carbon.

JUDGE KARLIN: So do you agree, disagree, or don't know?

DR. HOPENFELD: I don't know.

JUDGE KARLIN: You don't know. Okay. That's fair enough.

DR. HOPENFELD: If Mr. Chopra was here, I would find out, but I -- I would say given -- physically speaking, it doesn't cut off right there, because it's 150 degrees.

JUDGE KARLIN: Okay.

JUDGE REED: Mr. Stevens, in the cases where the components you're analyzing were stainless steel, did you use the correct value? If the temperatures fell down to 150 degrees, would you have used --

MR. STEVENS: Yes, sir.

JUDGE REED: But in the cases where it's -- like the feedwater nozzle where it's not stainless, you would have used an appropriate value.

MR. STEVENS: That's correct.

JUDGE REED: Which might be one.

MR. STEVENS: That's correct.

JUDGE REED: Okay. Dr. Mr. Fair --

MR. FAIR: Could I try to help clarify a little bit? I think there might be a little confusion on the calculation.

JUDGE KARLIN: All right. If you can make it relatively quick.

MR. FAIR: I will.

JUDGE KARLIN: We think we're --

MR. FAIR: If you have the NUREG/CR-6909, and go to the procedure A-1, page A-1 near the back of it --

JUDGE KARLIN: That's the Appendix 1. Okay. I'm with you.

MR. FAIR: And if you go to the equation A-2, which is one of the Fen inspections.

JUDGE KARLIN: Yes.

MR. FAIR: If you go down to the variables in A-5 with a T less than 150 degrees C, this T star is equal to zero. So while I think it -- that they're referring to the expression in A-2 that includes T star goes to zero at below 150 degrees, and you are left with an Fen as the exponential of that constant. So there is a value above one, but it's something close to two.

DR. HOPENFELD: That's correct.

JUDGE KARLIN: Okay.

DR. HOPENFELD: That's what I was talking about.

JUDGE KARLIN: That seemed to be helpful.

MS. TYLER: Judge Karlin, I have located the discussion in the transcript, if that would be helpful.

JUDGE KARLIN: Yes. Is that an exhibit?

MS. TYLER: It's Exhibit NEC JH-27, and the relevant discussion is on page 25.

JUDGE KARLIN: Great. Thank you. We'll take a look at that.

A couple more questions?

JUDGE WARDWELL: I just had a couple of followups to get back to --

JUDGE REED: I just need to understand what Mr. Fair is saying. Are you saying that we were wrong about the Fen being one below 150 degrees, that it's a constant below 150 degrees, but that constant is not necessarily one?

MR. FAIR: That's correct.

JUDGE REED: Okay.

JUDGE WARDWELL: Just a couple of followups that we've got. We blew by it, and I just -- they are just quick fixes again, and that deals with the hydrogenated water. Where in the plant -- I think, Mr. Fitzpatrick, you said that not all of the plant contains the hydrogenated water. Or it's only contained in certain parts of the plant.

MR. FITZPATRICK: The hydrogen is injected at the suction of the feed pumps. The feedwater stream in the reactors -- it's fed into the reactors.

JUDGE WARDWELL: And in that hydrogenated water, the oxygen levels are lower, is that correct?

MR. FITZPATRICK: It depends on where -- are you comparing the two values in the chart? The oxygen is measured in the same area. That's right. The oxygen values are measured in the same area, and the hydrogen is injected in a similar system -- same system in a different location, and in the reactor.

So the data is taken on the piping, we get the EWR BIA program, determine the oxygen level at different locations in the reactor, and we have that for hydrogen injection and prior to hydrogen injection.

JUDGE WARDWELL: One other point that you brought up that I'd like to just touch upon, and if it -- it will probably get lengthy, so we'll continue after lunch. I just want to know whether we -- if it's going to be lengthy or not. But we were discussing the relationship between solubility and oxygen and temperature. You implied that the effects of low temperature and the resulting increase in dissolved oxygen would be compensated for in a transient based on strain rate. At least that's how I interpreted what you were about to say.

MR. FITZPATRICK: In reality, yes.

JUDGE WARDWELL: That probably is going to be a longer discussion, is it not?

MR. FITZPATRICK: Yes. And --

JUDGE WARDWELL: Well, good. Let's just wait until after lunch, because it's on my list that I -- we'll do that, because Dr. Hopenfeld has that on his list and it will be one of those parameters we'll talk about after lunch.

DR. HOPENFELD: Just one comment before we go. I think Mr. --

JUDGE WARDWELL: Is this in response to one of my questions?

DR. HOPENFELD: Well, it's really related, because it -- no, it's not in response to --

JUDGE KARLIN: All right. We'll just have it after lunch.

We're going to take a break. We appreciate the witnesses responding patiently to our questions. It is now noon. Let us reconvene at 1:15.

We're now adjourned. Thank you.

(Whereupon, at 12:03 p.m., the proceedings in the foregoing matter recessed for lunch until 1:19 p.m.)

JUDGE KARLIN: We'll go back on the record at this point. I apologize that we're a couple minutes late and appreciate your patience on that. We'll try not to do it again.

We'll remind the witnesses that you're under oath and so please advise by that. And before we start, I would like to say I'm remiss in not mentioning this this morning. We have another judge with us from the Atomic Safety and Licensing Board, Michael Gibson, over here, most recently a partner with Jones Day down in Houston and has joined us as of two weeks ago and sitting in on this session because it's so fascinating on technical issues. And he's getting all of this, I hope. Welcome.

Okay. Now we're focusing on Contention No. 2, the metal fatigue and who wants to go first. Dr. Wardwell, I think, is --

MS. TYLER: There was on other reference that you had asked me to find.

JUDGE KARLIN: Great. Okay.

MS. TYLER: This is when Dr. Hopenfeld was referring to Dr. Chang's profession of the occupant issue and that transcript was an Entergy exhibit. It's E2-36 and the relevant discussion is on page 135.

JUDGE KARLIN: Thank you. That's great.

JUDGE WARDWELL: I think we broke right at lunch talking about, starting to talk about, the strain rate with Mr. Fitzpatrick in regards to how that affects the Fen value and to refresh everyone's memory, I think earlier on it was alluded to when we were talking about temperature effects on dissolved oxygen and how those reduced temperatures would increase the dissolved oxygen and possibly increase the Fen and I believe, Mr. Fitzpatrick, that you said that would compensated for or at least alluded to that by the strain rate. Could you elaborate more on why you feel that's correct?

MR. FITZPATRICK: It depends on the -- the rate temperature change and temperature change of -- the change in the stress and the strain. That's hypothetical for each transient. When we were talking about -- We were getting into the solubility. I was talking to other consultants and engineers. I think I'm corrected. The solubility may increase if the temperature goes down and if the temperature goes down

-- I think I was in error when I said it was one way or the other before. However, for the transients we're talking about, if the temperature goes down and the vessel is still pressurized and the oxygen won't come out of solution because it was not in saturated condition -- and the vessel is still in the power -- side. It won't get oxygen coming out of solution. If your oxygen does come out of solution, it's in the steam or low temperatures.

JUDGE WARDWELL: What is -- I hate to go back to oxygen. How have you incorporated strain rate into your Fen analysis?

MR. FITZPATRICK: We view a value of integrity that can be used for all the Fen factors. They've used the value of strain rate that would maximize the Fen value. When you has a very rapid transient and you have a very fast strain rate, there is no effect. The Fen is one or low. If you have a very slow transient, that maximizes the Fen. They used the minimum strain rate which maximizes the Fen value in the instructions --

MR. STEVENS: May I?

JUDGE WARDWELL: Would you like to elaborate?

MR. STEVENS: Yes.

JUDGE WARDWELL: Mr. Stevens.

MR. STEVENS: The strain rate, in the Fen expressions, the strain rate, there's a value that maximizes that term. In other words, the n is for a low strain rate. The Fen goes up with decreasing strain rate.

There's a value of strain rate below which the Fen does not increase in those equations. We've referred to that as a saturated value. That is it's the worst strain rate you can put into the expression to yield the maximum Fen. All of our calculations for all components whether we find it confirmatory use that saturated value of strain rate.

In effect, it makes the worst case assumption and takes strain rate determination out of the equation if you will.

JUDGE REED: Could you please explain from a physical point of view why an environmental factor would be affected by the strain rate? I don't see the connection.

MR. STEVENS: I think Mr. Fair might answer that clearer than I could.

MR. FAIR: Yes, I believe what happens when we strain the component is there's an oxide layer that protects the base material and you crack that oxide layer. So when you do it very fast you don't have much time to do much damage to the underlying material. But with a slow strain rate, you keep it exposed for a longer period of time and that maximizes especially the environment.

JUDGE WARDWELL: Wouldn't that also depend upon the magnitude of strain or is there an inherent assumption that the magnitude of strain is the same for all the transients?

MR. FAIR: No, once you -- The magnitude of the strain, there's a cutoff point where you don't crack the oxide layer and that's that strain level of which the Fen goes to one. Above that, once you crack the oxide layer you are getting the damage and that damage is a function of how long the base material is exposed before you reform the oxide layer.

And it's not dependent on the magnitude of the strain, but just how long you keep the base material exposed. The fatigue life now is a function of the actual strain level because the higher the strain the more damage you do on the fatigue cycle.

JUDGE WARDWELL: Dr. Hopenfeld, do you have any objections to what has just been said in regard to how strains handle before we get into whether or not you think it's adequate or not? Is there anything that they've said that wasn't your understanding of how they handled it?

DR. HOPENFELD: No, I understood how they handled it. I used their numbers when I came up with my numbers. I used exactly what they did. I just took their numbers and put -- flushed out their oxygen and put mine there.

JUDGE WARDWELL: We're talking about strain rate now.

DR. HOPENFELD: Yes, I know. I used the same strain because you see --

JUDGE WARDWELL: So you have no dispute with how they handled strain.

DR. HOPENFELD: Well, I used the same. No, I have no dispute of how they handled strain.

JUDGE WARDWELL: Okay. Thank you.

DR. HOPENFELD: I do have a -- I would like to comment if I may or maybe I'll comment some other time regarding on the mechanism --

JUDGE WARDWELL: If it doesn't deal with strain rate, I don't want you to comment right now.

DR. HOPENFELD: Yes and no because the implication here is that you -- that we really understand the exact mechanism of the oxide layer, how it cracks and when it cracks. There are some other theories, you know, other theories that compute things physically that I'm absolutely sure I have a good feeling with it, but it's something that our gang came up with, I don't know, within the next ten years that other people say yes and there was something about hydrogen -- It's a complex issue.

JUDGE WARDWELL: This is in regards to --

DR. HOPENFELD: It's so over simplified that my mind has been in shock.

JUDGE WARDWELL: So this is in regards to how the oxide layer behaves which --

DR. HOPENFELD: Right. What I'm saying is this is not given what the gentleman said. He may be right. This is a work in progress. So the best reason to conclude that he's conservative, that's where the problem comes in.

JUDGE WARDWELL: But you have no evidence to dispute that either. It's still as you say possibly a work in progress is all empirical things --

DR. HOPENFELD: I have no dispute in theory. You know, there are a lot of theories, but that's not the only theory and I'm not familiar with all of them, but I'm familiar with that one and it makes sense. But that doesn't mean that -- because you say the strain does this and doesn't do that and that's what's conservative just because of this theory. I mean, it's naive.

JUDGE WARDWELL: Dr. Hopenfeld, what -- Any other questions on strain rate? Dr. Reed, any questions on it?

JUDGE REED: No.

JUDGE WARDWELL: Dr. Hopenfeld, what leads you to believe that the base metal of the feedwater nozzle is cracked?

DR. HOPENFELD: Okay. In the -- I don't know exactly the history, but I believe somewhere in the '70s, late '70s or maybe mid '70s, a whole bunch of BWRs, I remember, where the feedwater nozzle cracked and a lot of BWRs are replaced. They remove the cladding, remove the welding. From what my understanding is, they haven't done so. In other words, the weld metal is still there. They haven't done anything with that as opposed to other plants.

JUDGE REED: Could we investigate that point for just a moment? I'm a little confused about the geometry of this nozzle. Isn't it clad with stainless steel?

MR. FITZPATRICK: It's clad with stainless steel in a blended use.

JUDGE REED: Pardon.

MR. FITZPATRICK: In a blend rate. It is clad with stainless steel and in '70s when they replaced -- In '76 they replaced the sparger. They pulled the sparger out to pull the original thermal sleeve out of the vessel. They were doing inspection. They actually did --

JUDGE REED: When you refer to "they" you mean you as Entergy.

MR. FITZPATRICK: Entergy and GE. GE was doing this for a lot of plants back then. They replaced the spargers at the same time they inspected the whole -- radius. They grouted out any indications they could find with -- I think they were doing PT inspections back then. People were sitting in the vessel core heads.

JUDGE WARDWELL: Are you talking about at Vermont Yankee?

MR. FITZPATRICK: At Vermont Yankee, yes.

JUDGE WARDWELL: The owner of Vermont Yankee at that time was doing what -- Your testimony is that they did this.

MR. FITZPATRICK: Yes.

JUDGE WARDWELL: Okay.

MR. FITZPATRICK: They inspected it and there was a period of inspection doing in the vessel during the PT inspections.

JUDGE WARDWELL: PT?

MR. FITZPATRICK: Penetrant testing.

JUDGE WARDWELL: What is it?

MR. FITZPATRICK: Penetrant testing.

JUDGE WARDWELL: Penetrant testing, okay.

MR. FITZPATRICK: You put a dye into the point of the crack.

JUDGE WARDWELL: Okay.

MR. FITZPATRICK: And through the years they've developed further UT techniques.

JUDGE WARDWELL: UT?

MR. FITZPATRICK: Ultrasonic testing.

JUDGE WARDWELL: All right.

MR. FITZPATRICK: Most inspection is done with ultrasonic testing. They can put the probes on the outside of the nozzle and investigate that the geometry is including the probe to -- Our exhibit, we have a diagram. It's a small one. E-233, we give you a diagram of the head of the nozzle.

JUDGE REED: E-233.

MR. FITZPATRICK: Yes.

JUDGE REED: And the page?

MR. FITZPATRICK: There are five pages in it. They are all marked 106.

JUDGE REED: The very last page.

MR. FITZPATRICK: Yes. The last page. This is a section called the nozzle looking in a vertical plane and the blend rate is, if you look down on the page, at section one where the radial surface is.

JUDGE REED: Yes.

MR. FITZPATRICK: That's called the blend radius.

JUDGE KARLIN: Okay.

MR. FITZPATRICK: That's where the CUFen is calculated.

JUDGE KARLIN: That's where the CUFen was calculated.

MR. FITZPATRICK: Yes. One of the locations.

JUDGE KARLIN: One of the locations, okay.

JUDGE REED: Is that called the nozzle core (phonetic)?

MR. FITZPATRICK: Yes, that's the terminology of the NRC is nozzle core.

JUDGE REED: Thank you.

MR. FITZPATRICK: And they've done inspections to demonstrate the method works in mockups. It's pretty much standard instrumental.

They'll do a UT exam on the exterior of this, on the whole nozzle, to investigate these areas. The UT technique is sized to capture a maximum or minimum size flaw and we have another analysis at Section 11 that the postulated flaw in that. We have postulated a flaw in that nozzle core already and we have done a Section 11 analysis for that. That's outside the fatigue.

JUDGE WARDWELL: Section 11?

MR. FITZPATRICK: ASME Section 11. That's a service inspection and that was in response. This inspection -- There's a special inspection called augmented inspection and it's in response to the NUREG that was done in the '70s. What is it? Six-nine -- I haven't got the number.

JUDGE WARDWELL: Are we looking at -- Does the feedwater go in between the lines of this nozzle or is this the cladding of the nozzle?

MR. FITZPATRICK: That represents the full thickness of the nozzle. The feedwater pipe will be here and the center line would be here. So it would be the top section of the pipe. This is the vessel wall. The pipe's coming in horizontally. This is the safe vent well down here and this is the port nozzle of these.

JUDGE WARDWELL: Where is the feedwater going?

MR. FITZPATRICK: (Indicating) This way. There is the thermal sleeve that fits in there and it's pressed right into the safe vent. You don't see it in this diagram and the feedwater flow is in through the thermal sleeve. It's a pipe within a pipe. You can think of it that way. So the full feedwater flow never really gets to this part.

JUDGE KARLIN: Try to describe what you're pointing to so we can have something on the record that will transcribe.

MR. FITZPATRICK: Try to describe it.

MR. STEVENS: May I?

JUDGE KARLIN: Sure.

JUDGE WARDWELL: Mr. Stevens please.

MR. STEVENS: On this picture where it says "Vessel" --

JUDGE KARLIN: Now we're referring to?

MR. STEVENS: We're referring to page five.

JUDGE KARLIN: E-233 Vermont Yankee and page five, the diagram. Right?

MR. STEVENS: That is correct.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: The diagram shows several lines. It looks like a closed in component.

