RAS
M-299

CHAIRMAN SHACK: We are just a little bit ahead of schedule, five minutes. But we'll go ahead and take our break until 10:45.

(Whereupon at 10:22 a.m. the proceeding in the above-entitled matter went off the record to return on the record at 10:44 a.m.)

CHAIRMAN SHACK: I think we can come back into session.

Our next topic is the final review of the license renewal application for the Vermont Yankee Nuclear Power Station.

And Dr. Bonaca is lucky enough to lead us through this again.

FINAL REVIEW OF LICENSE RENEWAL APPLICATION FOR VERMONT YANKEE NUCLEAR POWER STATION

VICE CHAIRMAN BONACA: It was kind of hard to keep FitzPatrick and Vermont Yankee apart.

We met a month ago to review the application for license renewal for Vermont Yankee. And I believe we covered pretty much every item of the agenda having to do with license renewal.

There was one remaining item that was left because of the time; we did not have a final SER. And

Template Secy-028

DS-03

U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of Entergy Nuclear Vermont Yankee LLC

Docket No. 50-271 Official Exhibit No. E2-36-VY

OFFERED by: Applicant/Licensee Intervenor ____

NRC Staff Other ____

IDENTIFIED on 7/21/08 Witness/Panel NEC 2

Action Taken: ADMITTED REJECTED WITHDRAWN

Reporter/Clerk MAC

it has to do with the environmentally assisted fatigue calculations.

I would just summarize very briefly what has happened since. Entergy has chosen to address environmentally assisted fatigue by demonstrating that CUF and the most sensitive locations would remain below one throughout the period of extended operation considering both mechanical and environmental effects.

The analysis performed by the licensee are supported also by assumptions that will be monitored and verified during the period of extended operation.

The analysis performed by the licensee had confirmed that in all locations CUF is going to be below one throughout the period of extended operation. This staff however has challenged the use of the simplified methodology used by the licensee for those locations which exhibit geometric discontinuities or no symmetric loads such as the feedwater nozzle for example or the circulation out that nozzle and the coarse spray line nozzle.

At the request of the staff the licensee has performed an analysis for the limiting location which is the feedwater nozzle, using the methodology at our command which is using ASME code Section 3. The analysis has confirmed that CUF will be below one okay through the period of extended operation. However I believe assuming the same environmental multiplier, the result with more analysis show a higher value of CUF though below one. And so the staff has requested the licensee to perform also the corresponding analysis for the two additional cases where there are geometric discontinuities or no symmetric loads and essentially the locations are the circulation outlet nozzle and the coarse spray line nozzle.

Today I believe the licensee wants to present their methodology and make the case for the analysis they performed originally. I believe the issue so far as the SER is closed in the sense that they have committed to perform the two additional analyses as requested by the staff.

But we will hear both from the licensee and the staff about this contention and it's an important issue because it may affect other licensees that have performed calculations before using the same methodology used by Vermont Yankee.

We would like to introduce and turn over to PT Kuo.

MR. KUO: Thank you, Bonaca.

Yes, this is indeed the last issue for the

Vermont Yankee license renewal application review.

It has taken a long time, longer than what we would like to, but I think at this point we believe that the applicant has done what we have asked for, and we are satisfied with what they have done.

We have supplemented our SER with our writeup. It's just I believe a week or so ago. And sent it to the committee members.

I believe that right now with the additional calculations the applicant has done we consider this issue is resolved, and the applicant will first give you the story of how it is resolved, and the staff will also give you the reason, the basis of why we think this is acceptable.

Thank you.

With that, applicant, please, take over.

MR. DREYFUSS: Good morning.

Thank you, Dr. Bonaca, Mr. Chairman, members of the committee.

My name is John Dreyfuss. I'm the director of nuclear safety assurance for Vermont Yankee.

Before we get going with the presentation I do want to make sure that we introduce our Vermont Yankee and Entergy team here.

First, I'd like to recognize Ted Sullivan, our site vice president.

