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JUDGE KARLIN: -- so people can hear.

MR. STEVENS: I've done quite a few calculations with 6909 going back a few years as part of the review process included. And we did the -- we calculated CUFens for the VY, all nine locations that were evaluated for environmental fatigue.

And the CUFens using 6909 are lower than those reported by Entergy in the testimony for all nine locations. And that would support what -- Mr. Fair's prior testimony or the ACRS comment that he made earlier.

JUDGE REED: Mr. Stevens, in fact, the only change was the Fens, not the CUFs, is that correct?

MR. STEVENS: No, sir. We used --

JUDGE REED: Did you also change the CUFs in this --

MR. STEVENS: Yes. We used 6909 in its entirety, so we used the curves, calculated Fens in accordance with that document, and also CUFens as a product of the two.

JUDGE REED: Okay. So we are looking at a result that was attained by changes both in the environmental effects as well as how you did the basic CUF analysis.

MR. STEVENS: Yes, sir.

JUDGE REED: Okay.

JUDGE WARDWELL: How long does that analysis take you to do?

MR. STEVENS: Approximately four hours.

JUDGE WARDWELL: Thank you.

JUDGE KARLIN: And let's just clarify. Dr. Reed's question I think was reasonably -- was well taken, and I think the clarification is you're saying NUREG-6909 involves more than just changing the Fen calculation, is that correct?

MR. STEVENS: That's correct.

JUDGE KARLIN: And it involves what other changes?

MR. STEVENS: It involves calculating fatigue with revised fatigue curves, compared to those --

JUDGE KARLIN: In air.

MR. STEVENS: Correct.

JUDGE KARLIN: Right.

MR. STEVENS: Compared to the ASME code fatigue curve.

JUDGE KARLIN: And what -- maybe we can just ask what the values you derived -- what were the values for the nine -- what, nine locations, six locations, nine pieces of equipment?

MR. STEVENS: Okay. The nine items -- and I'll report the values using 6909, and these are CUFens. Item 1 was the RPV shell bottom head location, CUFen .0263. Item 2 is the RPV shell at shroud support location. CUFen was .2637. Item 3 was the feedwater nozzle blend radius. CUFen was .2175.

Item 4 was the recirculation RHR Class 1 piping return T. CUFen .4151. Item 5 was the recirculation inlet nozzle forging. CUFen .1921. Item 6, recirculation inlet nozzle safe-in, CUFen .0152.

Item 7, recirculation outlet nozzle forging, CUFen .0278. Item 8, core spray nozzle forging blend radius, CUFen .0524. Item 9, feedwater Class 1 piping, CUFen .1350.

JUDGE KARLIN: And what was the highest CUFen calculated by that -- in that analysis?

MR. STEVENS: That would be Item 4, recirculation, RHR Class 1 piping return T of .4151.

JUDGE KARLIN: Okay.

JUDGE WARDWELL: How did this analysis -- how was this analysis performed in regards to the three sets of analyses that were presented as part of the testimony in regards to the basic initial calculation performed in the application, those that were done for the refined analysis, and those that were done for the confirmatory analysis? Analyses, I should say.

MR. STEVENS: We started with the -- all of the calculations that Entergy has done over the past year. And for the three nozzles that are a part of the testimony -- the recirculation outlet nozzle, the core spray nozzle, and the feedwater nozzle -- we used the refined analyses.

And the analysis -- the calculations we did here started with the stress results that went into the fatigue calculation. So we used -- you know, the majority of the analysis remained unchanged. We just took the stresses that fed into the fatigue analysis. We replaced the fatigue curve and recalculated Fens. The very tail end of the analysis was reperformed.

JUDGE WARDWELL: So let me make sure I understand this correctly. You used the stress analyses that -- the most recent stress analyses for a given component based on whether or not the -- it was -- the most recent was done as either a -- the original analyses, refined analyses, or confirmatory analyses.