MR. STEVENS: Correct. So remember the -- Recall the earlier description I gave the nozzle being the intersection of two cylinders, the large vessel cylinder and the incoming pipe and that's what you're -- What you're seeing here is a cross section of that intersection, one-half of that cross section. The lower half of that cross section is not shown here, but it would be an inverted image of this.

JUDGE WARDWELL: And it's a cross section of a doughnut. We're seeing one-half of a cross section of a doughnut type of --

MR. STEVENS: Correct.

JUDGE WARDWELL: Coating, yes.

MR. STEVENS: Another way I've described this to folks is if you took this and revolved it about a center line you would have -- There would be one difference in doing that to the real configuration. The vessel portion of this would be flat if you rotated that about a center line axis when, in fact, the vessel is itself a cylinder. But it's close. So if you do this solid revolution, call it, it gives you close representation of what the real component is.

JUDGE REED: Now the clad, would you specify exactly what portion of this nozzle is clad in this picture?

MR. STEVENS: Yes, the cladding is put on to the vessel wall interior surface and the nozzle forging.

JUDGE REED: And which part is called the nozzle forging.

MR. STEVENS: The thicker part. The part that's identified as nozzle in this diagram is the forging.

JUDGE REED: And the forging ends there on where the wall becomes thin or?

MR. STEVENS: Yes. On the one side, it's the forging itself, the nozzle, is attached to the vessel itself with a weld, a full penetration weld, which is shown by the dark region between vessel and nozzle.

JUDGE REED: Okay.

MR. STEVENS: And then it's adjoined to the safe end at the other end where the dark region between the nozzle and safe end.

JUDGE REED: I didn't understand, but those are wells.

MR. STEVENS: Those are depictions of

wells. Yes, sir.

JUDGE REED: Thank you.

JUDGE KARLIN: And when you say the interior is clad also, does that mean the lower horizontal line in the diagram that's over the interior on this?

MR. STEVENS: Yes. The nozzle forging itself is clad contiguously with inside the vessel and then if you look at these regions that are marked 1, 2a, 2b and 3.

JUDGE KARLIN: Yes.

MR. STEVENS: The nozzle itself is clad into those regions.

JUDGE KARLIN: All right.

JUDGE REED: Is it clad all the way down to the weld position or?

MR. FITZPATRICK: Some of the nozzles end up just before the weld.

JUDGE REED: When you're ultrasonic testing, is it able to detect cracks of the cladding even though you're testing from the outside?

MR. FITZPATRICK: It's designed to detect minimum sized flaw that is postulated in the base metal weld. It's either 3/16ths or 1/4 inch. I think it's 3/16ths. It can detect up to a 3/16ths crack in the base metal weld.

JUDGE REED: Now when you say a 3/16ths crack --

MR. FITZPATRICK: Yes.

JUDGE REED: Is that along -- Is that depth?

MR. FITZPATRICK: Yes.

JUDGE REED: So it's not opened up. I mean, it's just a microscopic opening.

MR. FITZPATRICK: Microscopic crack, yes. And there was another analysis that is done to support this issue back in the '70s that has been refined a few times and that crack analysis supports the inspection program for that nozzle. We postulate crack -- It's an analysis that shows crack erosion at the time and the inspection program is designed such that we've inspected prior to getting appreciable crack.

JUDGE REED: So it's my understanding that in some plants this cladding has been removed.

MR. FITZPATRICK: Yes.

JUDGE REED: Is that correct?

MR. FITZPATRICK: Yes.

JUDGE REED: And for what reason?

MR. FITZPATRICK: That eliminates the

possibility of getting cracks in base metal. The cladding actually drove -- The cladding drove the cracks because the original designed thermal sleeve allowed leakage by --

JUDGE REED: What? Leakage by?

MR. FITZPATRICK: Leakage.

JUDGE REED: Leakage.

MR. FITZPATRICK: The original thermal sleeve, there was a gap between the inside of the pipe and the outside of the thermal sleeve and they had leakage by the thermal sleeve and that mixed with the hot reactor water and so that was the mechanism that cracked the cladding.

JUDGE WARDWELL: Do you want to clarify?

MR. STEVENS: By leakage, we're not referring to leakage outside of the pressure boundary. It's a relative term to indicate leakage past this thermal sleeve.

JUDGE REED: I understand that. Yes.

MR. FITZPATRICK: When they replaced the thermal sleeve, they did what's called an interference fit. It's the design -- it's an -- material. They froze it and rammed it into the pipe and let it heat up and it gave a very rigid fit and we actually have thermal couples on the outside of the pipe indicating if there's leakage on that or not and that's monitored periodically.

JUDGE REED: So now there is not a lot of leakage past the thermal couple.

MR. FITZPATRICK: We tried in the analysis to determine if there was an possible leakage and if something changes with that, we will have to build a corrective action plan.

JUDGE REED: You do not believe you had cracks in the cladding prior to installation of this. Now the thermal sleeve was changed a long time ago, wasn't it?

MR. FITZPATRICK: Yes, and the eight cracks that were found were grounded down at that time. And they would do periodic inspections of the cladding from the inside of the vessel using PT. Given the exposure that these little inspectors would take over time doing that, the technology advanced over the years to do UT, ultrasonic testing, and it's almost done on every -- I think it gets done on every BWR feedwater nozzle on an -- basis. There's a second program to do investigation. Every plant has their own real specific program that they have.

JUDGE REED: With this background, what can you tell us about existing cracking in either the cladding or the base metal?

MR. FITZPATRICK: The inspection program is not showing any cracks. They haven't detected any cracks in the past 20 years that are bigger than 3/16ths and we know that. Our Section 11 analysis which goes into the protected corrective actions to be found for these cracks covers that site, covers that phenomenon.

The fatigue analysis --

JUDGE REED: What analysis?

MR. FITZPATRICK: The fatigue analysis in ASME Section 3, you don't postulate cracks in the base metal in trying to determine acceptance. A fatigue usage, again some acceptance of the -- Level 1 that has an assumption there are not cracks in that ASME 3 analysis. Once you get into cracking, you would be into the ASME Section 11 analysis.

JUDGE REED: So you assume no cracks in your analysis.

MR. FITZPATRICK: It's inherently ASME Section 3 analysis.

JUDGE REED: And that's the analysis you did, that you follow. Is that --

MR. FITZPATRICK: All Section 3 analysis.

JUDGE REED: But I guess what I'm asking

is the analysis that we've been talking about is Section 3 analysis.

MR. FITZPATRICK: Yes.

JUDGE REED: Thank you.

JUDGE KARLIN: Well, I don't know. Maybe I'm cutting to the chase a little bit too prematurely. But, Dr. Hopenfeld, when we look -- I've looked at your chart of uncertainties, Table 1 in your rebuttal, and you have these 13 factors listed of uncertainties in the ANLE Argonne National Lab.

DR. HOPENFELD: Right.

JUDGE KARLIN: 1998 and 2007. Then equations and I guess we turn to No. 13, is it, which is Factor 13 or Uncertainty 13 you have as "existing surface cracks." Right?

DR. HOPENFELD: Is it 13?

JUDGE KARLIN: Is that the one you're talking about?

DR. HOPENFELD: Yes, 13. Right.

JUDGE KARLIN: This is what we're talking about here with the crack --

DR. HOPENFELD: Correct. Yes.

JUDGE KARLIN: -- cracked cladding, cracking and all that.

DR. HOPENFELD: Yes.

JUDGE KARLIN: And you say, "Existing fatigue cracks" -- Does NUREG 6909 deal with this issue at all?

DR. HOPENFELD: No.

JUDGE KARLIN: No. And you say it was not addressed in the Entergy analysis. Is that correct?

DR. HOPENFELD: Yes.

JUDGE KARLIN: And your comment is "Existing fatigue cracks in the cladding or base metal can provide sites for accelerated corrosion, thereby, accelerate fatigue failure under cycling loads." Now as a theoretical statement, I suppose -- Does anybody challenge that as a theoretical statement? Mr. Stevens, theoretically, that could be true.

MR. STEVENS: Theoretically, I suppose it could be. Yes.

DR. HOPENFELD: I don't know if it's theoretical. I think it's observation. My experience if there was an ground surface you could get a crack.

JUDGE KARLIN: When I say "theoretical" I mean existing fatigue cracks in the cladding can provide sites.

DR. HOPENFELD: Right.

JUDGE KARLIN: Now the question is are there any existing fatigue cracks in the cladding and

I guess what we're hearing is, no, there aren't any.

DR. HOPENFELD: Can I answer that question?

JUDGE KARLIN: Yes.

DR. HOPENFELD: First of all, I take an issue here with the statement that it was -- what 3/16th of an inch. You said it was a microscopic crack. Is that what the statement was? I don't think it's a microscopic crack. In the testing that you do -- I'm not digressing here, but we were talking this morning about clads, about life. One definition of life is crack it completely onto the reflection itself --

JUDGE KARLIN: Definition of what? Light?

DR. HOPENFELD: Reflection. One definition of the life of a component, remember the big N on the bottom of the page.

JUDGE KARLIN: Okay. Got you.

DR. HOPENFELD: Remember we were doing all these -- Is fracture into the Nth. Another definition is --

JUDGE KARLIN: Fracture to the Nth?

DR. HOPENFELD: Yes. To the --

JUDGE KARLIN: To the end.

DR. HOPENFELD: And under that definition it's being one. That's all it is is one requirement. But some other people when you test they have a definition and maybe it's convenient to some degree is to run to a point which you have, what's called, an engineering crack of about three millimeters and then you see them when you're testing the loading drops. So that's a different definition.

What we're talking about here in the tests that Argonne ran, by the time you get three millimeter you're over the initiation process. You're analygating (sic) to the proposition. So when he says it's very, very small, it's not -- Three-sixteenths is not -- I can't remember what it is.

JUDGE KARLIN: Well, we don't need to debate whether 3/16ths is --

DR. HOPENFELD: It's not microscopic. Let's look at the microscope. I can feel. I know --

JUDGE KARLIN: Dr. Hopenfeld, we can posit that 3/16th is 3/16ths.

DR. HOPENFELD: Right.

JUDGE KARLIN: The adjective "microscopic' can be discarded.

DR. HOPENFELD: It's important because --

JUDGE KARLIN: Mr. Fitzpatrick.

MR. FITZPATRICK: I didn't say

"microscopic" in the same sentence as 3/16ths.

JUDGE KARLIN: All right. Let's just dispense with the word "microscopic" and say it's 3/16ths. Right?

DR. HOPENFELD: Okay. Now the reason for that, for one thing, when you do ultrasonic, it's difficult to do ultrasonic when you have a base metal and at the same time you have a clad of stainless steel and carbon. So it's difficult to distinguish between the two. Especially when you do the UT, you really get -- because you don't really know whether you've penetrated one millimeter in there or a fraction of a micron.

When GE examined a whole slew of damaged nozzles, there were some of them that cracked through the base metal. It's my understanding and I don't know what kind of machines they are using today for UT examination, but my understanding is that we're talking about minimum detection, something like one quarter of an inch and the clad if I understand correct is a little bit less. So there is a possibility of -- at the base metal.

But be it as it may, take a look what the people at Argonne ran. They're in 6909 or the other, 6583. These specimens were not cladding. These were not cladding. This was not the same type of a test. Now they've taken this and in one of their -- they said, "Well, we admit. We're going to make the assumption that the cladding is cracked." For whatever reason, NRC asked them and they said they're going to assume.

Well, if you assume something, first of all, you really cannot tell -- You have to admit you can't tell whether it's cracked beyond the base metal or not.

JUDGE KARLIN: So let me stop you there if I man.

DR. HOPENFELD: Okay.

JUDGE KARLIN: You're acknowledging that Entergy has assumed that they are cracked.

DR. HOPENFELD: Yes. In one of the labs, they said they assumed that they are cracked.

JUDGE KARLIN: They are making the assumption.

DR. HOPENFELD: And they also -- possible that they could, in fact, propagate it through the next 20 years. Once you've made that assumption, it seems to me you should be consistent in the calculation of the Fen.

JUDGE KARLIN: Well, let's ask Mr.

Fitzpatrick or Mr. Stevens.

MR. STEVENS: May I clarify?

JUDGE KARLIN: Go ahead.

MR. STEVENS: My comment on this issue, Item 13, is it's not relevant to our CUFen analysis. Our CUFen analyses inherent in them, there's a Section 3 analysis which does not allow cracks and we're also doing a calculation that demonstrates --

JUDGE KARLIN: Wait a second. What do you mean it doesn't allow cracks? It prohibits there will be never be a crack.

MR. STEVENS: Section 3 as part of fabrication of vessels if there were any indications it requires repair. The analysis --

JUDGE KARLIN: So it assumes there will be none. There are no cracks.

MR. STEVENS: That's correct.

JUDGE KARLIN: And if there are cracks it's invalidate.

MR. STEVENS: It would have to be repaired so that there were no flaws under the Section 3 fabrication.

JUDGE KARLIN: Yes. You have to have no cracks in order for this to work.

MR. STEVENS: And the analysis we're doing is a calculation of crack. Our criteria against crack initiation we're showing to be acceptable. So the presence of a crack is meaningless to an analysis that has to assume no crack to begin with and our criteria --

JUDGE KARLIN: Doesn't it invalidate the analysis if there is a crack?

MR. STEVENS: If a crack was detected, then you would be into a Section 11 program like Mr. Fitzpatrick explained and what we have here historically is, yes, they would indicate cracks in the VY feedwater nozzle. They were repaired and a complete repair was implemented that included grind out of the cracks as well as thermal sleeve and sparger replacement that restored that component to a new condition and since that time, Section 11 programs have verified within their capability the absence of cracking as well as analysis that's been done, updated analysis, to meet the CUF requirements of Section 3 which would say you would have and analyzed against the presence of cracks.

In addition to all that, we have a belt and suspenders program, a Section 11 program, that continues to inspect those nozzles and, as a part of that, there is the crack growth analysis tied into that program that Mr. Fitzpatrick alluded to. It says even if all of that might be mistaken, we're going to postulate a flaw and demonstrate the growth of that flaw as acceptable over the life of the plant. So it's a combination belt and suspenders program of acceptability and manage the fatigue in this component.

But with respect to the CUFen, cracks are not relevant. They don't factor into the analysis.

JUDGE WARDWELL: And is that a better way to say it that, in fact, you have, that Entergy has, a monitoring and maintenance program that repairs all cracks such that they have no influence on the CUFens?

MR. STEVENS: Yes, sir. That would be a correct way to say it.

JUDGE WARDWELL: Rather than to say it's not relevant. It is relevant but you don't allow them to occur from the monitoring and maintenance program.

MR. STEVENS: Yes. If you detected a crack, you would be outside of Section 3 and into Section 11 and would have to correct that situation.

JUDGE WARDWELL: Recognize that we don't understand the significance of a Section 3, a Section 11. That doesn't mean much to us. It sounds like it's a very important thing to you people at Entergy that when you go into a Section 11 means you have to do some stuff and that, of course, is a corrective action thing.

How often do you inspect this particular component to assure that those cracks are detected and repaired expeditiously so that provocation would not occur?

MR. FITZPATRICK: Right now, it's very four cycles there's a 100 percent UT done on all four nozzles.

JUDGE WARDWELL: Every four --

MR. FITZPATRICK: Every four cycles.

JUDGE WARDWELL: -- refueling cycles?

MR. FITZPATRICK: Yes. Approximately six years. We just finished the last one in 2007.

JUDGE WARDWELL: Describe if you could for me a little more detail of this suspenders part of the belt and suspenders and that being where you assume that it's cracked. What have you done with that assumption or what have you applied that assumption to?

MR. STEVENS: If we have a CUF analysis that indicates CUF is less than one, the indication would be that there are no cracks first off. Second though, because of the history of these components as well as Section 11 programs, they do get periodically inspected for any kind of deterioration due to fatigue and other mechanisms that might be present. Those as Mr. Fitzpatrick alluded to use typically ultrasonic techniques which have improved drastically in the last 25 years and are heavily qualified by organizations such as EPRI.

But nevertheless those inspections do have limitations. There is a threshold below which they cannot detect cracking. In order to compensate for that, an analysis is done postulating a flaw --

JUDGE WARDWELL: And is that the 3/16ths that we were talking about before?

MR. STEVENS: Yes, sir.

JUDGE KARLIN: Okay. So that can't see a crack that's smaller than that.

MR. STEVENS: Yes, sir.

JUDGE KARLIN: And therefore possibly there is a crack of that size in there.

MR. STEVENS: You postulate a flaw size that may have been missed.

JUDGE KARLIN: Right.

MR. STEVENS: And do an analysis that shows acceptability of that flaw and growth over future operation.

JUDGE WARDWELL: And what type of analysis is that?

MR. STEVENS: That is a fracture mechanics analysis.

JUDGE WARDWELL: And that allows you to estimate the propagation of that crack?

MR. STEVENS: Yes.

JUDGE WARDWELL: Dr. Hopenfeld, what evidence do you have that the feedwater nozzle cladding is now cracked?