MR. SULLIVAN: Good morning. I'd like to thank the committee for allowing us to be here today to continue the discussion on our license renewal application. And I'd like the team to identify themselves, and then we'll turn it back over to John. John's our lead spokesperson.

MR. MANNAI: David Mannai, licensing manager, Vermont Yankee.

MR. RADEMACHER: Norm Rademacher, engineering director.

MR. FITZPATRICK: Jim FitzPatrick, design engineer.

MR. STEVENS: Gary Stevens, structural integrity associates, consultant to Entergy.

MR. GOODWIN: Scott Goodwin, design engineer.

MR. METELL: Mike Metell, license renewal, project manager.

MR. YOUNG: Garry Young, manager of license renewal for the Entergy fleet.

MR. COX: Alan Cox, technical manager, license renewal.

MR. LOCK: Dave Lock, I'm part of the

Entergy license renewal team.

MR. DREYFUSS: All right, very good. Good morning.

Next slide, Beth, please.

For the agenda for today we will go through the environmentally assisted fatigue. And we do recognize the last time we were here we went through the rest of the SER and application and talked about a lot of different issues.

Our focus here on our presentation is as requested on the fatigue issue.

So we'll go through an overview of that, some of the timeline, how we got to this point. We'll talk about some of the bases, and go through both the evaluation that we performed where there were challenges from the staff, and confirmatory analysis.

And just from a nomenclature standpoint, I did want to mention, a number of different terms have been tossed out. What we will refer to during the course of our presentation, we had original analyses, for the license renewal we performed re-analysis. I think we referred to that in the SER; you may have seen the simplified analysis. So we've called it a re-analysis.

And then the confirmatory analysis that we did I think is also referred to variously as the updated analysis. So for us re-analysis and confirmatory and we'll step through that as we go through the presentation.

I think the key thing to talk about is that for the license renewal the confirmatory analysis that we performed for the feedwater nozzle is the calculation of record for license renewal.

Additionally we'll talk about the license condition. We do have a license condition where we will perform calculations, confirmatory calculations, for the remaining two nozzles that were the subject of the challenges, and we will perform those calculations prior to two years prior to entering into the extended period of operations.

Next slide.

From an overview standpoint we did, as far as the full scope of environmentally assisted fatigue, we did the locations that are identified in the governing NUREG 6260, and that was the focus and the basis for the calculations that we did do.

Our original piping was designed to the B31167 code so therefore we did not have the calculations. That is what drove why we had to do these calculations.

From a timeline standpoint in September we completed the re-analysis as well as all the rest of the work that we did on environmentally assisted fatigue. There was an audit by the staff of those calculations in October. And really during the course of that timeframe, from October through January of 2008, a lot of questions back and forth, and a number of different RAIs and audits that were performed questioning the approach that we had taken.

And the key challenge was how we treated stresses at the blend radius for these three particular nozzles, coarse spray, reactor recirc and feedwater.

So what we'll do during the course of the presentation is, we'll talk about what we did on that reanalysis, and provide you with the basis for that. We will also talk about what we did on the confirmatory analysis as well.

We did complete - we had requested a public meeting. And that public meeting was held on January 8^{th}, where we defined what approach we took with the reanalysis method. At that meeting we also said that we were working on a confirmatory analysis for the feedwater nozzle.

We did complete that analysis on the

nozzle and submitted that on February 14^{th} - I'm sorry, January 30^{th}, Ray. And NRC, Dr. Chang, did an audit of that calculation on Valentine's Day of 2008.

We also submitted an amendment that provided some chemistry data. That was one of the key questions on how we treated the chemistry effects, and how it may have influenced environmentally assisted fatigue.

So as far as basis for the evaluation, we are consistent in our approach, consistent with the Gall report. We did evaluate the specified locations as I mentioned in the NUREG 6260, and the Fen methodology that we used was appropriate and was driven by the two cited NUREGs there for the different materials, carbon steel and stainless.

Additionally we did use our as-built drawings to do our analyses. We used the design.

MEMBER ABDEL-KHALIK: How different are the as-built drawings from the design drawings?