MR. STEVENS: We did not use the confirmatory calculation for the feedwater nozzle, our reason being to be consistent with these comparisons.

JUDGE WARDWELL: Strictly the refined for the three nozzles and then they're basically --

MR. STEVENS: That's correct.

JUDGE KARLIN: Does that mean that the Green's function issue was eliminated, or still -- as I understand it, we have three analyses essentially that you submitted, that Entergy submitted. First, it's the initial analyses, right? With the application. Is that correct?

MR. STEVENS: That's correct.

JUDGE KARLIN: Then, there was the reanalysis in September and December of '07, right?

MR. STEVENS: Correct.

JUDGE KARLIN: And that was for all seven locations or pieces of equipment -- all nine, I'm sorry. And then, there was a confirmatory analysis with regard to the feedwater nozzle, right?

MR. STEVENS: Correct.

JUDGE KARLIN: So that's the terminology I'm going to use -- the initial analysis, the reanalysis for all of them, and then the confirmatory analysis for the feedwater nozzle. And as I hear what you're saying, you used the approach of the reanalysis, and then you applied NUREG-6909 to that, is that right?

MR. STEVENS: That's right.

JUDGE KARLIN: Now -- well, then, there may be a concern about that because the whole reason that the confirmatory analysis was done was because, as I understand it, the staff raised concerns about the simplification of being caused by using simplified data in the Green's function. Are you with me?

MR. STEVENS: Yes, sir.

JUDGE KARLIN: Was that -- is that problem still inherent in your reanalysis of these?

MR. STEVENS: Well, I'd just like to clarify that I don't consider that to be a problem with those analyses. But the presence of the Green's function is in the three evaluations of the nozzles in these results I reported to you.

JUDGE WARDWELL: And just for clarification, is it fair to say that the reason you did that is just to compare it to using 6909 versus 5783 -- what's the other NUREG number -- approach? You did it for comparison purposes rather than any final calculation of record.

MR. STEVENS: Yes, sir. I believe at

least two of the parties -- that would be Entergy and NRC Staff -- have made some statements that the newer regulatory guide and associate NUREG generally provide lower results on a CUFen standpoint than the ones used for license renewal. And so these were done to support those statements further.

JUDGE WARDWELL: Okay.

JUDGE REED: Mr. Stevens, I need to understand better how these calculations are actually performed. We've kind of jumped into the middle here, and I need to come back more to the beginning. You work for SIA, is that correct?

MR. STEVENS: That's correct.

JUDGE REED: And you personally did all of these calculations.

MR. STEVENS: Not -- no, sir. I was -- I did a few of them, and I supervised the staff that did the calculations.

JUDGE REED: But you are intimately familiar with the methodology that goes into calculating a CUFen number for a particular component.

MR. STEVENS: Yes, sir.

JUDGE REED: So you know from beginning to end exactly how that calculation proceeds and what assumptions are made.

MR. STEVENS: Yes, sir.

JUDGE REED: Could you give us a brief discourse on how that's done? I don't want a half-hour tutorial. I want a five-minute description of -- take a particular transient or a set of transients that are analyzed and tell us exactly how you calculate and arrive at a CUFen number.

MR. STEVENS: Okay.

(Pause.)

I'm trying -- I'm going to look my testimony up, so I can keep this as brief as possible. I apologize for the delay.

JUDGE REED: No, that's fine. You might start by talking about the kinds of transients that affect, say, a feedwater nozzle and how those lead to stresses, and then how you calculate the stresses, then how you determine what the maximum allowable stresses are, so that you -- and I don't know how to do these calculations, so I don't want to lead you too far.

MR. STEVENS: Okay.

JUDGE REED: But --

MR. STEVENS: I'll try and be brief but descriptive here. So we have to -- we have to collect all of the loadings for a particular component we're evaluating, and those would come from --

JUDGE REED: Can you speak just a little louder?