DR. HOPENFELD: It now cracked. No, I don't have direct evidence it's cracked. I looked at their inspection reports and they state not detected which means within the detection capability of UT. It was not -- As I said, 3/16th, it was my understanding one quarter of an inch, but that's not that different.

The point that's being missed here and that's a practical engineering problem that I've seen through all my life almost with different endeavors, nothing in the nuclear business, is when you have cracks you just grind them out. You get rid of them. You shim them out. You don't want them. That's a standard procedure.

He's talking about walking it to one section to another section and that's a ASME Code.

That's a different world. In the real world, you have these things and what happens is that these are site corrosion product, what those corrosion products would do if the -- time is unknown. But, more importantly, when you want to test and you want to test some smooth surfaces and then you say, "I'm going to use these at the end and I'm going to say these are conservative," well, he is absolutely sure that this is conservative. I don't see how that is conservative when he already starts with cracks because he doesn't know where they are. So he does the analysis and that's because the ASME asked him to an analysis. But that's a different world.

In the real world, you have these FUM (phonetic) numbers. They came in from laboratories for very, very smooth surfaces. I don't know.

JUDGE WARDWELL: What was the wording in the inspection program that indicated that there was no cracking in this nozzle?

MR. FITZPATRICK: No relevant indications.

JUDGE WARDWELL: There's no --

DR. HOPENFELD: No relevant indications. Usually you classify something like that in terms of POD which is probability of detection. They don't talk about that.

MR. FITZPATRICK: The SER states a quarter inch crack. The analysis maybe used in a quarter crack, too.

JUDGE KARLIN: Where is that?

MR. FITZPATRICK: If you look at SER -- The FSER study, the whole discussion starts at the bottom of page 4-25. Do you have the section?

JUDGE KARLIN: Are you talking about the final safety evaluation?

MR. FITZPATRICK: Yes, as it were.

JUDGE KARLIN: Okay.

MR. FITZPATRICK: It's Code 3 -- Analysis.

JUDGE KARLIN: Page four --

MR. FITZPATRICK: That's at the bottom of page 4-25.

JUDGE KARLIN: Four-25.

MR. FITZPATRICK: Yes, and continues on to 4-27.

JUDGE KARLIN: This is a discussion of feedwater nozzle fatigue analysis.

MR. FITZPATRICK: Yes, this is -- This was the section of the inspection prior to looking at EAF Section --

JUDGE KARLIN: Okay.

MR. STEVENS: May I clarify one thing on

that?

JUDGE WARDWELL: Yes, go ahead.

MR. STEVENS: On page 4-26, next to the last paragraph where it's talked about a 0.25 inch flaw, that doesn't necessarily mean that's the capability of the UT system. The technical basis behind this work which I'm very familiar with says that there are certain effects that would drive a crack to one quarter of an inch that are difficult to include in the analysis. The analysis is supposed to assume a quarter inch or the capability of the UT system whichever is greater. So this value here in initial crack size may, in fact, reflect that technical basis more than it reflects the capability of the UT system.

So, in fact, Mr. Fitzpatrick's comment about 3/16ths of an inch capability may be true. But the technical basis for this work requires us to assume one quarter inch minimum because of other stress effects that would be present. My point is I don't want you to look at the quarter inch and be confused that might be a UT capability. It might be far better than that.

DR. HOPENFELD: Can I --

JUDGE KARLIN: Dr. Hopenfeld, yes, would

you like to respond?

DR. HOPENFELD: Well, not a comment on that. You see, we don't -- When you weld something, you put a bead in there and that's a machine weld, usually there's an uncertainty with the thickness that you get there and it's -- I went to the original drawings and I read it and couldn't figure out exactly what those differences are and we asked them to tell us what is "as is dimension." It was wrong if you're interested.

Now the cladding is -- I believe it was like 5/16. So we're not talking -- I don't remember exactly what the cladding is. But that could be within the tolerances. If you're through the tolerances, you might be already within the base metal and whether you are in the base metal or not it doesn't really matter because you see the interfaces is the point of stress. It's the initiation point and when you put all that corrosion products, it's something that Argonne hasn't run and I can't see in the world how that could be conservative.

JUDGE WARDWELL: Thank you.

Moving onto your third of three most important issues relating to Table 1 Uncertainties in the Fen equation dealing with surface finish, would you like to elaborate a little bit more, Dr. Hopenfeld --

DR. HOPENFELD: Sure.

JUDGE WARDWELL: -- on what you mean by that or why it's so important?

DR. HOPENFELD: Yes. Let me get you in the right direction on this.

JUDGE WARDWELL: We always like that.

MS. BIELECKI: May we show him our copy?

JUDGE WARDWELL: Yes. Sure.

DR. HOPENFELD: Okay. Could you please -- You're talking about the number that would be the first one or the second one? The oxygen or the surface?

JUDGE WARDWELL: The surface.

DR. HOPENFELD: The surface, right. Okay. I have it. NEC JH-28.

JUDGE WARDWELL: Twenty-eight. I'm sorry. What is that again? NEC what JH?

DR. HOPENFELD: NEC at 28 page three.

JUDGE KARLIN: Twenty-eight what?

DR. HOPENFELD: Page three. NEC JH-28.

JUDGE WARDWELL: And this is the ACRS meeting?

DR. HOPENFELD: No. That's the -- It's my presentation. Do you see a table there?

JUDGE KARLIN: No. NEC JH-28 is an excerpt from the February 7, 2008 Advisory Committee Meeting on Reactor Safeguards.

DR. HOPENFELD: No.

MS. TYLER: Dr. Hopenfeld, what's the title of the document that you want to refer them to?

JUDGE KARLIN: Yes. What's the title?

MS. TYLER: What's the title of the document?

DR. HOPENFELD: Oh, yes. I see. I'm sorry. I got screwed up. Okay. NEC -- Well, it says JH-28 at 76. I think it's the NUREG 6909 report.

MS. TYLER: If it's 6909, it's JH-26.

DR. HOPENFELD: Yes, the 6909. Twenty-six.

JUDGE KARLIN: So you're referring to 6909.

DR. HOPENFELD: Right. Correct.

JUDGE KARLIN: NUREG 6909.

DR. HOPENFELD: Right and I believe it's page 76 that there's a table there and --

JUDGE KARLIN: Page? What page, sir?

DR. HOPENFELD: Seventy-six.

JUDGE KARLIN: Seventy-six.

DR. HOPENFELD: Right.

JUDGE KARLIN: There's a Table 12 on that page?

DR. HOPENFELD: Yes.

JUDGE KARLIN: Is that what you're referring to?

DR. HOPENFELD: Yes, sir. I'm sorry.

JUDGE KARLIN: All right. Let's wait for everyone else to get there.

DR. HOPENFELD: Yes.

JUDGE KARLIN: Okay? What's the question?

JUDGE WARDWELL: Yes. Would you like to elaborate more on how important that is?

DR. HOPENFELD: Sure.

JUDGE WARDWELL: And what impact does it have on the Fens? How sensitive are they to this --

DR. HOPENFELD: Sure. You see on that page what you have on the left-hand side is you have number 2, 2.5, 4 and proposed plan. These are parameters and not as Mr. Fitzpatrick said, this is not a safety factor. This is an adjustment parameter in the computer code, excuse me, ASME Code. And you notice that the surface roughness is a factor of four. So it's pretty heavy. It's considered to be very important. These things were done, I don't know, 30 or 40 or 50 years ago indicating there was clearance --

JUDGE WARDWELL: What does a Section 3 criterion mean?

DR. HOPENFELD: I'm sorry.

JUDGE WARDWELL: What does a Section 3 criterion document mean?

DR. HOPENFELD: Well, it's what the ASME Codes are based on for calculating the fatigue curve as the stress versus the best -- cycles.

JUDGE WARDWELL: Yes.

DR. HOPENFELD: That's where it comes from. That's what the -- calculating the stress, the fatigue, level of -- air by the ASME Code and I think there are a similar curve that was presented by the NRC somewhere in one of your exhibits.

JUDGE WARDWELL: Right.

DR. HOPENFELD: Yes, it's the ASME Code that the crack doesn't work by itself. The ASME Code, the data in here is based on a large number of experiments. Ninety-nine percent of them were conducted in air, okay, in an environment, not in an industrial environment. So -- And I've been -- for many years. So the person who agrees in charge at that time, Dr Cooper, and being a lot of people under us and they came up with numbers as to the various effects that you should really involve the experimental data that you got in the lab report and when you put it in the ASME Code, somebody could use it. It's still in air. Conceptually, it's probably not the same environment the same as air that you had in the laboratory. But it's air.

But realizing that factors like size and the most important one in the surface -- they put factors in it for best estimates, best guesses, they could. But those estimates were based on, the roughness of the surface was based on machine surfaces, what you leave on the machine, whatever the machine surface is. I mean, different components have different machine surfaces. You know, you grind it. You use a -- or whatever it is you use to forge it or whatever it. So you have different surfaces and they did a number before.

Okay. So now when you come to the issue of surface roughness being in water, definitely it would be like water reactive, the first question is the surface roughness here the same as the surface roughness there (Indicating). And, of course, you look at it and I believe that they did and I even believe that Argonne didn't look too far beyond that is they said, "Well, they're still talking about machine surfaces."

But what you have, a lot of these components are carbon steel, low-alloy steel, that have been cooking there for many, many years. Their surface is corroded and we'll talk about that later. The surface what you heard is not on a machine surface and the corrosion corroded some of the corrosion surfaces and you might have pits, ridges. These all could be high stress points for crack initiation. Some of the pits could be points for accumulating corrosion products. It is not the same thing.

Now Dr. -- I don't think they went beyond the point of assuming that these surfaces are really machine surfaces. They haven't considered it because there's no ordinary problem they've considered -- on the -- surface.

JUDGE KARLIN: Well, let me stop you there.

DR. HOPENFELD: Sure.

JUDGE KARLIN: Let me stop you there, Dr. Hopenfeld. We're looking at this chart. It's on page 76 of the NUREG 6909. Right?

DR. HOPENFELD: The chart?

JUDGE KARLIN: Yes, the chart you just

referred to.

DR. HOPENFELD: Oh, this thing. Right.

JUDGE KARLIN: That you referred us to.

DR. HOPENFELD: The table, yes.

JUDGE KARLIN: The table. I'm sorry. And it's 6909 table and it has a parameter and the parameter is surface finish. Right?

DR. HOPENFELD: Correct.

JUDGE KARLIN: On the left-hand column and it says, "Section 3 Criterion Document" and by that we mean the ASME document?

DR. HOPENFELD: I don't know. I would think so, yes.

JUDGE KARLIN: In air. Well, they say you should have a factor of 4.0.

DR. HOPENFELD: Right.

JUDGE KARLIN: And then the present report, I suppose that means the 6909 NUREG, that report says the factor should be less.

DR. HOPENFELD: Yes.

JUDGE KARLIN: 2.0 to 3.5.

DR. HOPENFELD: And I'm saying that's right. That's exactly the point.

JUDGE KARLIN: And these are the environmental factors, are they not?

DR. HOPENFELD: No.

JUDGE KARLIN: But you're starting with the curve in the air and you're saying, "Why don't we adjust it by four or why don't we adjust it by 3.5?"

DR. HOPENFELD: No. Let me explain. That's the reason I'm being here so that you can understand so we're talking about the same thing.

JUDGE KARLIN: That's what I thought.

DR. HOPENFELD: But you're right. But here is the point. They say this is not -- This has nothing to do with the Code. Remember on the right-hand side it's a present report. It's when they calculated their air volume. Okay. They believe that these are the numbers that should be in there.

One reason their number is -- reason they believe is the Code is very conservative is because they said, "Well, this is one parameter that we believe is between 2.0 to 3.5. That's what he believes and that's not necessarily correct. I don't know how to work with the way this has been tested to see whether he really talks about the real surface that you have in a reactor. And then you look at the corroded surface that you have or surfaces that especially the surfaces which are carbon steel and low-alloy steel and you see that they were exposed to high accelerated corrosion, I mean, there's a landscape of entirely different surfaces and I'll show you those pictures in the --

JUDGE WARDWELL: What are these numbers used for if they're not Fens?

DR. HOPENFELD: I'm sorry.

JUDGE WARDWELL: What are these numbers --

DR. HOPENFELD: These were used more or less as a recommendation. If he had his choice, he would have recommended a new air and detect the ASME Code and replace it with his.

JUDGE WARDWELL: I'm sorry. I don't think you understand me. I don't -- The question is now what is the 2.0 to 3.5 versus the 4.0 you used or any of these numbers you used.

DR. HOPENFELD: Well, the number of these things, what he is trying to say here with regard to the Fen, he's trying to say here that the ASME Code which has their air curve in there is very conservative to compare what he has. But then he says that it's his judgment. He says it's between 6.0 to 27.4 which is a range that he gives and he said he used that and that's the reason when they say, they're talking about, there's a lot of conservatism. There is a judgment that there is conservatism in the ASME

Code. I've had people think that it's not conservative.

JUDGE KARLIN: Can we stop you there?

DR. HOPENFELD: Yes.

JUDGE KARLIN: Mr. Fair, maybe you could help us. Do you agree with his, with Dr. Hopenfeld's, discussion of this chart and what it's showing us?

MR. FAIR: I'm not sure that I understand his discussion of the chart.

JUDGE KARLIN: Okay. What's your understanding of these factors and the loading history, I'm sorry, the surface finish? There's 4.01 for Section 3 and then there's a 2.0 -- What are those things?

MR. FAIR: Yes, the numbers in the left-hand column under the Section 3 Criterion Document come from an original ASME criterion document that they published in 1960s explaining the bases for the fatigue evaluation procedure and these were the assumed values they used to adjust the mean test data that they used to establish the fatigue air curve adjusted downwards to get the design curve.

JUDGE WARDWELL: So they divided that curve for 4.0.

MR. FAIR: No. By 20 for the total.

JUDGE WARDWELL: No. We're only talking surface now.

DR. HOPENFELD: No, they did it altogether because --

JUDGE WARDWELL: We're talking to Mr. Fair now.

DR. HOPENFELD: I'm sorry.

JUDGE WARDWELL: Thank you.

MR. FAIR: The right-hand column is the latest assessment that was done by Argonne of the available literature to relook at those parameters to see what they thought those parameters would be in light of the current data and these were the estimates of the range of estimates they got from the literature on these parameters.

JUDGE KARLIN: If I may stop you. These are the air curves, right, and adjustments?

MR. FAIR: That's right.

JUDGE KARLIN: And this is an example where you might say -- When you said the 6909 is less conservative than the old method, this is an exact example of that, is it not?

MR. FAIR: That's right because --

JUDGE KARLIN: Because the old method was at an adjustment factor of 4.0 and the new method of

6909 has an adjustment of 2.0 or 3.5.

MR. FAIR: Well, that wasn't the specific area I was referring to because the old adjustment just put an fixed adjustment of 20. The current 6909 assumed a probability distribution with all of these parameters and then did a simulation to determine what the adjustment factor should be and the current --

JUDGE KARLIN: Is this the Monte Carlo 9595?

MR. FAIR: That's exactly right. And the current testament based on that Monte Carlo simulation was that adjustment factor could be 12 so that the previous air curve was conservative in comparison to the current Argonne assessment.

JUDGE KARLIN: Right.

JUDGE WARDWELL: What did you use, Entergy, in your analysis? Either Mr. Stevens or Mr. Fitzpatrick.

MR. STEVENS: We used the ASME Section 3 fatigue curve which is represented by the numbers under the Section 3 criteria document.

JUDGE WARDWELL: So it's represented by the 4.0 number if we are only talking about surface roughness.

MR. STEVENS: Yes, sir.

JUDGE WARDWELL: Dr. Hopenfeld, do you have any indications besides just your common sense that says there must be adverse surface finish beyond what was assumed in the Section 3 Criterion Document.

DR. HOPENFELD: Yes, I think 6909 gives an equation of the effect of surface roughness and if you look at the surface roughness that these people are talking about it's not the same surface roughness that you would see in an actual plant, in an actual component -- So this is an uncertainty.

I don't know exactly what the exact effect is in effect because there is an equation in 6909 relating to surface roughness. But that surface roughness is again a machine.

JUDGE WARDWELL: Let me clarify something with yourself if I might.

DR. HOPENFELD: Yes.

JUDGE WARDWELL: Or let you clarify for me. Entergy just testified they use a Section 3 criterion for this discussion that you're just bringing up in regards to 6909 sugars down to a recommendation herein of a value of somewhere between 2.0 and 3.5 of which 2.0 if you look at the asterisks can be used for carbon and low-alloy.

DR. HOPENFELD: Yes.

JUDGE WARDWELL: That seems to be if you're using the present report half as much influence as what was used. So they're more conservative by a factor of two.

DR. HOPENFELD: This is the -- Yes. That two was the number. But I'm saying this 2.0 to 3.5 was not based on actual surface. That was --

JUDGE WARDWELL: But where -- What evidence do you have and what are the numbers for that evidence of actual surfaces?