MR. FITZPATRICK: There is additional thickness for - this is Jim FitzPatrick - the shell has additional thickness in it from the design for rolling, like a quarter inch, and the nozzles have a little additional thickness from the original design provided on the fabrication drawings.

MEMBER ABDEL-KHALIK: And when were those as-built dimensions acquired?

MR. FITZPATRICK: They are on the GE drawings of the design before the plant started up.

MEMBER ABDEL-KHALIK: Thank you.

MR. DREYFUSS: We did use design transients versus the actual transients, so did not take credit for any - we used the conservatisms associated with design transients.

We'll talk a little bit more about cycle projections, but we did project cycles for 60 years. We'll talk about some conservatisms that we have inherent in those projections as well.

We also assumed -

CHAIRMAN SHACK: So when you say design versus accident transient severity, it means you are using the stresses from the design transient, not the numbers of the design transient?

(Simultaneous speakers)

MR. DREYFUSS: And again we did assume full uprate conditions for the 60-year period. We did do the uprate in 2006.

MEMBER ARMIJO: From day zero uprated conditions, and put those into all of these analyses?

MR. DREYFUSS: That's correct. Assume from

1972 up to this point and through the 60-year period.

Now we are going to talk about the specifics of the evaluation itself, and Jim do you want to talk on this a bit.

MR. FITZPATRICK: We used existing design analysis for the RPB shell, the lower head, the recirculant nozzles, and by the FEM to those existing analysis, and for the fatigue analysis MB 3200 rules, for three nozzles that entire original design fatigue usage, we analyzed for new models, new analysis, for the feedwater recirc outlet nozzles and the coarse spray nozzles.

MEMBER ARMIJO: Was the feedwater inlet temperature changed as a result of the uprate?

MR. FITZPATRICK: 372 to 392.

MEMBER ARMIJO: Now is that change in the conservative direction as far as this analysis is concerned?

MR. FITZPATRICK: It increases the stress range from your normal operating down to your injection. Delta T goes from, instead of 372 to 100, it goes from 392 or 394 to 100. It's a small increase in range.

MEMBER ARMIJO: Okay, thank you.

MR. FITZPATRICK: And then for the piping we performed new ASME class I fatigue analysis for the recirc RHR.

On the reanalysis of the three nozzles, we used 60-year cycles projected based on design transient severity and the cycle. So basically reviewed our design spec, and updated BWR for thermal cycle definitions.

We had new answers, find out what models are developed for these three nozzles using the as-built drawings and the material specs for each one of these nozzles.

Heat transfer coefficients were based on the design report and design specifications.

A thermal stress response in the reanalysis was developed from a step change in the temperature. And Green's function was developed from that.

Using the Green's function we developed thermal transients, stresses, for each set of the design transients for each nozzle.

And we calculated component stress differences. This is where the difference between - we'll explain a little further on, but this is where -

CHAIRMAN SHACK: Let me just come back to your Green's function. So you got your Green's function essentially from a finite element analysis -

MR. FITZPATRICK: Yes.

CHAIRMAN SHACK: - with a step transient.

MR. FITZPATRICK: Yes, sir. And you pull component stresses from there versus - it calculates stress intensity. And that has led to some confusion before.

Taking those, the thermal stresses, the pressure stress intensities were directly from the answers found with the models, and they were factored to account for the actual pressure during the transients, the unit load case and then factored up for that.

Adjusting intensities to detached piping loads were conservatively calculated and added to the other stress intensities for each transient and each temperature.

The maximum stress differences from the temperature transients were combined directly with the stress intensities from the pressure stresses, and the detached piping loads.

And the ASME MB 3200 fatigue calculations performed on the collective thermal transient stress systems.

And that gets rid of the ASME CUI. Then we used a bounding fatigue life correction factor for all the transients, one bounding number applied to that CUF for the entire 60-year operating period.

And then the environmental CUF is that bounding factor times the CUF.

We had a list of -

CHAIRMAN SHACK: One other - every time I read the analysis it says, axi-symmetric ANSYS model. This is a nozzle on a cylindrical shell. Why is it axi-symmetric?