MR. STEVENS: Okay. Sorry. We have to collect all of the loadings for a particular component in order to analyze it from a stress and fatigue standpoint. We would typically collect those loadings from the design specifications for the component by the vendor or manufacturer. So we would collect geometry and we would construct a model that would allow us to calculate stresses for all loadings. In this case, a finite element model is an industry standard, so we would model that component geometry --

JUDGE REED: So if I may interrupt, these are static loadings on a particular component. You calculate a stress tensor for that or a stress field?

MR. STEVENS: Correct.

JUDGE REED: Okay. So the issue of transients has not yet come into it.

MR. STEVENS: Not yet.

JUDGE REED: Okay.

MR. STEVENS: As a part of the loadings, though, there are thermal transients which are loads that vary with time, and we would also use the finite element model to evaluate stresses as a function of time for those loadings.

JUDGE REED: So you take a series of snapshots during a transient, and all of which have different loadings is --

MR. STEVENS: That's --

JUDGE REED: -- and calculate the stresses?

MR. STEVENS: Yes.

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

MR. STEVENS: So during a thermal transient, we would have a stress history versus time for that transient. And then, knowing how pressure and other loadings vary during that transient, we would calculate those stresses and combine them. This is all a linear, elastic analysis, so we would combine them by superposition. And we would get a stress -- a total stress history for the component from those analyses.

JUDGE REED: For a particular transient, you develop a stress history, meaning the stress as a function of time.

MR. STEVENS: That's correct.

JUDGE REED: Okay.

MR. STEVENS: And then, we have 20 transients, we would repeat that process 20 times and come up with 20 stress histories.

JUDGE REED: Now, when you say "20 transients," you don't mean the same thing happening again and again. You mean 20 different kinds of -- the plant responding to something happening.

MR. STEVENS: That's correct. Different --

JUDGE WARDWELL: Are these plant-specific?

MR. STEVENS: Yes. So you are correct. There would be 20 different transients of a different type. Each of those transients would occur a different number of times. So the quantity of those 20 transients would be specified and would be different.

JUDGE REED: And some of the transients are more severe than others?

MR. STEVENS: That's correct.

JUDGE REED: And would lead to larger stresses?

MR. STEVENS: That's correct.

JUDGE REED: But they may occur fewer times, so you may have a smaller transient that occurs much more frequently that is going to contribute relatively more to the ultimate answer, is that correct?

MR. STEVENS: That's correct.

JUDGE REED: Okay.

MR. STEVENS: So now, once we have the stress history, and we would feed that into a fatigue analysis, and the fatigue analysis first tells us how to take those stress histories and link them together or combine them in such a way that we can count number of stress fluctuations on a component. Stress fluctuations are what lead to fatigue.

JUDGE REED: So it's not stress, but fluctuations in stress.

MR. STEVENS: That's correct. It requires a stress fluctuation to contribute any kind of fatigue.

JUDGE REED: Okay.

MR. STEVENS: So, and the ASME code gives us guidelines and methodology for doing all of this analysis. And, in particular, counting cycles, how that's done in a conservative fashion, because in a fatigue analysis of the component we don't necessarily know the order of occurrence of the events. So the methodology assumes the worst possible occurrence by pairing the extreme stresses together.

So when we go through this counting process, we take the highest extreme, the highest peak stress with the lowest low stress and pair these off to get these stress fluctuations.

JUDGE REED: So that's a conservative assumption you are making? Is that the point?

MR. STEVENS: Yes, sir.

JUDGE REED: So you don't take the actual stress history of the transients. You somehow take the high stress and the low stress and pair them up to --

MR. STEVENS: Well, when we -- when we -- that's correct.

JUDGE KARLIN: May I ask a question in this -- on any given transient, you are talking about the stress load that occurs during a transient, right?

MR. STEVENS: Yes.

JUDGE KARLIN: Do you have monitors that are telling you what the stress load is on this particular valve or nozzle or outlet? How do you know -- where are you getting the data that tells you how much stress they have?