DR. HOPENFELD: No evidence but based on the surface roughness of a corroded surface on the pipe and you see it on carbon steel or low-alloy steel is much higher than a machine surface that you get it out of --

JUDGE WARDWELL: So you disagree with Argonne in regards to the development of 6909.

DR. HOPENFELD: I doubt that it was raised. That's the reason I brought it up because --

JUDGE WARDWELL: Who else disagrees with Argonne?

DR. HOPENFELD: I'm sorry.

JUDGE WARDWELL: Who else -- Can you quote then reference a cite that disagrees the way you do with what Argonnne has done and supplied on that?

DR. HOPENFELD: Okay. I don't know the invested issue, the specific issue, of the surface roughness either.

JUDGE WARDWELL: Thank you.

DR. HOPENFELD: But with regard to the ASME Code --

JUDGE WARDWELL: No. We're talking surface finish now.

DR. HOPENFELD: Yes, but the two come together. They talk about a 20 factor. They add all these factors together. They added here 20 and they added here to whatever the number of times. But if you're talking about just the surface itself, okay, and that's what -- Let's say that a factor of -- that this reference here, the 4.0, the average number. Let's say just for -- I'm not saying that that's right. Let's say 10. Okay. Then you say, "I didn't run these, didn't generate equations for a number of 10. We generated" -- They're using actually a number of four because when they multiplied their Fen which is their Fen divided by -- in water divided by air, they're basically using the number 4.0. But if they take a number -- if their thing was really 10, then you would have a different number. That's how you do the surface.

JUDGE WARDWELL: I understand.

DR. HOPENFELD: You have to extend it --

JUDGE WARDWELL: If you had a number of 100, what happens?

DR. HOPENFELD: I'm not going -- Look. If you want me to give you a number on this, I cannot because --

JUDGE WARDWELL: I'm asking you for a cite of someone else's support of the position you're taking because it seems to me you can't support any other number besides what's here.

DR. HOPENFELD: No, I don't support this -- Look. This number reflects surface which was a machine, not surface that was exposed to corrosion.

JUDGE WARDWELL: Can you point us to where it says that this is an assumption that is a machine surface that's not corrosional (sic)?

DR. HOPENFELD: Yes. I would have to go back there. It's in the discussion. There's nothing talked about the actual surface. You have to talk about the actual surface.

JUDGE WARDWELL: Mr. Stevens or Mr. Fitzpatrick from Entergy, do you have any indications that these numbers refer to machine surfaces as opposed to operational surfaces that may not be perceived?

MR. STEVENS: No, sir. The testimony we heard yesterday was the purpose of these factors was to translate the ASME air data to components in reactors and one of the items included in that is surface finish. So that indicates that the surface finishes that were considered are consistent with components in nuclear reactors.

JUDGE WARDWELL: So to say it another way if, in fact, it was a machine surface, the recommendation may have been under here of a factor of 1.0 possibly.

MR. STEVENS: Possibly.

JUDGE WARDWELL: So the 4.0 accounts for those types of operational surfaces that you would expect.

MR. STEVENS: Yes, sir.

JUDGE KARLIN: Let me ask. On this chart on page 76 of NUREG 6909 -- Let me ask this of Mr. Stevens. These two columns, the present report and Section 3, are those CUFs or are they Fen numbers?

MR. STEVENS: Neither.

JUDGE KARLIN: Okay. Neither.

MR. STEVENS: Do you recall we talked about --

JUDGE KARLIN: They are the air -- Are they the air curve on smooth pieces of metal?

MR. STEVENS: They are adjustments to the air curve to come up with a design curve.

JUDGE KARLIN: Right. Okay. So they don't have -- They're not Fens. They are the air curve, smooth metal, adjusted to reflect some conservatism.

MR. STEVENS: Yes.

JUDGE KARLIN: Okay. So where is the Fen? Is there Fen? Where is the Fen -- These are not Fen factors.

MR. STEVENS: No.

JUDGE KARLIN: These are not environmentally adjusted in any way, shape or form. They don't say, well, you know -- Is a rough surface a different environment than a smooth surface or is there just not a Fen at all?

MR. STEVENS: These describe adjustments made to the curve prior to application of Fen factors.

JUDGE KARLIN: Right.

JUDGE REED: Mr. Stevens, to help my colleague, if you adjust the curve down by a factor of 4.0 it implies that the Fen also is -- Well, I guess the Fen goes up by a factor of 4.0, doesn't it? Isn't that --

JUDGE WARDWELL: Only the same. They are two different things. The factor of 4.0 is in recognition that you don't have a machine surface even in air so that you're reducing that to a recognition that you're not having a machine surface.

DR. HOPENFELD: No.

JUDGE WARDWELL: Is that a fair assessment, Mr. Stevens?

MR. STEVENS: Yes, that is.

JUDGE WARDWELL: Why is it not, Dr. Hopenfeld?

DR. HOPENFELD: Because -- Let's stick to the point in time. Because go back to where the original ASME Code comes from. It comes from laboratory tests. Then we have -- I said it already. Then they got altogether. So we know we don't have a perfect surface in a laboratory. We're using smooth surfaces and -- reproducibility. Let's make allowances. Okay. Then we made allowances and they say, "We made an allowance before." Okay.

JUDGE WARDWELL: Because it's not a machine surface.

DR. HOPENFELD: No. Because it is a machine. Because those tests we're doing -- with a machine surface.

JUDGE WARDWELL: Right.

DR. HOPENFELD: In real life, you're going to have a machine surface.

JUDGE WARDWELL: That's why you have 4.0.

DR. HOPENFELD: That's why they put 4.0.

JUDGE WARDWELL: Thank you.

DR. HOPENFELD: But now comes the concept that they have here and comes along and he says, "We want to get rid of all the curve. Okay. We want to get it out there and" --

JUDGE WARDWELL: Who is they? Who says this?

DR. HOPENFELD: The people who came -- The Argonne people with the hefty end concept. We want a curve that uses the -- In air, I want to take it out and put in, substitute, with a value, a light value, okay, a stress value versus fatigue cycles in air -- in water. The simple way of doing it is dividing the value and multiplying it by the same factor.

Do you see what I'm saying? That's -- Fen is a factor of any air divided by 10 or -- in -- what do you call it, in the reactor and Fen in air and divided it by the reactor and multiply by the ASMU which is the AMA argued that you got in the reactor.

MR. STEVENS: May I clarify?

JUDGE WARDWELL: Mr. Stevens.

MR. STEVENS: This factor, surface finish, on NUREG 6909 page 76, the factor of 4.0 for the Criterion Document and 2.5 to 3.5 in the present NUREG, the specimens that were tested mirror polished specimens. What's in a vessel are machine components, forged components. That factor is intended to account for that difference.

JUDGE REED: And can you say what the ultimate effect is on a Fen value that would be calculated for machine if you had the exact same transient on the exact same specimen except one is mirror polished and one has a surface roughness? How do these factors translate to the ultimate answer that we're looking for, the Fens?

MR. STEVENS: The surface finish is included in these factors that develop the curve. Therefore, you don't double-dip and do it again when you compute an Fen.

JUDGE KARLIN: It's not in the Fen.

MR. STEVENS: That's correct.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: The surface finishes are already accounted for in the --

MR. STEVENS: It's already accounted for. So there's no need to put it in the Fen.

JUDGE WARDWELL: Translation apply this factor of 4.0.

DR. HOPENFELD: I think that's a good --

JUDGE REED: I guess I need a better answer than that. I'm sorry. If I do a calculation of a CUFen for a mirror polished specimen and I do the same calculation for -- What I'm trying to understand is what these factors mean in terms of the ultimate limits that we're placing on these. So you have to help me understand whether a factor of 4.0 or a factor of 20 here, how does that translate into an effect on the calculated CUFen numbers?

MR. STEVENS: The calculations we did were components in a reactor. So we used a curve that had been adjusted for surface finish.

JUDGE REED: And if you had not used a curve that was adjusted for surface finish, what would -- how much smaller would the CUFens have been? Can you say?

MR. STEVENS: From Section 3, approximately a factor of 4.0.

JUDGE REED: That was my question. So it's directly proportional to these numbers.

MR. STEVENS: Yes.

JUDGE REED: Okay. Thank you.

(Off the record discussions.)

DR. HOPENFELD: Are we allowed to explain this a little, just a little bit about that?

JUDGE KARLIN: I think we are going to take a break for a moment. It's 2:30 p.m. We will reconvene in ten minutes. We'll take a break and adjourn for ten minutes. Off the record.

(Whereupon, at 2:29 p.m., the above-entitled matter recessed and reconvened at 2:41 p.m.)

JUDGE KARLIN: We're back on the record. Ms. Tyler, did we lose Dr. Hopenfeld?

MS. TYLER: I just asked one of the ladies in the back.

JUDGE KARLIN: Great. I'll wait until he comes in before I remind everyone you're still under oath. But I appreciate that you all have been sitting there for most of two days in the warm and heat and we're sitting here with glasses of water and enjoying ourselves and I don't think you have any sustenance over there. So a secret weapon. Okay. That's fair enough because it's been pretty warm.

I think our questions at this point are not for Dr. Hopenfeld.

JUDGE WARDWELL: I just want to make sure that he hears them though.

JUDGE KARLIN: Yes.

(Off the record discussions.)

JUDGE KARLIN: Ms. Tyler, could you go and get Dr. Hopenfeld?

MS. TYLER: Yes. Apparently he has injured himself downstairs and I think we need to go down and see what happened.

JUDGE KARLIN: Oh my gosh.

MS. TYLER: Yes. Hopefully

JUDGE KARLIN: Okay.

MS. TYLER: Hopefully, it's not serious. I'll be right back.

JUDGE KARLIN: Please do. Yes. Maybe we should take a short break.

JUDGE WARDWELL: Might as well.

JUDGE KARLIN: Why don't we take a five minute break and see if we can find out what Dr. Hopenfeld -- So we'll be adjourned for five minutes. Off the record.

(Whereupon, at 2:43 p.m., the above-entitled matter recessed and reconvened at 2:50 p.m.)

JUDGE KARLIN: We'll go back on the record now.

The Atomic Safety and Licensing Board is now back in session. I would remind the witnesses that you are still under oath.

Dr. Hopenfeld, are you all right? I understand you had an accident?

DR. HOPENFELD: I'm sorry for interrupting.

JUDGE KARLIN: No, that's all right.

DR. HOPENFELD: Actually, I wanted you to feel sorry for me.

JUDGE KARLIN: All right. Well, we'll work on that. You've been very patient, and there's been a lot of warm days and afternoons.

So I think we have some more questions.

JUDGE WARDWELL: I think we have pretty much finished up with surface finish, drain rate, oxygen and existing surface cracks or surface cladding, which seem to be the most important.

I surveyed my colleagues, and we are pretty clear on your position, Dr. Hopenfeld, on the other issues.

DR. HOPENFELD: May I just make one comment?

JUDGE WARDWELL: In what regard?

DR. HOPENFELD: I left you with the

impression that I felt that I had done something wrong. I didn't mean to do that. What I wanted to say is they just haven't gotten that far.

JUDGE WARDWELL: Thank you.

For Entergy, these -- with the notice that in fact this table was presented as part of the rebuttal, I wanted to query you in regards to whether or not you had any comments on the other ones that Dr. Hopenfeld has brought up in his rebuttal with regards to how you may have addressed these in your analyses.

JUDGE KARLIN: Let's clarify what the table is.

JUDGE WARDWELL: Yes, it's table one, page four of NEC JH 63.

And so the remaining other ones that Dr. Hopenfeld agrees are less important than the three most important ones are, deal with data scatter, size, flow rate, heat to heat variation, loading history, cyclic strain hardening, temperature below 150 which we really have covered, trace impurities in the water, and sulfite morphology.

If you have no additional comments, that's fine. Also, that is fine, see if you wanted to address how -- or refresh our memories of how these are addressed in your cumulative use factors, environmentally factored into that analysis.

MR. STEVENS: I guess the only thing I would say is that this table indicates that none of these factors were addressed in Entergy's analysis. I don't agree with that.

All but two of them were either directly or inherently included in the analysis.

JUDGE WARDWELL: And which two weren't either directly or indirectly included?

MR. STEVENS: On page six, we have already talked about item #13, existing cracks, and I had identified that was not relevant.

In item #11, it talks about trace impurities, and NUREG 6909 in fact points out that those kinds of things were not considered because it's not -- it's very improbable that any kind of an impurity would be present during a transient event. So therefore they did not feel it appropriate to evaluate.

JUDGE WARDWELL: Were all the others considered under 6909?

MR. STEVENS: Yes.

JUDGE KARLIN: Were they considered -- you mentioned considered under 6909. As I understand it, you didn't apply 6909. But they were considered by

Entergy, or were they considered by 6909?

MR. STEVENS: I would say both.

JUDGE KARLIN: Okay.

MR. STEVENS: With that comparison I testified on yesterday using a 6909 bounding the previous results.

JUDGE KARLIN: Okay.

MR. STEVENS: They are covered.

JUDGE WARDWELL: Thank you.

JUDGE REED: Dr. Hopenfeld, you claimed that Entergy used incorrect heat transfer questions in their analysis; is that correct?

DR. HOPENFELD: Yes, absolutely.

JUDGE REED: You agree? Do you believe that the heat transfer coefficient should have been larger or smaller than it actually is?

DR. HOPENFELD: I don't know, in some places it should be larger, in some places it should be lower. I wasn't concerned that much with the absolute volume but more with the distribution. And I would like to give you the background for that if I may.

JUDGE REED: Yes, please.

DR. HOPENFELD: When I was into getting into the area of calculating the CUF--

JUDGE REED: We've left the FDN, and we're now back on CUF.

DR. HOPENFELD: We're on CUF now, you're not on the FDN. There were two items here that I'll have to go through. And I left off about the Green function that we've talked a lot about this morning, and I'd like to give you my perspective, that is different from you hear from the grievants.

JUDGE WARDWELL: A little louder, please.

DR. HOPENFELD: My perspective is different than Mr. Stevens with respect to the refunction, and also, and then I'll talk about the heat transfers, which apply both to the Green function, Green's function, and the final element of the other analysis that they have done.

First, with respect to the Green function, what one has to understand that what the basic equation is that heat transfer, not linear heat transfer equation. When you go and make approximations by using the Green's function, what you are doing, you are linearizing that equation.

JUDGE REED: I'm a little puzzled. The Green's function has to do with how the stress is calculated.

DR. HOPENFELD: Correct. I said we are in the area of the CUF, not the CFEN. And the CUF does a phase in calculating the -- using the Green function and the finite element. Except it is not --

JUDGE REED: We're going to relate this to heat transfer?

DR. HOPENFELD: Yes.

JUDGE REED: You used the term, heat transfer equations.

DR. HOPENFELD: Right.

JUDGE REED: I think it's the heat transfer coefficients, the expression.

DR. HOPENFELD: No, no, I'll get there. But I will give you -- I am trying to elaborate what you were told this morning about the Green function. And I think it will be different, starting with the heat transfer. I mean I could go immediately to the heat transfer coefficients if you wish. But I thought I would give you the whole background.

JUDGE REED: Please help me understand what your contention is.

DR. HOPENFELD: Well, there are two items. One has to do with the Green function, which was discussed, and the heat transfer coefficient is equally important there.

JUDGE REED: Does the Green function

influence the heat equations, or are the heat equations evaluated with the heat functions?

DR. HOPENFELD: Well, we are about to suggest -- and that's why I was going -- because to answer your question I would like to talk about two things, and if I start with the Green's function, I think that will come out.

JUDGE REED: We'll listen to your comments about the Green's function.

DR. HOPENFELD: I'm sorry?

JUDGE KARLIN: Proceed with Green's function.

DR. HOPENFELD: And you will see where it goes. It does go to the heat transfer. I'll give you the exact words when we get there. So what you are going, because it is a nonlinear equation.

JUDGE KARLIN: Now what's a nonlinear equation?

DR. HOPENFELD: Well, the terms under the second differential equation depends on location and time.

JUDGE KARLIN: But what equation?

DR. HOPENFELD: The basic energy equation that describes the temperature distribution in a component from which they take the stresses.

JUDGE KARLIN: Is this the heat conduction equation?

DR. HOPENFELD: This is the heat conduction equation.

JUDGE KARLIN: Now I understand.

DR. HOPENFELD: I call it the heat transfer equation. This is the basic heat transfer equation.

JUDGE REED: This is diffusion theory?

DR. HOPENFELD: Correct. The terms is, the heat capacity, the conductivity, the so forth. And the reason I'm bringing it up is because they made several assumptions which are not justified, and it just went through there. And I want to make sure that you understand what is behind them.

They have linearized that equation. In other words, I assume that the properties could be used as an average volume.

Another place --

JUDGE REED: Pardon me, that equation is basically linear. It is only the properties.

DR. HOPENFELD: That is correct.