MR. STEVENS: It's a simplification to - obviously when you model a nozzle axi-symmetric you treat, the vessel then becomes a sphere. So we also had to apply a correction factor to account for the ovalization of two intersecting cylinders.

And that's just a traditional way of industry way of modeling these nozzles.

MR. FITZPATRICK: Did that answer your question?

Some of the conservatisms in the analyses, the major ones -

MEMBER ARMIJO: Just before you go on, the bounding fatigue life correction factor, you say you calculated from water chemistry conditions expected to occur over the 60-year operating period. But you have had major changes with the water chemistry with hydrogen implemented many years after. So which is the water chemistry you used? Did you use the appropriate water chemistry for the normal water chemistry period, and a different water chemistry correction? Or the hydrogen water chemistry period?

MR. FITZPATRICK: Did both, and Gary can give you a detail on that.

MR. STEVENS: We actually broke the operating history up into three parts. The prior to hydrogen water chemistry, or normal water chemistry, where the factors, at least for the carbon and low alloy would be much higher and the oxygen content was higher.

Then we had the operation that was post hydrogen water chemistry implementation, with the historical duty if you will or availability of the system.

And then in the future and what that's projected to be. And that was based on water chemistry guidelines that the plants are following.

CHAIRMAN SHACK: And you used bounding strain rates for all these transients? Or you actually tried to estimate strain rates?

MR. STEVENS: We used bounding strain rates for everything.

MR. DREYFUSS: And we will talk a little bit more about chemistry during the course of the presentation.

MR. FITZPATRICK: Some of the major conservatisms in the nozzle reanalysis. The number of transient cycles using analysis was greater than the expected number of cycles for 60 years based on our plant experience. For example, heat up and cool down, there were 300 cycles - heat up cool down for the feedwater nozzle includes heat up and then a turbine roll. It's basically the major transient. We used 300 cycles of that. To date we've had 95 over 36 years of operation, and the original design was 200; we don't even expect to hit that number, based on the past history of 20 years of operation.

But the plant had more transients in the beginning than they do in later life.

The transient severity is a conservatism versus using actual transients. We used the bounding values, the pressure and temperature of the EPU for the entire life, and the bounding Fen multiplier. We used values, the input stat, the temperature strain rate, the sulfur content were chosen to maximize that.

And that multiplier was basically applied to all transient stresses, and that was the reanalysis method that we used.

MR. DREYFUSS: We talked about the chemistry itself. Bottom line is we chose our chemistry factors conservatively, and chemistry effects have been conservatively factored into the analysis that we did.

We did use the Fen factors from the cited NUREGs. Additionally we selected the various parameters that you see here in such a way as to maximize the effects and maximize the contribution that they had in terms of their effect on the environmental factors.

So strain rates, temperatures, dissolved oxygen, were all factored in that way.

CHAIRMAN SHACK: Of course there is no conservatism in that sulfur number since your sulfur probably is well over .015. In the materials you actually have in the plant.

MR. DREYFUSS: Correct.

MR. STEVENS: Plus that particular parameter tends to have less effect on the relations than some of these, oxygen and temperature and strain rate for example.

MEMBER ABDEL-KHALIK: Well, typically, how long would these oxygen excursions last?

MR. FITZPATRICK: A couple of days when there's the heating up, and you do a cycle flush, and then you start heating the reactor up, conduits come online. It takes awhile to get to the steady state on the chemistry.

MR. DREYFUSS: The startup might be over an 18-hour period, but getting it back to a stable condition will sometime take a day or two.

MEMBER ABDEL-KHALIK: So the different between the value that you used and the analysis, which is the mean plus one standard deviation, the difference between that value and the nominal value for dissolved oxygen, what would that be in percentage?

MR. FITZPATRICK: It's a little different. That number could be significantly higher, but there's no transient occurring at that time. So looking at 60 years we tried to do a bounding number, a representative number for all the transients expected to occur over 60 years.

MR. CHANG: If I may interject something. The staff did a focused review of what they did, especially in the oxygen content and excursion.