MR. STEVENS: The stress comes from the finite element analysis of that component.

JUDGE REED: And what code is being used to do that analysis?

MR. STEVENS: We use the ANSYS finite

element code.

JUDGE REED: And that is a commercially-available code?

MR. STEVENS: Yes, sir.

JUDGE REED: And ANSYS stands for?

MR. STEVENS: I don't recollect.

JUDGE KARLIN: Could you spell the acronym?

MR. STEVENS: A-N-S-Y-S.

JUDGE KARLIN: Okay.

JUDGE REED: And that code is in wide use or very narrow use throughout the industry or --

MR. STEVENS: It's widely used in the nuclear industry for finite element analysis.

JUDGE REED: And what can you say about the accuracy of the code, the benchmarking of the code? How confident are you that it is giving you correct numbers?

MR. STEVENS: The code is extensively benchmarked. It comes with verification manuals that -- where analyses are run and compared to theoretical or hand solutions and checked for accuracy. It is all controlled and developed under a 10 CFR 50 Appendix B quality assurance program.

And when we bring that code into our house we also have to adopt it as part of that program and do the extensive checking and verification in accordance with those verification manuals, and then ensure that our use is consistent with those -- the QA program and those checks.

JUDGE REED: So when you generate a finite element mesh for ANSYS, do you do a mesh refinement study?

MR. STEVENS: Generally not on a case-by-case basis. This is one of the areas where it does require analyst judgment and experience to do it properly. We have done those as a part of our company extensively for other reasons, but we don't do it on a case-by-case basis.

JUDGE REED: Would it not be possible that as you refined the mesh you would find a little local area where the stress is much higher than it would be calculated with a much coarser finite element grid?

MR. STEVENS: That's possible. I don't think that that's -- I would not agree with that assessment for the models used for Vermont Yankee.

JUDGE REED: But you can't rule it out, since you haven't done the mesh refinement study.

MR. STEVENS: No. We can only rule it out based on our experience.

JUDGE REED: So you can't actually be certain that higher stresses might not be generated if you refined the meshes in your calculations.

MR. STEVENS: Generally, that kind of an artifact would come near discontinuities.

JUDGE REED: Yes.

MR. STEVENS: And the locations that we're evaluating here don't have those kinds of discontinuities.

JUDGE REED: Okay.

MR. STEVENS: So I'm confident that you would not experience a significant change in stress with your suggestion.

JUDGE REED: So is it your point that you believe that you have resolved the stress field reasonably accurately with the finite element meshes you're using in your calculations?

MR. STEVENS: Yes, sir.

JUDGE REED: Okay. I hope we can proceed with how you do the calculation now. And I'm sorry that --

(Judges confer.)

JUDGE WARDWELL: Dr. Hopenfeld, do you have any major objections or arguments with the way Mr. Stevens just described the approach that they use?

DR. HOPENFELD: Yes.

JUDGE WARDWELL: Is that your understanding of how the approach was used?

DR. HOPENFELD: Yes. Yes, Your Honor. I understand exactly what he's talking about.

JUDGE WARDWELL: And is that your understanding of how it was performed when you supplied your testimony?

DR. HOPENFELD: Yes. Yes, it is.

JUDGE WARDWELL: Okay. That's all I needed to know. We'll get to you in a moment. Just wanted to make sure we're all in agreement.

DR. HOPENFELD: Well, make sure you pick me up.

JUDGE KARLIN: No. But I'm trying to -- when you said yes, do you have disagreements with what he just said, or are you on board?

DR. HOPENFELD: I have no disagreement with what he said.

JUDGE KARLIN: Okay.

DR. HOPENFELD: But that's only part of it.

JUDGE KARLIN: Yes, right. We'll get to that.

DR. HOPENFELD: That's not the whole

story.