JUDGE REED: The thermal conductivity --

DR. HOPENFELD: Yes, conductivity, heat capacity, and density.

JUDGE REED: Are functions of the temperature of the metal, hence nonlinear.

DR. HOPENFELD: That's correct, the patterning of the temperature.

JUDGE REED: Okay, then I understand.

DR. HOPENFELD: But that's part of it. So what you are doing in the concept, we're in the concept here so you will see where I am going with this, what you are doing is basically, the beginning of the Green's function is taking the surface integral, it's a double integral; you convert them into a lining, right, you look beneath the surface, just like you know if you are in the farm, instead of looking at the cows, you look at what's going on with the fence.

What is important here for doing this, when you apply this when you have Green's function, one of the inputs is the heat flux coefficient. First off that's how you calculate the temperature.

So the heat transfer coefficient has to be constant, you see. That is one of the basic assumptions there that they had made.

My contention is that the heat transfer coefficient is not constant. And the reason for that it's not constant during the transient which you have a force convection flow, and it is not constant during the transients where you have a free convection flow, and you have condensation.

JUDGE REED: Let me see if I understand precisely what you say is not constant. I thought I heard you say heat transfer coefficient?

DR. HOPENFELD: Correct.

JUDGE REED: Now this is the coefficient expressing the heat transfer from the fluid to the surface of the metal; is that correct?

DR. HOPENFELD: Correct. It's written as K -- the heat flux H into the heat transfer coefficient times the bulk fluid, that's the wall temperature, or vice versa, that's being closed by either way. And that heat transfer coefficient, as I said, it's not constant, it's not constant along the symmetry -- along the nozzle, either in the X direction or circumferential.

You see the basic assumption of this asymmetric model that they have that all these properties are constant. Now why is that important?

If you go --

JUDGE WARDWELL: And all your discussion relates only to the three nozzles, is that correct? It doesn't --

DR. HOPENFELD: I am focusing on these three just for discussion. But anything else, because they are using different computer code in some type of pipe, what they call pipe, or proprietary code. I'm not too familiar what's in there. But I basically know when they have to.

But if you would please look at NEC JH-15.

JUDGE KARLIN: JH-15?

DR. HOPENFELD: Yes.

JUDGE KARLIN: Page?

JUDGE WARDWELL: That's another calculation summary from Structural Integrity Associates?

DR. HOPENFELD: No, there is a curve there, let's see if I don't have the page number.

(Pause)

DR. HOPENFELD: There is a curve in the document. I will talk about it if it doesn't come.

MS. TYLER: Dr. Hopenfeld, is that the stress/time.

DR. HOPENFELD: It provides the flat stress versus time with two different heat transfer coefficients.

MS. TYLER: That's on page one dash seven.

JUDGE KARLIN: This is page one dash seven of the exhibit? JH-15?

MS. TYLER: Yes.

DR. HOPENFELD: I thought I had the page marked, and then I didn't. So it's -- okay. But you see the point here is that this was provided by Entergy, and what it does is, it shows you the result, the thermal stresses, are very sensitive to the heat transfer coefficient.

This is average heat transfer coefficient; it doesn't recognize the local heat transfer coefficient, because they made assumptions that it doesn't vary.

In the meeting that we had on January 8th, we had --

JUDGE KARLIN: Meeting? What meeting?

DR. HOPENFELD: The meeting we had that -- the public meeting between NRC, public and Entergy, they had discussed the results of their calculations with regard to the CUF for the prenozzle, because they wanted to continue with that Green function, to use the Green's function.

And in doing so, one of the items that wasn't very clear was they indicated that any discrepancies were very important to the heat transfer coefficient. The results were very very sensitive to the heat transfer coefficient.

JUDGE REED: Now I have to question you about this particular figure, because this figure is making the point that the stress depends on the heat transfer it says for a different set of heat transfer coefficients representing different flow rate conditions.

MR. STEVENS: Correct. Correct.

JUDGE REED: Since this calculation was done by Structural Integrity, let me turn very quickly to Mr. Stevens, and ask him to explain to me what these two curves really represent?

MR. STEVENS: This is a, first off it's a typical representation for the purposes of describing the methodology in the report, so -- but it's showing the stress response to two different flow rates, same transient. It doesn't specify what flow rates. It's just showing as a typical example.

JUDGE REED: What was changed between the two curves? Was it just the heat transfer coefficient itself, or was it the entire assumption of what the heat transfer equation is struck, as Hopenfeld would call it, it looks like.

MR. STEVENS: This curve would have only varied the heat transfer coefficient.

JUDGE REED: Because different flow rates have different Reynolds numbers. So you have a Reynolds number dependence built into your heat transfer expression.

So what I'm trying to understand is, the coefficient in front is also dependent on the flow rate? Or is it just the Reynolds number to the point eight power?

MR. STEVENS: Just the Reynolds number.

JUDGE REED: Okay, so you really are not -- you are just changing -- this is just basically two curves at different flow rates.

MR. STEVENS: That's correct.

JUDGE REED: I don't get the point then.

JUDGE WARDWELL: Before we get to that, can I just fix one other thing?

In your confirmatory analysis this doesn't apply at all; is that correct?

MR. STEVENS: That's correct.

JUDGE WARDWELL: And it won't for the future, two other nozzles that will be evaluated using the same confirmatory analysis. This only applies to the refined analysis for those two?

MR. STEVENS: That's correct.

JUDGE WARDWELL: Thank you.

JUDGE REED: However, you would expect a similar curve, a similar dependence on heat transfer even with the confirmatory calculations, would you not?

MR. STEVENS: Yes, sir.

JUDGE REED: So the only thing that doesn't apply here is that you use this Green's function methodology, but a different, an improved methodology would produce similar curves, different but similar.

JUDGE WARDWELL: Well, it wouldn't linearize it as much, would it, as Green's function does?

MR. STEVENS: The effect of heat transfer on stress results depicted in this figure would be important to the confirmatory analysis. The Green's function shown in this figure would not.

JUDGE REED: So Dr. Hopenfeld, you were in the process of discussing.

DR. HOPENFELD: I want to make sure I'm not running ahead of myself. I'm going really step by step.

JUDGE REED: Well, you called our attention to this particular curve, and now I understand it, so we can move along.

DR. HOPENFELD: Yes.

JUDGE KARLIN: We don't want to go too step-by-step. Let's move it along if we can.

DR. HOPENFELD: The next step is the important one.

JUDGE KARLIN: Great.

DR. HOPENFELD: And what it is, it says, that because the two different velocities, you see, if I had doubled -- that's the first thing -- if I double the velocity, okay, I double the stress, I affect the changes in the stress, and that's the message of this graph, okay.

In turn the velocity affects the heat transfer almost linearly if you say the stresses are directly affected; it's very sensible.

MR. STEVENS: May I clarify from the standpoint of a fatigue analysis, would you care about peak stress? There is no difference between these two curves. The peak stress of the two curves near the coordinate is the same. So whereas the stress out at steady state is different, what is important to the fatigue analysis is the peak stress, and in this particular case those two curves are not distinguishable.

So depending on the heat transfer level, it may or may not have an impact on the stresses of interest for fatigue analysis.

DR. HOPENFELD: Can I say --

JUDGE KARLIN: Please respond.

DR. HOPENFELD: Because that is not where I'm going. I will just tell you that you don't want to come from nowhere and tell you there's a relationship between different velocity and different stress modes. That's all I'm trying to say here, in setting out the basis. You see the affected velocity on the stress level.

Now they made the assumption that the velocity is similar throughout the flow, and I'll define similar in a minute; and they also made the assumption that there is now circumferential difference in the velocity, and because of that there is no difference in the heat transfer coefficient, and the temperature is uniform throughout the whole thing.

How does that affect, how that assumption affects the -- where he picks up -- decides where the maximum stresses are is something that I cannot say. But I can show you from this that the effect is significant on the local stresses.

Now so the next thing is, we look as to why -- what is the justification for them to neglect the velocity distribution throughout the nozzle, both circumferentially and axially.

JUDGE REED: Now, can we pause there for a moment, and let me repeat back to you what I think you said, and see if I understood correctly.

If I'm understanding, your point is that if we go take a point in the nozzle and go circumferentially around the nozzle, that the flow field may be larger at the top of the nozzle than it is around the bottom. Hence the heat transfer coefficients would be different as we go around the nozzle.

And your contention is --

DR. HOPENFELD: And axially.

JUDGE REED: And by axially, you mean as you move along the length of the pipe.

DR. HOPENFELD: Yes.

JUDGE REED: So whereas the bulk flow through the nozzle is constant. So if they used this bulk flow to determine a single velocity, then they would not -- your conjecture or your assertion is that Mr. Stevens used a constant heat transfer across the entire surface, the inner surface of this nozzle.

DR. HOPENFELD: Right.

JUDGE REED: And that if he had varied the heat transfer coefficient, it would have caused significantly higher stresses --

DR. HOPENFELD: Correct.

JUDGE REED: -- to be calculated in the nozzle?

That seems to me on the face of it to be a plausible argument. Could I ask you to respond, Mr. Stevens?

MR. STEVENS: Yes, would you like me to respond with respect to the refined analyses or the confirmatory analyses?

JUDGE REED: Well, I think both.

MR. STEVENS: Well, the refined analyses used -- well, let me back up.

Heat transfer, I agree, is a function of velocity and temperature. So we need to account for those in our calculations.

One way I can do that, because it is commonly recognized by analyses of this type that the higher the heat transfer coefficient you apply, the more conservative your stress results are, because you increase the heat transfer and introduce larger temperature differentials in the component which would lead to higher thermal stresses.

So if I am going to do a linear

integration technique like the Green's function, it is important that I pick a bounding heat transfer coefficient if I'm only going to use one single value.

When I do the Green's function, I do have to use one set of heat transfer coefficients.

JUDGE REED: One set meaning uniform on the entire surface, inner surface of this nozzle?

MR. STEVENS: One set as in we would transfer different values of heat transfer coefficient along the component where appropriate. But in each region there would only be one value of heat transfer coefficient.

JUDGE REED: What would a region be?

MR. STEVENS: A region would be an area where it is constant, say diameter. So therefore the velocity in that region would be the same.

JUDGE REED: I see.

MR. STEVENS: I change diameter, that's another region, I need to use another diameter because the velocity changes.

JUDGE WARDWELL: And you designed your finite element mesh to be able to do that in the regions of your interest, to change that heat?

MR. STEVENS: Well, an input to our finite -- not exactly. Yes, our model is built with those transitions in it. But an input to that model is heat transfer coefficients. So when we calculate those heat transfer coefficients, we have to take account of those different diameters in the model.

JUDGE WARDWELL: But your mesh is still also designed so that you can put them into the model --

MR. STEVENS: That's correct.

JUDGE WARDWELL: -- and not only calculating from those regions, but it gives you an opportunity as an application point for those coefficients.

MR. STEVENS: That's correct.

So I would calculate for each one of those regions a value of heat transfer coefficient. And I would pick it to bound flow rates, and temperatures that the component will seek.

So for these 20 transients that we talked about yesterday, where the flow rate might range from very low to very high, I would pick the highest flow rate to compute my heat transfer coefficients.

JUDGE WARDWELL: And is that what you did during the refined analysis?

MR. STEVENS: Yes.

JUDGE WARDWELL: Thank you.

JUDGE REED: So again you believe you are picking conservatively large heat transfer coefficients that would yield maximum stresses?

MR. STEVENS: Yes.

JUDGE REED: Or conservatively large stresses.

MR. STEVENS: We calculated heat transfer coefficients to cover these effects I just mentioned, velocity and temperature, to bound those effects.

JUDGE REED: Now in these models, your model, your finite element model of this nozzle is two-dimensional or three-dimensional?

MR. STEVENS: It's an axi-symmetric model which you have seen in cross section and it's two dimensional.

JUDGE REED: So that's two dimensional.

MR. STEVENS: But it is treated as a solid revolution. The computer program can actually give us stresses at different azimuths circumferentially.

JUDGE REED: How would it do that if in fact you have no mesh grid in that azimuthal direction?

MR. STEVENS: It's a technique of the finite element program that if all conditions are the same, you tell it that, it will compute the same answer around circumferentially. But it also gives the ability, a good example is moment loading on these nozzles. It does allow you to supply non-symmetric loading to that component, and then it will properly compute the stresses around the circumference of that component for that non-symmetric loading.

So the conditions have to be right in order to use that model for those. They have the ability to analyze certain non-symmetric loads, like applied mechanical loads, but not things like temperature transients. So the temperature transients are assumed to be uniform around the circumference.

If you wanted to take into account those kind of effects, where appropriate, you would have to build a three-dimensional model that also included the circumferential portion of the structure.

JUDGE REED: Would it be excessively difficult to build that model?

MR. STEVENS: It does take a significantly longer amount of time to perform these analyses using such a model.

JUDGE WARDWELL: Certainly more than 30 percent more time that the extra direction might indicate?

MR. STEVENS: That's correct.

JUDGE WARDWELL: What about your confirmatory analysis? Are we ready to move on?

JUDGE REED: I'm not sure we're done with heat transfer.

JUDGE WARDWELL: No, I mean what he did, he said this is what he did for the confined. Now what you do for the confirmatory.

MR. STEVENS: On the confirmatory evaluation, since we modeled the transients in the finite element model, apply them as the temperature variation, now we have the ability to change the heat transfer coefficient through that transient, since we are modeling it, as opposed to the Green's function, where we want to make sure we bound it because we are going to use that result to integrate the stress response of this transient, and that process requires us to have a constant value for that integration process.

So we kind of have one shot at heat transfer in a Green's function input. And the confirmatory evaluation, much more sophisticated, we can specify it throughout the transient.

So we can vary heat transfer as a function of temperature and flow rate during that transient as it would occur during the confirmatory analysis.

JUDGE REED: Wouldn't you expect significantly larger shear stresses at the nozzle corner if in fact there was considerable variation in the heat transfer coefficient azimuthally around that opening? And isn't that not accounted for in your model?

MR. STEVENS: We -- our axi-symmetric model does not account for circumferential variations in temperature. There is no indication -- I mean that would be an inappropriate assumption under the transients and the high flow rates we are using.

JUDGE REED: Well, it was Dr. Hopenfeld's conjecture that in fact the heat transfer coefficients would vary significantly as we go azimuthally around the nozzle. That would lead to a significant fluctuation in the temperature field azimuthally around the nozzle. That would lead to larger shear stresses, would it not?

MR. STEVENS: Under the conditions we are evaluating, I don't known of any circumstances where that would come into play.

JUDGE REED: So you don't --

MR. STEVENS: I don't agree with that assessment.

JUDGE REED: You don't agree with the

assumption that the heat transfer coefficient varies around the -- is that --

MR. STEVENS: That is correct, for the condition, these transients that we are evaluating, yes, I agree.

JUDGE KARLIN: Are you saying it didn't happen, or it's not scientifically correct?

MR. STEVENS: Not scientifically correct.

JUDGE REED: I'm sorry, now what does that mean, not scientifically correct?

JUDGE KARLIN: I withdraw the question.

JUDGE REED: Because I believe it's scientifically correct to say you have got a significantly distorted temperature field as you went azimuthally around the nozzle, that you would develop fairly large shear stresses.

JUDGE KARLIN: Right, now let's ask that question, is that scientifically true? Do you agree with what he just said?

MR. STEVENS: I agree with that.

JUDGE KARLIN: Okay. I thought you said the opposite a moment ago.

MR. STEVENS: Well, what I was saying is, for the conditions we are evaluating --

JUDGE KARLIN: You're saying it just

didn't happen here.

MR. STEVENS: That's correct.

JUDGE KARLIN: So scientifically the proposition Dr. Reed just said, yes, you agree with the proposition that Dr. Hopenfeld stated you agree with, but you are just saying it didn't happen here?

MR. STEVENS: Yes, I agree.

JUDGE WARDWELL: And why doesn't it happen here? You mean by happening here is for the modeling associated with Vermont Yankee?

MR. STEVENS: Yes.

JUDGE WARDWELL: And why -- I guess I don't understand what you mean by, didn't happen here. You didn't incorporate it, or it physically doesn't happen at Vermont Yankee for whatever reasons?

MR. STEVENS: Given the conditions we are evaluating, that does not happen. We have very high flow rates causing these significant transients on these nozzles, fully developed flow that would not allow for those kinds of temperature variations.

JUDGE WARDWELL: So now it seems like we are getting down to whether or not you have fully developed flow.

DR. HOPENFELD: I would like to say that Mr. Stevens is scientifically wrong. And if you please go to NEC JH-14, 10.

JUDGE REED: Fourteen, page 10?

DR. HOPENFELD: Right, this is feedwater piping, it's a sketch, it's a cartoon of the feedwater piping in -- at VY that we were given.

JUDGE REED: Where is the vessel in this? Where is the nozzle?

DR. HOPENFELD: I believe it's on the top there. By the two hangers there. Hard to see. But my point here is, Mr. Stevens makes the assumption that it doesn't happen, then he said it doesn't happen.