Now this is a BWR, not a PWR. The PWR, the maximum transients for the most critical components is during the heat up and cool down. The PWI especially the feedwater nozzle - now excursion of the oxygen content occurred during the heat up, but at that time there are no significant transients. So even excursion rate is high, applied to - if you apply to zero it's still zero. I don't mean zero; I mean small number.

MEMBER ARMIJO: So these excursions, these oxygen excursions, really had a very small contribution to the number that you used for the Fen?

MR. DREYFUSS: Right, it did not significantly impact it.

So the summary here is that the cumulative usage factors at Vermont Yankee under all analyses that we did perform do remain below one for the full 60 years of extended operation with margin.

I'll talk a little bit about the audit that NRC performed of the calculations. And the key challenges really were when we had done the analysis, we did the feedwater coarse spray and reactive recirc nozzle corners. The challenges were at the nozzle corners, the blend radius as it's referred to as well.

And the methodology by which we treated

the stresses was really the key factor as Jim had talked about as well. So we used component stresses, stress difference versus the maximum stress intensities. And what it comes down to is the treatment of sheer stress and are you neglecting sheer stress using this methodology.

That was the challenge. So we did submit this amendment 33, based on or in response to an RAI. And we documented the evaluation that we had performed and the methodology by which we had treated the stresses versus the component stress difference.

And we did essentially a sensitivity calc that resulted in a change, a maximum difference between the reanalysis that we had performed and the sensitivity that resulted in a very small maximum change, a .003 change which I think would have been complete at that point. But we really only addressed one element of the challenge.

And Gary, if you would explain a little bit about that.

MR. STEVENS: Yes, I think what we really addressed in that response was the effect of sheer stress.

Another part of the challenge was on this, it's been coined in several different ways, uni-axial stress, one-D virtual stress. And I think what I'd prefer to do is, we have a slide coming up where we show the analyses we did side by side, and I can get into a little more detail on that one.

But for the purposes of this slide, I think we generally agree that we might have satisfied the sheer stress issue, but we didn't satisfy the uni-axial or one-D virtual stress issue. And we'll talk about that in a few more slides.

MR. DREYFUSS: And Jim, if you could step us through the approach that we did here on the confirmatory calculation.

MR. FITZPATRICK: We did a confirmatory calculation on one nozzle, a feedwater nozzle. It's the controlling nozzle, because it is the most severe in design transients; had the highest fatigue uses of the three nozzles in question.

And we tried to put this, in simple terms, basically it's cold return water and is the hot vessel. That's why it is the more severe - the most limiting nozzle.

A number of design transients at two to three times the number of transients for the other nozzles. All the injections occur at that nozzle, versus the other ones feeling just the environment in the vessel.

And industry experience has shown that the fatigue usage is typically higher at the fatigue - at the feedwater nozzle than any other nozzles.

We used the same ANSYS finite element model, the same transients, the same cycles, and the same water chemistry that is the previous nozzle reanalysis.

And the confirmatory analysis, you combine six stress components for NB-32, 16.2. The sheer stresses are included for each stress.

And as the fatigue analysis was done for NB-32 2.4 for all the stress pairs, and this is the same methodology used in the reanalysis.

CHAIRMAN SHACK: What is the difference between the confirmatory calculation and the reanalysis?

MR. DREYFUSS: We are going to show that on a slide. I make that very clear.

CHAIRMAN SHACK: Not the difference in the results. What's the difference in assumptions?

MR. STEVENS: Should we go to that slide now? So this slide has the two analyses in parallel, the reanalysis, and the confirmatory calculation.

And what's in bold we'll talk about is

going to answer your question on what the differences are.

And I don't mean to simplify this calculation, and this analysis; it's done in six steps. We've simplified into six boxes, which in no way indicates that there are six simple steps to this. It's an ASME code analysis, and there is a lot of rigorous detail built into this.

So let's start at the left, and we'll kind of go through these both in parallel. Because you'll see a lot of the boxes are identical.

On the left we have 60-year cycles in design transients. That was the same and identical for both analyses. We assumed the same transients and the same quantity; we didn't differ on those.