JUDGE KARLIN: Okay. Fine. I just want to be clear on that. We'll get the rest of the story.

DR. HOPENFELD: Okay.

JUDGE WARDWELL: Go ahead. I just wanted to --

JUDGE REED: Well, we were partway through this issue of exactly how you take a series of transients and calculate a CUFen number.

MR. STEVENS: Correct. So once I have all of these different stress histories for, arbitrarily talking, 20 transients here, the ASME code tells me how to start to pair these together to get fluctuating stresses that would contribute to fatigue. So I have to combine these transients. As I said, it does it in a conservative way that it takes the most -- the extreme stresses and pairs those and uses those fluctuating stresses into a fatigue analysis.

And very, very simplistically, if I took the highest stress and the lowest stress that would be a stress range, and alter -- a possible alternating stress range that that component may have been exposed to --

JUDGE REED: For that one kind of transient.

MR. STEVENS: For that one pairing of two extremes, which could be from two different transients. Remember, I'm going after extremes to get the most conservative fluctuation of stress that component would have seen.

JUDGE REED: I'm failing completely to understand why you picked the high stress from one transient and the low stress from a completely different transient that presumably occurs at some other time in the plant's history.

MR. STEVENS: Well, because that -- the component would see the stresses caused by both of those transients at some point in its life. So in terms of a fluctuating stress --

JUDGE REED: These could be days, months apart, though.

MR. STEVENS: Could be years apart. But you see that a typical design analysis does not know the order of events. So if it's analyzing 20 transients, and it has no particular knowledge on the order those events could occur, and if it puts them next to each other as if they occurred minutes apart, that would be the most conservative.

JUDGE REED: And that's what you do.

MR. STEVENS: That's what we do. And it's a conservative way of stating the extreme stress fluctuations that that component will go through, not knowing the order of events ahead of time.

JUDGE REED: I'm struggling to understand. I want to ask you at some point -- you've got 20 different kinds of transients.

MR. STEVENS: Correct.

JUDGE REED: Presumably all sorts of things that happen to the plant -- changes in power level, turbine trips, whatever. And these are all stressing this particular component, and they are all occurring with different frequencies, some occurring once a year, some occurring every several years, some occurring every decade. Am I right, in this --

MR. STEVENS: That's correct.

JUDGE REED: So what I want to understand is how you ultimately take all of those various transients, calculate some sort of utilization factors, and then cumulate them up into a CUF.

MR. STEVENS: Let me try again. Let's start with the stress history for one transient. So I have one transient that has temperature during the time, and I have calculated stresses for that transient. So I have a stress versus time plot I can make for that one transient.

JUDGE REED: Okay.

MR. STEVENS: Now I have 19 other transients that I do the same thing. And what I'm going to do is I'm going to take the stress history for each of those other 19 transients, I'm going to tag it on to the end of the stress history for transient number 1. Now what I've got is this very, very long stress history versus time that has all 20 transients attached together to each other.

JUDGE WARDWELL: These aren't 20 actual transients that occurred at Vermont Yankee. These are 20 different types of transients that are generically experienced at a boiling water reactor similar to might be at Vermont Yankee.

MR. STEVENS: These are specified by the designer for the plant.

JUDGE WARDWELL: Okay.

MR. STEVENS: So I now have a long stress history, stress versus time, that represents 20 transients attached together, one after another.

Now, when I put that history together, I made a big assumption on the order of those transients. If I would have done transient 1, transient 2, transient 3, then that stress history represents that the order of occurrence of those 20 transients was in that order -- time order I put them in.

JUDGE WARDWELL: And the time is not a real time, it is the linkage of all of the transients, and they are attached based on the link that the transient occurs. Then, you immediately start the next transient after that one is over with, is that correct?

MR. STEVENS: Yes, that's correct.

JUDGE REED: So you are putting the plant through all of its paces basically one right after the other with no intervening period of six months of stable operation, is that --

MR. STEVENS: That's correct.