He said the flow is fully developed because it's 48 inches.

JUDGE REED: Because what?

DR. HOPENFELD: Because it's 48 inches away from the entries.

JUDGE KARLIN: You're saying there is a linear flow of 48 inches and therefore he says it's fully developed, and you are saying 48 inches is enough for it to be fully developed.

DR. HOPENFELD: That's the next dialogue.

JUDGE KARLIN: Oh, yes.

DR. HOPENFELD: But let me first say what is a fully developed flow. Fully developed flow is a flow where the velocity is similar everywhere along the pipe. If you take a cut section somewhere, anywhere, the velocity distribution for turbulent flow is going to be like power, one-seventh power, and it is well established.

If you go somewhere else, it's all the same. It's similar. When you come for undeveloped flows, for an undeveloped flow, and I am talking about force convection now -- there are two items here I want to talk -- one is force convection, another is pre-convection, because some of those transients are both.

I am going to go now to the force convection first. If he says that all you need is 48 inches, and this 48 inches, you look at this figure, that's exactly what it is. If you look at the data, before you look at the data, you usually in engineering terms, you need 48 inches for the feedwater. The feedwater diameter is about 10 inches, so you are talking about four diameters, five diameters.

Usually in engineering --

JUDGE REED: Well, can I stop you? We are looking at this exhibit, NEC JH-14, page 10, and there is a Figure 1, and where does it say 48 inches?

DR. HOPENFELD: That is the --

JUDGE REED: You said it's right here.

DR. HOPENFELD: Yes, it's right here. If you look on the top you see a scale there. But you can't read the scale. If I try to strain my eyes, and I really don't want to cause you to do that. But you can see it's around four to five. But he claims it's four.

JUDGE KARLIN: What's 45?

DR. HOPENFELD: Four to five inches.

JUDGE KARLIN: What is?

DR. HOPENFELD: I mean four to five feet; it's about 48 inches.

JUDGE KARLIN: What is?

DR. HOPENFELD: The length of the pipe from the elbow to where it enters the nozzle.

JUDGE REED: We don't see -- we don't even know where the nozzle is.

DR. HOPENFELD: Well, I think there's a nozzle in the end there, you see the very end. But if you can't see very well, I can't either. Mr. Stevens testimony is that the length is 48 inches, from the straight line is 48 inches.

JUDGE WARDWELL: So why did you have to refer us to this figure? All we have to say is, his testimony is that it's 48 inches.

DR. HOPENFELD: Right. Because you can see it with your eyes --

JUDGE WARDWELL: No, you can't, that's what I'm saying. And you can't say it either, you can't point to where it is.

DR. HOPENFELD: Okay, but there is a point I want to show the figures too, because it's not only that straight actor. There's a whole -- I have a reason to get there.

JUDGE WARDWELL: You are arguing about the 48 inches in regards to developing flow? You think it should be longer?

DR. HOPENFELD: Oh, yes. Let me just say why. First of all I provided you data here showing --

JUDGE KARLIN: Well, why don't we -- let's all take a time out here. Do we have any questions? Where are we in terms of questions?

JUDGE REED: Well, the subject was heat transfer coefficients. And I think I am essentially done.

JUDGE KARLIN: You don't have anymore? You are done? Rich?

JUDGE WARDWELL: Yes, I do. I'd like to go back to Mr. Stevens, and ask him to defend the 48 inches for uniform flow, fully developed flow, because I think that hinges on how you do your justification for the selection of your heat coefficients.

MR. STEVENS: Okay, I'm going to actually point to one of Dr. Hopenfeld's exhibits, NEC JH-29.

JUDGE KARLIN: Okay, we're there.

MR. STEVENS: That's a two-page extract of a textbook, Heat and Mass Transfer by Eckhard. I'm looking at the second page which is page 212 of the textbook, Figure 8-9. What this figure is, it's not really applicable to the conditions and geometry we have, but it's useful for me trying to answer your question.

This says, this is flow near entrance of a tube. And the chart is showing what is called the Nusselt number on the ordinates, NU, and that is proportional to the heat transfer coefficient.

As a function of X over D, which is the distance downstream of the tube entrance, as nondimensionalized to the diameter of the tube, so if you will what this graph gives us is a variation of heat transfer downstream from that discontinuity.

Now we don't have a sharp entrance to a tube; what we have is an elbow, and therefore the discontinuities associated with this, this would be overstating it. But nevertheless, let's take a look at it.

The other thing you will see on this picture is several lines that is a function of Reynold's number. And given that we are looking at a constant diameter tube, these lines would indicate increasing velocity in that tube as you move vertically up the chart. Higher Reynold's number, higher velocity.

What you see here is -- and actually as you look to the far extreme right of the curve, of these curves, that would be indicative of fully developed flow, what the heat transfer coefficient does for fully developed flow.

What you see with increasing velocities is that these lines flatten out. The effect of that entrance becomes more and more insignificant.

Now the part of this graph that is not really applicable to some of our nozzles is the Reynold's number. This goes up to -- the largest Reynold's number is 101,600; it's one E to the five.

Our Reynold's number in the upper E to the five to the mid-E to the sixth range, well off the chart here.

But I think if you look at the tendency of this chart is, you can see that the effects of the entrance are diminished. And now when you add to the fact that we don't have an entrance; what we have is an elbow. These effects of using fully developed flow are appropriate. And in fact that's what has been done in our industry in piping for more than 40 years, as Dr. Hopenfeld testified yesterday, the way we do these analyses has been very robust, and hasn't changed in 40 years, with respect to this element. In fact these textbooks we are looking at, the methodology has been well developed for many years longer than I've actually been around. It has not changed; it's still consistent.

And all the commercial piping codes still use this methodology. I'm not aware of any instances of any components in our industry where it's been shown that the relationships we are using are inappropriate or nonconservative.

JUDGE REED: Dr. Hopenfeld, what would you use in regards to the number of diameters --

DR. HOPENFELD: Could I answer the --

JUDGE REED: -- flow.

DR. HOPENFELD: Can I make a comment about --

JUDGE REED: I would like you to answer my question.

DR. HOPENFELD: What would I use?

JUDGE REED: What do you -- what do you recommend being used as a number of diameters to develop fully developed flow?

DR. HOPENFELD: Oh, okay, I would say that for this -- that for their application it would be, at the minimum, at the very very minimum, 12. I would say that you probably would go up to 40.

JUDGE REED: Forty?

DR. HOPENFELD: Forty. Let me tell you why, where the 12 comes.

JUDGE REED: I'm not interested -- yes, I want to know the basis of that.

DR. HOPENFELD: You try to put a flow meter in a line. You just want to measure your flow. You are going to talk to the vendor, and he will tell you you need at least 100 feet in order to get accurate readings on your flow meter so the flow would be similar; it would be fully developed.

And he will tell you, well, I don't really believe -- they don't need that kind of accuracy. What you need is a flow meter, because especially if you are running and gauging fuel.

So the guy will tell you, well, you could put a flow straightener ahead of that component so the flow is not going to be -- you have all these tornadoes around, it's going to be fully developed.

But you still have to have even with a flow straightener some section ahead which is straight, and then you ask, you know, what -- how straight should it be? And so what it depends what's up there, if you have an elbow or you have a valve, or whatever you have, an elbow is one of them. An elbow by my memory, the minimum number is -- like one of the twelve and a half diameters with a straightener. If you don't have a straightener, the customary engineering number is hedging for years. It's not today. This is a new invention here, what we got. It's been for -- since I can remember going to school.

And this I gave you, this is just an example and it -- the -- because this is easy to understand what's needed. But it -- the flow is going to be different whether you are downstream from the valve or you are downstream from the elbow.

JUDGE WARDWELL: Thank you, I think you answered my question, thank you.

Dr. Reed?

JUDGE REED: Dr. Hopenfeld, in your testimony, JH-03 on page 20, you give a table in which you recalculate your own CUFen numbers.

DR. HOPENFELD: Yes.

JUDGE REED: Page 20, there is a table, Table 3, recalculated cumulative usage factors for sample locations.

Do you have that table?

DR. HOPENFELD: Yes, it's on page 20.

JUDGE REED: So you -- you would propose that for Vermont Yankee that these are more appropriated CUFens than the ones they calculate, is that correct?

DR. HOPENFELD: Correct.

JUDGE REED: Now the largest CUFen that you calculate is 13.77 on a particular outlet and all --

DR. HOPENFELD: Yes.

JUDGE REED: Is that correct?

DR. HOPENFELD: Yes.

JUDGE REED: So if I use the definition of a CUFen, and apply it to that particular component, then I would maintain that one would expect failure of that component, since this was calculated for 60 years; correct?

DR. HOPENFELD: That's correct.

JUDGE REED: You assumed 60 years for the

--

DR. HOPENFELD: That's correct. I used their numbers.

JUDGE REED: Then would you not expect failure of that component in 4.63 years?

DR. HOPENFELD: I don't know, I do not know how to relate these numbers --

JUDGE REED: By the very definition of C-U-F-e-n.

DR. HOPENFELD: Well, yes, for the -- regarding the definition of term, which I really wanted to elaborate on that, because it depends how people define, how they got the number of cycles under what conditions, whether it was engineering crack, or whether it was complete failure. I would say this is all statistical. The higher the number --

JUDGE REED: Of course it's statistical, but there is a definition fo what this factor is supposed to mean.

DR. HOPENFELD: Right, it means potential failure, but it doesn't mean --

JUDGE REED: It means that you are way past failure. You expect failure in much shorter than 60 years.

DR. HOPENFELD: Well, you have to

understand the way they defined their FEM and the way their FEM has been used here, it's an engineering crack.

JUDGE REED: No, I'm talking about a definition. There is a very simple definition of both a CUF and an FEN. So it's the number of cycles to failure, divided by - I'm sorry, the expected number of cycles, divided by the number to failure.

DR. HOPENFELD: Correct, but the number to failure doesn't mean that it really has to fail.

JUDGE REED: No, no, that's the definition. It has to fail.

DR. HOPENFELD: By definition, it has to fail.

JUDGE REED: That is the definition of this factor. You are talking about conservatisms built into how we calculate it. I'm talking about the definition.

DR. HOPENFELD: But sir --

JUDGE REED: I can put it to you, sir, that if you calculate a number, 15.77, for a 60-year analysis, that you are predicting failure in four years, or a little over four years.

How can that be possible?

DR. HOPENFELD: I don't predict it. I

don't believe that that's what it is.

JUDGE REED: That's your number.

DR. HOPENFELD: Yes, my number is 13.7, but I don't agree with your supposition that this relates to -- that there is a correlation between this number and when it fails.

JUDGE REED: Given that the plant has not failed, that none of these nozzles has failed, how can you justify proposing that the CUFen numbers could possibly be as large as what you propose?

DR. HOPENFELD: How can I justify? All this says, all these numbers say, and I think that's what the ASME code, to the best of my understanding, and what the guidance are, to say if you have -- and I believe that Mr. Stevens talked about that too -- it doesn't mean everything falls apart once that number is about one. All it says, when you reach about one you have got to do something. I cannot buy your supposition --

JUDGE REED: Even if I accept your point, that it doesn't fall apart, just major cracking occurs, we have not seen major cracking in any of these components in 30-something years of operation. And yet your CUFens predict that they fail in periods of time that would be substantially shorter than that.

Hence I have to infer that your calculations are extremely excessively conservative.

DR. HOPENFELD: They are conservative, but I'd like to explain why.

JUDGE REED: Well, I'm concerned that these CUFens that were 100 or 200, but that doesn't mean that they are appropriate for use in licensing.

DR. HOPENFELD: Well, for the reason that this tells you, this is the guideline, it tells you, because of this I have got to do something. They calculate it in such a way that less than one they say you don't have to do anything.

All this says, you've got to take an action.

JUDGE WARDWELL: Let me ask it in this way if I might. It seems to me that the CUFens that you calculate are highly dependent on the FEN that you selected.

DR. HOPENFELD: Correct.

JUDGE WARDWELL: What is your technical justification for a selection of 17 and 12 for stainless and carbon steel, specific technical basis.

DR. HOPENFELD: Specific technical base, the specific technical base that in the abstract of your 6909, the people have -- that came up with these equations to calculate the FEN have done research and have looked -- and I've counted about 41 different papers -- different research and concluded that you could have bounding numbers, conservative numbers, which are -- would vary. One major difference between 6909 and 6583 is that this gives you a guideline.

But I'd like to say one more thing --

JUDGE WARDWELL: Are you saying Argonne recommends these things?

DR. HOPENFELD: Yes, I'll give you the reference.. Let me just read this thing to you please. That's the most important thing in the whole presentation.

This is in the abstract of the -- of NUREG 6909. That's what this thing does.

JUDGE KARLIN: You are saying they recommend this for all plants and --

DR. HOPENFELD: There --

JUDGE KARLIN: -- in lieu of that there are no other values.

DR. HOPENFELD: The implication as far as I'm concerned, there is an uncertainty in this technology, and we gave into bottom numbers.

JUDGE KARLIN: But that's not an application of that in a practical sense then; is that correct?

DR. HOPENFELD: I think it is. Because it doesn't say -- I don't buy into the proposition that in fact it's 12 even if it was 20. The fact that this falls apart.

JUDGE KARLIN: Well, point us to where that is anyhow.

DR. HOPENFELD: All I'm saying, it doesn't take -- You can run up, I have done it --

JUDGE KARLIN: Point it out, could you, where 17 and 12 is used here?

DR. HOPENFELD: I'm sorry?

JUDGE KARLIN: In 6909 you say, 17 and 12 --

DR. HOPENFELD: Yes, I'm just trying to get --

JUDGE KARLIN: Could you point that out so we have it on the record?

DR. HOPENFELD: Yes, I am just trying to find where the exact word is.

JUDGE KARLIN: Well, why don't we give you time, and you can come back to us later with where that is.

DR. HOPENFELD: Oh, I know where that is.

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

DR. HOPENFELD: It's in the abstract. It's on the top of that page.

JUDGE KARLIN: That's okay. Just take your time and find it. We'll get back -- you can just give it to us later, give it to your counsel.

DR. HOPENFELD: Can I make just one comment if I could say, I would like to --

JUDGE KARLIN: Well, let's just stop here. Let's look at NUREG 6909, I have the abstract in front of me, Dr. Hopenfeld. I think we should all refer to that. Because it does appear to me that there are a number 12 and a number 17 show up on that page. I'm not sure what they all mean, but hopefully somebody will explain that to me.

And in the abstract, on page triple I, is this what you are referring to, quote: Under certain environmental loading conditions fatigue lives and water relative to those in air can be a factor of 12 lower for austenitic stainless steels, three lowers for nickle-chromium-iron alloys, and 17 lowers for carbon and lower alloy steels.

Is that where you are getting the 12 and 17?

DR. HOPENFELD: That is exactly what I was referring to, saving time looking it up here.

JUDGE KARLIN: I'm not sure what that means, but I found the numbers for you. You tell us -- do my colleagues have any questions? Does that mean anything?

So that's where your numbers came from on this chart?

DR. HOPENFELD: Yes, yes. For the FEN.

JUDGE KARLIN: The FEN.

DR. HOPENFELD: The original came from the application.

JUDGE KARLIN: All right.

JUDGE REED: Mr. Fair, what gives you confidence in the analysis performed by Entergy?

MR. FAIR: Well, I have to say I was not the reviewer on these analyses. I think based on the safety evaluation report, though, we did have a review of these calculations that determined that the parameters input were adequate, and the analysis methodologies were adequate.

That's the basis for my conclusion that they have an acceptable calculation.

JUDGE REED: So you believe that -- let's talk in terms of their refined analysis -- you believe their refined analyses are conservative. I think there is a statement in the testimony by the staff that the staff believes the refined analysis were conservative.

MR. FAIR: The confirmatory analysis of the feedwater nozzle came up with a lower ultimate CUF than the defined analysis, so that it did demonstrate that the original refined analysis for the feedwater nozzle was conservative.

JUDGE REED: So it's still the position of the staff that all of the refined analyses for all nine locations are conservative?

MR. FAIR: No, that is not the position of the staff. The fact that the feedwater nozzle confirmatory analysis came out to demonstrate that the refined analysis was conservative in that particular nozzle, we couldn't draw a conclusion that the same level of conservatism would exist in the other two nozzles, which is why we requested that they do further confirmatory analysis.

JUDGE REED: Were you completely comfortable with all the changes that were made to do the confirmatory analysis?

MR. FAIR: Again, I was not the one who went in an audited and reviewed that analysis. But I believe based on what I've read in the essay, the review of that analysis, that it -- that that analysis was adequate.

JUDGE REED: Even though that analysis assumed that -- used a different FEN technology, a different assumption, instead of using a single environmental factor applied at the tail end of the calculation, they used different FENs for each transient I believe, and the net effect was that the correction factor, the FEN applied, was substantially lower in the confirmatory analysis of the feedwater analysis than it was for the refined analysis.

You are still comfortable with the way that was done?

MR. FAIR: Yes, I am comfortable with using the FEN that applies to the transients being analyzed for each fatigue usage calculation.

JUDGE REED: So why then did the staff ask after the fact, ask that Entergy go back and apply the original FEN to the new CUF that was calculated in the confirmatory --

MR. FAIR: Well, the reason that the staff did that was to try and determine whether we could use the feedwater analysis as a confirmation for all three nozzles, so we wanted to get as close to a one-to-one comparison of the two analysis methodologies as possible, with only the Green's function being a difference.

And when that analysis came up higher than the original analysis, then we decided we couldn't assume that they were going to get the same level of additional conservatism by breaking the transients up and looking at an FEN for each transient, without further confirmatory analysis.

JUDGE REED: And that's what led you to require that Entergy do additional calculations of two more nozzles?

MR. FAIR: That's correct.

JUDGE WARDWELL: That calculation will include individual events for each transient?

MR. FAIR: Well, we didn't specify how they are going to do it. They could -- the CUFens are fairly low on those two nozzles. They may make a conservative assumption --

JUDGE WARDWELL: Just to save time?

MR. FAIR: -- just to save time.

JUDGE REED: Okay.

JUDGE WARDWELL: Quick question while we are on JH 03, we had that out for Dr. Hopenfeld on page 16 of that. I'll quote you, so I think you will remember it anyhow.

It said: In my opinion -- this is you saying this -- the number of transients proposed by Entergy should be a minimum multiplied by 1.2 to account for the probability of an increase in unanticipated failures due to the 20 percent uprate, power uprate.

How did you arrive at the 1.2 number?

DR. HOPENFELD: Okay, as we briefly talked the other day, with the -- from the information given to us, from the information given to us, the first time, I thought I understood how they calculated the numbers. They took the number of transients today after 40 years, multiplied that number by 1.5, and that was the number of transients.

Then there was a change evidently. And then when I went to read -- when I read and I quoted to you what Entergy stated, it was difficult for me to understand how they arrived at that number. They had -- they talked about it, but they haven't really indicated how they got it, and what kind of changes were involved with in the past. Because I don't know what they were counting. They didn't really give us data from day one. I don't know whether some of these changes were more severe or less severe.

JUDGE WARDWELL: How did you arrive at

1.2?

DR. HOPENFELD: I arrived at 1.2 through judgment because they increased the power by a factor of 20, and I wanted to account for the fact that under EPU conditions, even recent experience shows that the proprietary a few years ago, as the EPU and the power is increased, I want them to take into account that factor.

JUDGE WARDWELL: You selected it using engineering judgment?

DR. HOPENFELD: Oh, completely engineering judgment. I needed a hangar to hang my hat on.

JUDGE REED: Well, just a quick follow up to that, what is the experimental observation, what, two years of operation now at increased power, have you seen an increased number of transients in that period? I'm assuming you are tracking these transients, so you should now?

MR. FAIR: The only transient we had since power uprate and the normal shutdown for the 2007 fuel outage was in August running at 25 percent power. We went down in the spring to the refueling outage, or the plant. We went down in the spring for the refueling outages. There were no transients during the power extension phase. Not even the test transient. We actually did a test transient. It did not -- the feedwater pump trip test phase. But that was part of the EPU power extension plan.

JUDGE REED: Was the change in power level held as transient?

MR. FAIR: Yes.

JUDGE REED: Didn't you recently change power level?

MR. FAIR: Power level went up. The power level at EPU, they had this big test to show that if they lost one of their Carter tank pumps, the feed pumps will -- research all that before you got your reduced power.

JUDGE KARLIN: So you had a transient in August of 2007. This was unplanned reduction in power as a result of the problem with the cooling structure? Okay, so there was a transient there.

Did you have a transient two weeks -- a week ago when you had another problem with the cooling switch?

MR. FAIR: Yes, when they were at 25 percent power, they tripped.

JUDGE KARLIN: Okay, let me ask. What I'm trying to get to is, I guess, from the first, from the point of startup to the uprate there was a certain number of transients that occurred over a certain period of time, from the point of uprate to today there are a certain number of transients that occurred over a certain period of time.

Has the rate increased, decreased, or remained the same?

MR. FAIR: We've got three data points. I'd say -- I wouldn't characterize it as an increase. It may have decreased. But it's a small --

JUDGE KARLIN: You are saying it's a small data point, small timeframe. I understand the small timeframe. But if you extrapolated that out for, you know, the 36 years or whatever minus the time since the uprate would you have the same number, more or less?

MR. FAIR: Same, probably.

JUDGE KARLIN: You haven't done that?

MR. FAIR: I don't have those numbers, no.

JUDGE KARLIN: So you don't know whether it's increasing after the uprate, or decreasing or the same?

MR. FAIR: No.

JUDGE KARLIN: Okay. Did you have something on that, Mr. Stevens?

MR. STEVENS: No, sir.

JUDGE WARDWELL: Mr. Fair, in your experience, reviewing -- well, let me ask you, how many license renewal applications have you reviewed?

MR. FAIR: It's more than a dozen. I don't have a count.

JUDGE WARDWELL: That's fine.

Cumulative use factors are calculated as a predictive mode in the license applications; is that correct?

MR. FAIR: That's correct, yes.

JUDGE WARDWELL: Is it fair to say that these are continually calculated and recalculated during actual operations once we get into -- once the plants get into the renewal period as a tracking tool?

MR. FAIR: Well, there are two ways they do it. One is to monitor the actual fatigue usage and track that.

Another method is to count the number of cycles that were used in the calculation, and assure yourself that you don't exceed that number of cycles, and therefore that verifies the CUF --

JUDGE WARDWELL: So it's essentially doing the same thing in regards to that?

MR. FAIR: Correct.

JUDGE WARDWELL: It's used in some fashion as a tracking tool; is that correct?

MR. FAIR: Correct.

JUDGE WARDWELL: And those are really two different types of applications of the CUFs, isn't it? One is a predictive mode, and one is a tracking, monitoring, and however else you want to call it, type of mode during operations?

MR. FAIR: That's correct.

JUDGE WARDWELL: Thank you.

JUDGE KARLIN: I have, Mr. Fair, probably these questions are for you, relating to what I'll call commitment #27. If you could refer to the FSER, which I guess is staff Exhibit No. 1, and we will go to page 4-34 again.

I'm interested in what y'all refer to there as commitment #27, and there are four pages in the FSER, 4-34 to 4-37 inclusive I think, that spent almost the bulk of the time talking about the evolution of this commitment, #27.

Now I understand you didn't do the review. Mr. Chang, Dr. Chang, did the specific review here. But perhaps you can help me.

MR. FAIR: I'll try.

JUDGE KARLIN: Okay. Now on page 4-34 in the I guess the second full paragraph on that page, you start talking about, the staff reviewed the applicant's commitment #27 which was provided in a letter dated July 26th, 2006.

So that was way back there in 2006 they came in with a commitment #27, I guess, that's what it reflects. Then later in that paragraph it talks about January 4th, 2007, the applicant provided a revised commitment #27, all right.

You see that?

MR. FAIR: Yes.

JUDGE KARLIN: Agree that's there?

Then over on page 4-35 in the one, two, three, four, five, the fifth paragraph down, we have yet another revised commitment #27 of July 3rd, 2007; right? You see that?

MR. FAIR: Yes.

JUDGE KARLIN: You agree with that?

And then the next page talks about a letter dated July 30th, 2007, from the applicant. You follow that? And there is a long quote that goes into 4-37, page 37, right?

MR. FAIR: Right.

JUDGE KARLIN: You have to speak so he can record it, yes?

MR. FAIR: Yes.

JUDGE KARLIN: Okay, because what I'm trying to get at is, you know, let's see if I can find that other exhibit, this conversation that took place on August 20th, around 2007, right in the middle of all this it seems like. And I don't see a word about that in here.

JUDGE WARDWELL: It's a 10/25/07 memo that summarizes that if that helps you locate that.

JUDGE KARLIN: Yes, a 10/25 memo. I'm trying to find the --

JUDGE WARDWELL: While he's looking for that, is there any indication of why a submittal summarizing a phone call took from August 25th to 10/25 to be written?

MR. FAIR: Well, usually, the staff documents their correspondences with licensees. I don't know the specifics of the memo.

JUDGE KARLIN: Okay, well, let's to the memo. It's NEC JH 62, but if you could look at that exhibit.

NEC JH 62, are you with me?

MR. FAIR: I'm with you.

JUDGE KARLIN: Okay, great. And it's an October 25, 2007 memo from the NRC, subject, summary of telephone conference held on August 20th, 2007, all right?

MR. FAIR: Yes, I'm following.

JUDGE KARLIN: Okay, and it says, enclosure two contains a summary of the issues discussed with the applicant, and this concerns commitment #27, right?

MR. FAIR: Yes.

JUDGE KARLIN: So we go to enclosure two, and it's in that memo it says, the enclosure two, that the NRC staff's position is that in order to meet the requirements of 10 CFR 54.21©)(1) an applicant for a license renewal must demonstrate in the LRA, the license renewal application, that the evaluation of the time limited aging analysis has been completed. The NRC does not accept the commitment to complete the evaluation of the PLAA prior to entering the period of extended operation.

Now were you involved in that conversation?

MR. FAIR: No, I was not.

JUDGE KARLIN: No, you weren't in the meeting, but are you familiar with this memo or this concept?

MR. FAIR: I believe I saw it when I was looking through the exhibits is the only time I've seen it.

JUDGE KARLIN: Well, one question is, why isn't that reflected in the FSER? You have a four-page discussion of commitment #27, and this seems like a significant event?

MR. FAIR: Again, I can't answer the question, because I didn't develop that section of the SER.

JUDGE KARLIN: Okay. And it's true to note, if you would look at that, that the regulation being cited is 10 CFR 54.21(c)(1),right?

MR. FAIR: That's correct.

JUDGE KARLIN: It doesn't say (c)(1)(3),does it?

MR. FAIR: No, it doesn't.

JUDGE KARLIN: Or one or two or three.

MS. BATY: Your Honor, if you look at those documents, it lists the individuals who were present for this phone call. And there were three individuals, NRC staff representatives, and one of those individuals is in the room right now, and that is the project manager, Jonathan Rowley. The other individual -- the other staff individual has passed away, and then the other one was Dr. Chang.

JUDGE KARLIN: All right.

MS. BATY: If it would be helpful to the board, Mr. Rowley is in the room and will be testifying later on, and he wrote this document, to explain it. But otherwise I don't think Mr. Fair knows any of the other details.

JUDGE KARLIN: I posited that Mr. Fair was not part of that conversation. I did want to make that clear, and I asked him that question. So I think that is clear on the record; the thing speaks for itself.

Enclosure one has a list of participants, and Mr. Fair's name isn't on it, and he said he did not participate in this, and Dr. Chang did. And that's one of the problems with Dr. Chang not being here.

And I don't think we are in a position to add new witnesses on behalf of the staff at this point on contention number two.

But I'm just troubled by the fact that that is never mentioned in the FSER. And it just seems like a significant event.

But let's go to the FSER, and the last of the appendix, what, A -- I think it's appendix A to the FSER, if you could refer to that, because now we are going to get to the actual commitment #27 as it survived the evolution that the FSER mostly reflects with the absence of the August 2007 problem.

And what is that, Appendix A, FSEN, Vermont Yankee NPS license renewal commitments. Mr. Fair, what are these commitments?

MR. FAIR: Well, they are commitments by the applicant to the NRC staff to complete certain actions.

JUDGE KARLIN: Okay. Are they legally binding?

MR. FAIR: I believe the commitments in the FSER are not legally binding, but the -- I believe there is a -- that they have to be made conditions of the license.

JUDGE KARLIN: Okay, all right. How are they made conditions of the license? What happens -- these are not legally binding in the FSER. But are all of these converted into some license condition?

MR. FAIR: I can't speak to that.

JUDGE KARLIN: Okay. Or sometimes they are and sometimes they're not?

MR. FAIR: I believe they are. I believe they normally are taken as license conditions when they have commitments.

JUDGE KARLIN: Okay, do you want to ask

something?

JUDGE WARDWELL: Yes, just a quick question.

To the best of your knowledge are all the promises made by the applicant in response to RAIs converted into these commitments as presented here as best you know?

MR. FAIR: As best I know.

JUDGE KARLIN: So everything they say in the whole licensing process for two years or three years, I don't think you really want to say that everything they promise is put into writing as a commitment?

MR. FAIR: Well, every commitment -- okay.

JUDGE KARLIN: Every commitment -- it's a more formal thing. There may be other informal things that are not incorporated as commitments, and thus perhaps not incorporated as license conditions?

MR. FAIR: That's possible. I can't say.

JUDGE KARLIN: Yes, we are speculating. But we can go -- if we could go to Appendix A of the FSER on page A8, and here we have the wonderful commitment #27, all right. Two years prior, at least two years prior to entering the period of extended operation for the location specified in -- and there's locations -- NUREG 6260 for BWRs of the VY vintage, VY will refine our current fatigue analyses to include the effects of reactor water environment, and verify that the cumulative use factors are less than -- that one, I think it's a typo, less than one.

Does that say -- is that the condition we are talking about where they are going to do two additional CUFen analyses on the core spraying of reactor recirculation?

MR. FAIR: I believe that is.

JUDGE KARLIN: Okay, I mean that's what I thought. But why didn't they just say that?

MS. BATY: Your Honor, the license conditions expresses that out in part one of the SER.

JUDGE KARLIN: Okay.

MS. BATY: One point seven of the SER.

JUDGE KARLIN: Okay, 1.7. We'll go to that in a minute perhaps. But let me go to the next one.

This includes applying the appropriate FEN factors to valid CUFs. Who decides what's appropriate?

MR. FAIR: In implementing the commitment, it would be the applicant.

JUDGE KARLIN: So the applicant decides

what he thinks is appropriate?

MR. FAIR: Yes.

JUDGE KARLIN: Down on subparagraph two of this, more -- I'm reading -- more limiting VY-specific locations with a valid CUF may be added in addition to -- who decides whether they are added?

MR. FAIR: Again, this would be the applicant.

JUDGE KARLIN: Okay, and number three, represented CUF values from other plants adjusted to or enveloping the VY plant-specific external loads may be used. Who makes the decision on that, the NRC or the applicant?

MR. FAIR: Again, it's the applicant.

JUDGE KARLIN: Why doesn't the NRC make these things? I mean isn't it a judgment call?

MR. FAIR: Yes, it is.

JUDGE KARLIN: What if the applicant makes a choice that's wrong? Anyway to catch them?

MR. FAIR: Well, yes, they could be all expired but have a period of extended operation to verify the commitments are implemented.

JUDGE KARLIN: So the licensee will make a choice on all these "mays" in here, because there are quite a few more of them.

MR. FAIR: Yes.

JUDGE KARLIN: Item #4 says, an analysis using NRC-approved version of ASME code, or an NRC-approved alternative may be performed in the next paragraph. During the period of assembly operations, VY may also use one of the following options.

So there are a lot of options, a lot of discretion in there, right?

MR. FAIR: Yes.

JUDGE KARLIN: And those discretionary choices are the applicant's discretionary choices?

MR. FAIR: As this commitment states.

JUDGE KARLIN: If the applicant chooses something the staff doesn't agree with, can the staff say something and get them to change it?

MR. FAIR: If they audit the implementations of these commitments and have concerns with it, yes they can add some kind of an issue.

JUDGE KARLIN: All right, now what if Dr. Hopenfeld didn't agree with one of these choices that was made, would he have an opportunity to come weigh in? Would NEC have an opportunity to file an contention and have a -- is there a notice of opportunity for a request a hearing every time one of these things happens?

MR. FAIR: I don't believe so.

JUDGE KARLIN: Okay, so it's just the -- it's pretty much the applicant's choice to do Yankee's judgments, and unless the staff objects that is going to be it. No public scrutiny allowed on whether that cuts the mustard or not.

MR. FAIR: Yes, I agree that's true.

JUDGE KARLIN: Thank you.

Okay, I think we are getting there with regard to convention #2. We have asked pretty much the questions we thought were of concern to us.

We are going to go back into the room and take a recess now, 15 minutes, and go over our notes and see if there is something we think we might have missed or want to ask any further clarification on.

During that timeframe hopefully you all will think about whether you think there is something that has come up in this process that we should probe or ask or something we missed.

And this is the time when you will give us suggestions. So we will take a -- well, why don't we reconvene at 4:30. That will be a 20-minute break.

So we are now adjourned for 20 minutes.

(Whereupon, at 4:12 p.m. the proceeding in the above-entitled matter went off the record to return on the record at 4:52 p.m.)

JUDGE KARLIN: All right. As we discussed, the Board went back and reviewed its questions to try to think through if there was something we thought we hadn't covered or we still wanted to get some information on or needed elicitation in the record. And so we've done that.

We have also received -- thank you -- from a number of the parties some proposed questions. I'm not going to read the questions that we have received, but I would acknowledge that we received questions from the State of New Hampshire, several questions in written form, and we received some questions from Entergy. And we received a set of questions in writing from New England Coalition, I believe in coordination with the State of Vermont. So thank you.