JUDGE REED: Okay.

JUDGE KARLIN: Let me just -- may I ask basic questions, where we're going here. I was concerned by the answer you gave to Dr. Wardwell's question. Are these -- when you were talking about the 20 transients, are these actual transients that occurred at Vermont Yankee that you were basically saying, okay, there are 20 transients and here is how much stress -- transient 1 gave X stress, transient 2 gave Y stress.

We're going to add them all together, and here's how much stress Vermont Yankee has experienced over the 35 years it has been operating. Is that what is going on, or are these some sort of assumed stresses that are theoretical?

MR. STEVENS: These are -- the transients that we're calculating these stresses for are specified by the designer, they are part of the design basis, and they have been shown to be conservative -- very conservative definitions, compared to the actual transients that Vermont Yankee --

JUDGE KARLIN: Yes, because here's where I'm going. Let me just be real basic. Metal fatigue, I'm focusing on the NUREGs and the CUFens and that sort of thing, metal fatigue. As I understand it, metal fatigue -- you take a paper clip, it's made of metal. You bend it once, twice, you bend it 100 times and then it breaks. And you do this experiment a dozen times and it breaks at a hundred.

With the hundredth bend, 90-degree bend, it breaks. So now you know that that piece of metal is going to break at the hundredth twist of 90 degrees. That's my simplistic way of thinking about this. This is the ASME curve that says at a hundred breaks in air -- bends at 90 degrees in air this paper clip will break.

Now you go and say, "All right. I've got a paper clip here. I bent it 37 times. And I bent it 90 degrees some of those times, and I bent it 45 degrees some of those times. I bent it 200 degrees some of -- I bent it a lot of different ways." And I total up those 37 bends, and I say, "Okay. I have used up this amount of stress." And if I -- and now I know how long it is going to take for me to get to the hundredth time when it breaks. Is that what's going on?

MR. STEVENS: That's simplistically what is going on.

JUDGE KARLIN: And so when we are talking about the calculations of the 20 transients, which are bends, the times that there was stress imposed upon this, are you talking about the -- how we get to the hundredth, the theoretical one hundred, or how do we get to the actual history of this plant?

MR. STEVENS: The transient severity is analogous to your how far did you bend your paper clip?

JUDGE KARLIN: Right.

MR. STEVENS: Because if you bent your paper clip 90 degrees and got 100 times until failure, you would get a different number if you only bent your paper clip 45 degrees.

JUDGE KARLIN: Right.

MR. STEVENS: It's a measure of the load on that component. These transients all have different severity. One transient may have a 45-degree bend analogy, another one a 90-degree bend analogy, another one a 10-degree bend analogy.

JUDGE KARLIN: Right.

MR. STEVENS: They all have different severities. They are specified by the designer to be very conservative, so that the designer can do a fatigue design of the plant prior to construction. And those have been shown through numerous studies throughout the industry over the history to be conservative, and those are the definitions that were used in the analyses for Vermont Yankee.

JUDGE KARLIN: So the American Society for Mechanical Engineers and the people who designed this particular boiling water reactor figured out for each type of metal in that reactor how many bends, how many stresses it would take before it broke. Is that right?

MR. STEVENS: Not quite.

JUDGE KARLIN: Okay.

MR. STEVENS: What they would do is an

analysis in accordance with ASME code to demonstrate that for those loadings the component will not show unacceptable results. And in this particular case that's a usage factor less than one.

JUDGE KARLIN: Right.

MR. STEVENS: That does not necessarily mean failure.

JUDGE KARLIN: Yes. So you have a hundred -- if you had -- so the calculation is this thing will -- you can bend it a hundred times 90 degrees and it will break. Now, you've actually only bent it 70 times at 90 degrees, so your CUFen factor is .7, right?

MR. STEVENS: That is correct.

JUDGE KARLIN: And you've got 30 bends left before it is going to break or before the calculation says it will break, right?