We have taken a look at those and tried to study whether we think the matter is -- needs clarification on the record. I also understand -- does the Staff have something you want to give us orally?

MS. BATY: Your Honor, we have changed our mind. We don't have anything further.

JUDGE KARLIN: Okay. All right, fine. That's great. I appreciate that.

And having done that, we have several questions we are going to ask. And if your question does not get asked, it's because we believe -- we don't have any -- we feel we are clear enough on the record and we're clear enough for our understanding that we don't need to ask those questions. The record and the evidence is sufficient for us to understand the issue.

So with that, we have several questions that are going to be asked, and I believe Dr. Wardwell will start.

So let me say this -- the witnesses all remember we are -- you are still under oath. So thank you.

JUDGE WARDWELL: I think the first will be addressed to Mr. Fitzpatrick in regards to discussions we had in relationship to the transients that have occurred so far under the -- our uprate existing there. And the first question is: what is your definition of the transients for the purpose of the cycle count? Is it only the zero to full power, or full power to zero, or all transients included in anything considered to be a major transient?

MR. FITZPATRICK: Major transients -- startup/shutdown is a major transient. A trip from power level would be a major transient. A power reduction and a gradual heat -- for example, when they -- the cooling tower was offline last year, they reduced power 50 percent, they reduced power gradually. There's a tech spec they have to follow to reduce power and increase power.

JUDGE KARLIN: You previously testified that you have approximately 90 transients over the history of a facility, right?

MR. FITZPATRICK: The question was since we did power uprate.

JUDGE KARLIN: Well, let's just go from the beginning. What is your -- when you say you had 90 transients since the beginning -- 96 -- is that just full power transients, or all transients of whatever magnitude?

MR. FITZPATRICK: That's startup/shutdown transients. That was that one particular category.

JUDGE KARLIN: So that only includes startup and shutdown transients?

MR. FITZPATRICK: Yes.

JUDGE KARLIN: Are there other transients you've had since -- the last 36 years?

MR. FITZPATRICK: Yes.

JUDGE KARLIN: And that's not included in the --

MR. FITZPATRICK: That was one number from one transient that gave us that example.

JUDGE KARLIN: Well, I misunderstood.

JUDGE WARDWELL: So what are the total number from -- do you know?

JUDGE KARLIN: Yes. What's the total number of transients?

JUDGE WARDWELL: From '72 to 2008.

MR. FITZPATRICK: The total number of every transient? I'd have to go back and recalculate it -- or look it up and calculate it. It's calculations out there that were put in discovery that evaluate the plant, how many transients you've had at certain times. They are documented in that. The last time we did an assessment was in -- in response to an RAI -- peak usage, CUF -- at the end of 2005. And that was one of the license renewal amendments.

JUDGE WARDWELL: Do you have any estimation of how many of those would be in the life of a plant? And how it compares to --

MR. FITZPATRICK: Well, major -- turbine trips, I think it was -- say HPSI injections in the feedwater. Turbine trip is one of those shutdown -- in 2005 we had that when we -- failure, the plant went from zero power, breakdown, and tripped offline. That was included in the CUF that's -- we've tracked.

JUDGE KARLIN: Well, but we're not asking about 2005. I'm trying to understand -- I was under the impression that you -- we asked you, for CUFens, how many -- and a transient is an event which causes stress, I thought, which is a part of the calculation of the metal fatigue, stress, and that sort of thing, and so how many transients have you had since the plant started operation. And you said something in the range of 90 to 96. Now I understand that that's only a special kind of transient, and you have a lot of other kinds that you didn't tell me about.

MR. FITZPATRICK: I said, for example, startup transients, shutdown transients, and --

JUDGE KARLIN: What about '78 or '83? I don't care about a year. I just want the total number of transients.

MR. FITZPATRICK: That's the total number of startup/shutdown transients.

JUDGE KARLIN: Well, I want all transients. Since the beginning of time to today, how many have you had, of any magnitude, of any kind, of any color or description?

MR. FITZPATRICK: I don't have that answer offhand.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: Can you get that to us?

MR. FITZPATRICK: Yes, sir.

JUDGE KARLIN: All right. Then, we'll --

JUDGE WARDWELL: Within this week?

MR. FITZPATRICK: I'd have to consult with the people who --

JUDGE KARLIN: Mr. Lewis, do you think you all could arrange to have that for us?

MR. LEWIS: I'll do my best.

JUDGE KARLIN: Thank you. I think that number actually came out in the uprate proceeding, so you might go back and check. It might need to be updated.

JUDGE REED: Would Mr. Stevens have those numbers, since he did -- you had to have those figures for those transients in order to do your analyses, is that correct?

MR. STEVENS: Well, no, we had the input provided by Entergy. Recall, those were design numbers that were shown to be conservative compared to the actual counts. The only indication I have of what you're asking for was in the license renewal application.

I believe it was Table 4.3.2 maybe that had a tabulation for several different transients and the number that had been accumulated as of a certain date in the projection forward. I don't recall specifically what those numbers are, but they were in the application.

JUDGE REED: So in the CUFen transient count, did you include all transients or only some subset of transients?

MR. STEVENS: We included all transients that had any impact on fatigue.

JUDGE KARLIN: So that's a subset of transients.

MR. STEVENS: A subset of design transients, that's correct.

JUDGE KARLIN: And how many were they?

MR. STEVENS: I can only speak approximately.

JUDGE KARLIN: Okay.

MR. STEVENS: Depending on the component, so for a feedwater nozzle approximately 20.

JUDGE WARDWELL: Different types of transients.

MR. STEVENS: Different types of transients.

JUDGE REED: Types, not numbers.

MR. STEVENS: No, not numbers.

JUDGE REED: Not quantities. How many total numbers?

MR. STEVENS: Each one of those transients would have had a different quantity associated with them.

MR. FITZPATRICK: May I speak?

JUDGE KARLIN: Yes, Mr. Fitzpatrick.

MR. FITZPATRICK: The calculations for the feedwater nozzle show the transients that were actually evaluated. And each one of those is a certain number. There are --

JUDGE KARLIN: Was that in one of the exhibits?

MR. FITZPATRICK: Yes.

JUDGE KARLIN: Okay, great. Which exhibit would that be?

JUDGE WARDWELL: That number is based on what?

MR. FITZPATRICK: That's the design number, plus any additions we did for 60 years using the EF analysis.

JUDGE WARDWELL: But it's a selective design number, not the actual number that has occurred.

MR. FITZPATRICK: Right. The actual numbers are lower than that, and there is a calculation that actually tracks it. The results --

JUDGE WARDWELL: Well, what would be useful for us is to see the actual numbers, just to confirm --

MR. FITZPATRICK: Yes.

JUDGE WARDWELL: -- what you intended to do for your analysis.

MR. FITZPATRICK: Yes. Yes.

JUDGE REED: I think a comparison between the actual numbers that occurred and the numbers assumed in the analysis would make us more comfortable.

MR. FITZPATRICK: Entergy has that.

JUDGE KARLIN: But we haven't seen it yet. We haven't been provided it.

MS. HOFMANN: We don't have that as an exhibit?

JUDGE KARLIN: No. They are still looking for the exhibit.

MR. FITZPATRICK: We have -- this shows the numbers that we used.

JUDGE KARLIN: Do you have it, Mr.

Stevens?

MR. STEVENS: Yes, I can answer half the question, which is, what did we analyze?

JUDGE KARLIN: All right.

MR. STEVENS: Exhibit E-2-11. E-2-11 is Structural Integrity Associates' calculation, VY 16Q-302, dated July 18, 2007.

JUDGE KARLIN: Yes, okay.

MR. STEVENS: There's a couple of places we could refer to in here. The best one, in terms of number -- different types of transients and the quantity, one place we could look is starting on page 18, Table 5.

JUDGE KARLIN: Table 5, yes. It's a nice, long table.

MR. STEVENS: Two pages.

JUDGE KARLIN: Two pages, okay. Long enough.

MR. STEVENS: In column number 1, it's transient number. These would be the different types of transients, 25 transients.

JUDGE KARLIN: Twenty-five different types of transients.

MR. STEVENS: Different type. In the far right column, 13 is the number of cycles of each of those transients. Each transient is defined by multiple points in time. That's why you'll see multiple lines within each transient number.

So just as an example, on page 19 --

JUDGE KARLIN: No, but wait a second. Let's just stay with this -- or I guess we're still on the chart. Go ahead, 19 is --

MR. STEVENS: This would be the second page of that table.

JUDGE KARLIN: Yes, okay.

MR. STEVENS: Event number 20, far right, 300 cycles were assumed for 60 years.

JUDGE KARLIN: We're still -- but that doesn't tell us the actuals.

MR. STEVENS: That's correct.

JUDGE KARLIN: And when you say transients are assumed, are these -- these are 25 different types of transients. Okay. Within each type, is there any -- is it only a -- is it any amount of amplitude of a transient, or is it only a major? Is there any other qualifier which excludes or includes -- you know what I mean?

MR. STEVENS: Within each transient, the temperature and pressure would vary.

JUDGE KARLIN: Yes.

MR. STEVENS: And those --

JUDGE KARLIN: I mean, is there something that says, "Well, they are too small, we're not going to count those," within each category or --

MR. STEVENS: Not within those listed here, I don't believe. We had --

JUDGE KARLIN: Oh. But -- okay. But this does not give us actual transients.

MR. STEVENS: No.

JUDGE KARLIN: And --

MR. FITZPATRICK: Entergy has those numbers.

JUDGE KARLIN: Great. And I think we would probably request that be submitted by Entergy, if you could, Mr. Lewis. Thank you.

JUDGE REED: I'm a little curious about one thing. One particular transient occurred 10,000 times?

JUDGE KARLIN: It didn't occur, actually.

JUDGE REED: I'm sorry. Well, they assumed it occurred. It must have occurred a large number of times in -- what's that, a small power fluctuation?

MR. STEVENS: That's a daily power reduction.

JUDGE REED: Okay.

JUDGE WARDWELL: Mr. Fitzpatrick, have you had any actual thermal transients throughout the life of the plant that are outside the design basis as provided by the designer?

MR. FITZPATRICK: Not that I know of.

JUDGE WARDWELL: You testified, did you not, that there is -- well, maybe there's some confusion on how many transients have occurred since the uprate. And I think you stated that there has only been one full transient; there are other less than. Have you included the July '08 power reduction down to 25 percent for the cooling towers as a transient, the August 7th cooling tower collapse, and a 50 percent power-down, an August '07 turbine stop valve incident resulting in a 100 percent power-down, and the 2004 condenser leak resulting in a 50 percent power-down?

MR. FITZPATRICK: 2004 was prior to power uprate.

JUDGE KARLIN: Right, prior to the power uprate.

JUDGE WARDWELL: Would the other three be included in the transients that have occurred since power uprate, in your testimony?

MR. FITZPATRICK: Power reductions and the trip at 25 percent in August.

JUDGE REED: Sorry. You've got to speak louder.

MR. FITZPATRICK: The power reductions and the trip from 25 percent power in August 2008. The power reductions have a small -- a power reduction has a small effect on cumulative usage. It's mostly seen in the feedwater. That's why there's -- it's a large number of transients where feedwater is evaluated, and this is small usage -- very small usage factor -- factor from those deductions.

PARTICIPANT: Could you speak up?

JUDGE KARLIN: Yes.

MR. FITZPATRICK: I think I am.

JUDGE KARLIN: Yes. Try to speak up some more if you could. It has been a long day. Appreciate it, Mr. Fitzpatrick.

JUDGE WARDWELL: Let me rephrase. Hasn't the total number of less than full transients that have occurred in the uprate include the July 8th power-down of -- July of '08, power reduction down 25 percent because of the cooling tower leaks? Would that be considered a transient?

MR. FITZPATRICK: It would be considered

a transient. I did leave Entergy in March, so I haven't followed every case since then.

JUDGE WARDWELL: How about the August '07 cooling tower collapse, resulting in a 50 percent power-down?

MR. FITZPATRICK: That would be a transient, yes.

JUDGE WARDWELL: How about the August '07 turbine stop valve incident resulting in a 100 percent power-down?

MR. FITZPATRICK: Pardon me?

JUDGE WARDWELL: The August '07 turbine stop valve incident resulting in a 100 percent power-down.

MR. FITZPATRICK: Stop valve incident occurred at 25 percent --

JUDGE WARDWELL: Okay. And it occurred August '07.

MR. FITZPATRICK: Yes.

JUDGE WARDWELL: Was that an incident? Is that a transient?

MR. FITZPATRICK: That was a transient, yes.

JUDGE WARDWELL: Thank you.

JUDGE REED: We're really confused, still, about this issue of trace elements and impurities. And, first, I want to clarify that we are talking about trace elements in the fluid itself, not in the mud. Is that correct? In your earlier testimony about trace elements --

MR. STEVENS: Yes.

JUDGE REED: -- we were speaking about impurities within the cooling.

MR. STEVENS: Correct.

JUDGE REED: Okay. And so I believe your testimony was that they were not considered because you felt it was unlikely that they would be present during a transient.

MR. STEVENS: Correct.

JUDGE REED: Now, it has been brought to our attention that there was an incident in which there was a leakage of service water through the condenser. Was it -- is it possible that impurities were injected into the system as a result of that incident?

MR. STEVENS: I can't speak to that.

MR. FITZPATRICK: What date is the incident?

JUDGE REED: I'm assuming it was probably this incident in 2004, but I'm not certain.

MR. FITZPATRICK: Some sort of --

JUDGE REED: Pardon me?

MR. FITZPATRICK: Some sort of impact to the condenser that -- under normal operations.

JUDGE REED: All right. So that answers our question. Thank you.

JUDGE KARLIN: Now, this is a question for Mr. Stevens. We had talked -- I had asked you some questions, I think probably yesterday, about 6909 and the calculations that you did over a weekend I guess, applying 6909 to the nine I guess locations, and you took four hours to do it, remember that?

MR. STEVENS: I do, sir.

JUDGE KARLIN: Good. That was fast, that was good. I'm trying to make sure I understand what you did and what was meant by that. When you did that analysis, did you -- you substituted the 6909 curves, by just substituting the 6909 curves? What would have been the result if you had done everything according to 6909?

What did -- when you did the four-hour analysis applying 6909 -- let me back up -- what did you do? You used 6909 in full, the air curves, the 95/95, you know, confidence levels, the Fens, and everything else, or just some component of it?

MR. STEVENS: Everything.

JUDGE KARLIN: So you did the soup to nuts as if the -- from scratch it was calculated under 6909.

MR. STEVENS: Yes, sir.

JUDGE KARLIN: Okay. And so you applied all of 6909 to the CUFen analysis for Vermont Yankee, and came up with the numbers that were less than one, in all respects.

MR. STEVENS: Yes, sir.

JUDGE KARLIN: Okay.

JUDGE REED: But let's see, those numbers -- and maybe I'm recalling the testimony wrong, but I thought your point was that they were not only less than one, but less than the refined analyses. Was that --

MR. STEVENS: That was my testimony, yes.

JUDGE KARLIN: Yes, yes, that's right.

Well, do we have anything else at this point? I think we are done with the witness panel today. Thank you very much for all of your time and effort. You have obviously spent a lot of time on this, and have been patient in trying to answer our questions.

We are about to adjourn until tomorrow.

We'll obviously start with contention number 3 tomorrow morning. I think it's safe to say contention number 4 will not -- they don't need to show up until after lunch at least.

(Laughter.)

But we may go a little faster with contention 3 and 4 than what we had with 2.

We have also thought about the Chang testimony problem. And it's our ruling that we are going to leave the Chang testimony in for what it's worth. And we think that we've had some reference to Dr. Chang's testimony here today. I think that was all right.

And I think we found it to some extent helpful, and so we are going to leave that in as testimony that we might, for what it's worth, use in this proceeding. And so that's our ruling on the Chang testimony -- and the exhibits that went along with it.

With that, we are adjourned for today, and I look forward to seeing everyone here tomorrow morning at 8:30.

MS. BATY: Your Honor, I want to ask a question. I was wondering, are witnesses on contention 2 panel, are they excused or --

JUDGE KARLIN: They are excused.

MS. BATY: Okay. They don't need to remain in Vermont.

JUDGE KARLIN: They are excused. Good question.

MS. BATY: Thank you.

JUDGE KARLIN: Thank you. We are adjourned. See you all tomorrow at 8:30, please. Thank you.

(Whereupon, at 5:14 p.m., the proceedings in the foregoing matter were adjourned, to reconvene at 8:30 a.m., the following day.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of: Entergy Nuclear Vermont Yankee, LLC & Entergy Nuclear Operations, Inc.

Name of Proceeding: Hearing

Docket Number: 50-271-LR, ASLBP No. 06-849-03-LR

Location: Newfane, Vermont

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Toby Walter
Official Reporter
Neal R. Gross & Co., Inc.