MR. STEVENS: Well, again, the calculation isn't indicating breakage. It's --

JUDGE KARLIN: Failure of some kind.

MR. STEVENS: -- the acceptance criteria that's used, and there is margin on that acceptance criteria.

JUDGE KARLIN: Okay. I understand.

MR. STEVENS: We work with safety factors and other things that prevent breakage.

JUDGE KARLIN: Okay. Sorry for the digression. Go ahead.

JUDGE REED: Please continue.

MR. STEVENS: Back to our -- we now have our 20 transients linked together. I have made an assumption in how those transients link together, the order they occur. And what the ASME code tells us to do as well, in order to capture the most conservative order, we're going to go through this history and we're going to take the largest extremes and say that they define a stress fluctuation that the component will go through.

So perhaps of this entire stress history let's say the highest stress experienced was transient 1, and the lowest stress was transient 18. I would start by pairing those, and that would define a stress range, the maximum stress range that could be conceivable for that component to see throughout that stress history.

When I make that choice it is like taking transient 18 and moving it next to transient 1, assuming that order, adjacent order.

JUDGE REED: Well, aren't you, furthermore, assuming that these two transients occur with the same frequency? Suppose one is an annual thing and one is a weekly thing. How do you justify putting them together in your analysis when you know that one occurs 50 times more often than the other?

MR. STEVENS: That would be something I would like to take advantage of, because -- but this way is conservative and it's making that assumption. It is very bounding.

JUDGE REED: Okay. I understand that.

JUDGE WARDWELL: This is just defining the angle at which you're bending the paper clip.

MR. STEVENS: It's trying to -- back to your paper clip analogy, it is trying to just say that based on the stress history, and if I could reorder things in any order I wanted to, the worst extreme your paper clip may go through is 90 degrees, so I want you to take that as the top cycle, the most severe cycle to evaluate. But it's --

JUDGE WARDWELL: The right paper clip would -- the fact that one transient occurs now and another one occurs a week later isn't necessarily -- I'm trying to find a word that -- with a paper clip you could bend it once, and then a week later bend it, it's still going to know -- it's got a memory -- it's going to know you have bent it. So it's not completely unreasonable to move 18, because this is an arbitrary number, up next to the other one, because that range of stresses has been felt by that metal.

MR. STEVENS: That's correct. But it ignores that there could have been events in between those two. But in principle what you're saying is correct.

JUDGE KARLIN: Why does it make any difference, I mean, whether you put them together -- you have had 37 events at this -- on this paper clip, you know, of bending at different angles. I don't care whether they are all done, what order they are done, at the end of the day 37 events have occurred, this much stress has occurred, and you have used up this amount of your CUFen before you get to 1, right?

MR. STEVENS: If transient 15 actually occurred after transient 1, and had a much smaller stress associated with it than transient 18, then the cycle the component saw on that day is much smaller than the one I assumed by putting transient 18 next to 1.

JUDGE KARLIN: So you're assuming a conservative assumption, the worst case as it were.

MR. STEVENS: It's the worst possible --

JUDGE KARLIN: Higher stress. So it would be more consumption of the -- what's available fatigue, what available fatigue there is before it breaks or fails.

JUDGE WARDWELL: I hate to beat this, but 180 degrees as opposed to 90 degrees is --

MR. STEVENS: That's a very good analogy, yes.

JUDGE REED: So if we move on now, you've taken and done this pairing, what do you do with all of the other transients?

MR. STEVENS: Well, I go -- okay.

JUDGE REED: You pick the worst two, put together, and you put those together --

MR. STEVENS: One occurrence of the worst two.

JUDGE REED: One occurrence.

MR. STEVENS: If you can imagine now, remember in the beginning I told you that each transient has a specific number of occurrences associated with it.

JUDGE REED: Yes.

MR. STEVENS: So, if you will, each peak and valley of this long stress history --

JUDGE REED: Yes.

MR. STEVENS: -- has a number of cycles

associated with it that's equal to the number of transients. If I take the portion that's transient 1, and if my designer said 100 of those could occur during the life of the plant, then that stress history -- every point on it -- could occur 100 times, almost analogous to now I've got this third dimension kind of on this graph. I've got a stress versus time history, and each point has a different number of occurrences associated with it -- the number of transients that were specified by the designer.

So if I take transient 1 and transient 18, I have now taken one occurrence of each of those events. If I had 100 occurrences of transient 1, I have 99 of those points left to deal with. So you can imagine, if I go through this history and take the highest and the lowest, and cross one site -- one occurrence of each of those off, and take the next highest or the next lowest, and I repeat that process until all occurrences of all transients have been consumed, I'd get a nice stress array right from largest stress range to lowest with the number of occurrences next to it.

JUDGE REED: I see that.

JUDGE WARDWELL: So far, the three NUREGs of interest haven't even come into play yet, is that correct?

MR. STEVENS: Yes.

JUDGE WARDWELL: This is all stress analysis.

MR. STEVENS: That's correct.

JUDGE KARLIN: So in that respect it's the ASME code as opposed to the Fen part of the analysis?

MR. STEVENS: That's correct.

JUDGE KARLIN: Okay.

MR. STEVENS: So now I have a spectrum of stress range and cycles applied to that stress range. So now I have what's required to calculate fatigue. I'll stop here for one --

JUDGE WARDWELL: To calculate what?

MR. STEVENS: Fatigue usage.

JUDGE WARDWELL: Fatigue.

MR. STEVENS: CUF.

JUDGE WARDWELL: CUF.

MR. STEVENS: Now, this represents 90, 95 percent of the work.

JUDGE WARDWELL: How long does it take to do this -- person-hours, labor-hours?

MR. STEVENS: Just as an example, the confirmatory calculations for Vermont Yankee feedwater nozzle took about three weeks dedicated. approximately three individuals full-time.

JUDGE KARLIN: So let me understand. The confirmatory analysis for one nozzle, the feedwater nozzle, took three people three weeks of work?

MR. STEVENS: That's correct.

JUDGE KARLIN: It took nine weeks of time, nine --

MR. STEVENS: Nine man-weeks.

JUDGE KARLIN: Nine man-weeks.

MR. STEVENS: You must understand that that includes all the quality assurance checks and documentation proper filing.

JUDGE KARLIN: Well, how did you do all of them in four hours?

MR. STEVENS: No.

(Laughter.)

MR. STEVENS: This is the point I was going to make. What's left took us four hours. So I'll describe what's left next.

JUDGE WARDWELL: Before you do that, Dr. Hopenfeld, is everything Mr. Stevens has said to date your understanding of how they did it when you did your review and filed your testimony?

DR. HOPENFELD: With respect to the specific numerical analysis, I am not an expert in stress numerical analysis.

JUDGE WARDWELL: I'm not asking you any opinion. I'm asking you whether or not, when you were reviewing this for NEC and filed your testimony, is everything that Mr. Stevens said consistent with what you thought they had done?

DR. HOPENFELD: Yes, yes.

JUDGE WARDWELL: That's all we need right now.

DR. HOPENFELD: Oh, yes. I will --

JUDGE WARDWELL: Thank you. Just want to make sure he hasn't told any --

DR. HOPENFELD: Even now, I don't have any issue with what he said.

JUDGE WARDWELL: And there isn't a misunderstanding --

DR. HOPENFELD: No, no, no. I have no -- I am absolutely in agreement with it.

JUDGE WARDWELL: So you don't contest --

DR. HOPENFELD: No.

JUDGE WARDWELL: -- the basic approach that they have said they did.

JUDGE KARLIN: And the answer to that is -- Dr. Hopenfeld, you don't contest that approach.

DR. HOPENFELD: I have -- no, this has