We built an ANSYS finite element model. It was the same for both analyses. There was no different in model at all.

The model how we used it was, and the stresses we obtained, is where it was different, and that's the next one. So for in both analyses we'll take the simple part first, pressure stresses and piping stresses - pressure stresses were determined from that finite element model, pressure stress intensity, and piping stresses were done by hand.

That was identical for both.

Now let's go to the first box, and here's where we have the first difference. In the first analysis rather than run all the transients, and we have approximately 20 transients in the feedwater nozzle - there's many and they are complicated - rather than run all of those individually through the finite element model, we used a Green's function to generate the stress history for those transients.

That's - the Green's function is a well known technique in most all college mathematical textbooks. I don't think there is any controversy in how the Green's function generates stresses. But we'll talk about this uni-axial or one-D stress in a minute, and that's really where the contention lies there.

But in the first case, the reanalysis, we used the Green's function to generate stress histories for all those transients. That takes a significantly less effort than running all those transients through the finite element model.

CHAIRMAN SHACK: But this is purely an elastic problem, right?

MR. STEVENS: That's correct, so Green's functions would be appropriate for that. Everything is linear.

Now in the second case, the confirmatory calculation, we ran everything, all the transients individually through the ANSYS finite element model. So up to now the only difference is, we used a Green's function in the first case to generate stress histories; in the second case the ANSYS finite element model.

To your point the two should be identical, because everything is linear.

So how did we combine - moving on to the fourth box - how did we combine and determine maximum stress intensities? Here is where we get into some esoteric differences between the two.

I'll take the easy one first, which is the lower one, the confirmatory calculation. We basically take for all those transients, we get six stress components out of the finite element program, X, Y, Z and three shears. And we combine those for NB 32 16.2 of the code, which for every peak and valley you take differences, in those six stress components, and you rotate those into principal stress differences, and it's stress intensity. And you use that history, resultant history, to calculate fatigue usage.

What did we do with the Green's function?

We'll move up to the reanalysis. The Green's function, what we did there is, the Green's function itself, the stress history we got out of the finite element program, we could have had six Green's functions to use to generate six stress histories, six component stress histories for all the transients.

What we took out of the finite element program was basically the maximum stress difference, which is essentially equal to the stress intensity from the finite element program.

So what we got from the Green's function was a stress intensity history, and we used that to integrate and come up with a stress intensity history for all of the transients. So I think you can see that the simplification here that was made, and there are several, we are obviously by using the maximum stress component difference we are ignoring sheer stresses.

And in some of the responses to the RAIs, and John mentioned on the one slide we showed the sheer stresses were negligible.

But the other issue that we didn't address in those RAIs is taking a single stress intensity history and using that through a Green's function to generate a stress intensity history for all these transients.

Is that identical or proximate or close to taking all the six stress component histories and doing differences and rotations into a stress intensity difference? I think there is where the difference and the contention really lay was that approximation.

Both of these analyses, the intent is to do an ASME code fatigue calculation. There was never any intent not to do so.

The difference in that step I think is really key to our differences. And obviously doing a confirmatory calculation was intended to resolve that issue, proof that how close these were.

So after that step then we have a stress intensity history that was computed differently in each of the techniques. But given that stress intensity history, the fatigue usage analysis was performed identically between the two.

There is a type on the slide here. It's not NB 32 24, it's 32 22.4.

MR. RADEMACHER: So that is 32 22.24?

MR. STEVENS: Correct. So that step is identical between the two. And then the last step is - we get a fatigue usage out of that fifth box that we then apply environmental factors to.

In the reanalysis, the first one we did, the maximum Fen was applied to the total usage, to come up with the environmentally assisted fatigue number.

In the confirmatory calculation a maximum Fen was computed for each load there, where the only thing that was taken into account was the temperature. We took the maximum temperature of each load, put the strain rate and the sulfur and all the other primaries were the same. And good or bad the intention of that difference there was to demonstrate yet another conservatism built into the analysis.

So the only thing different in the last step, which is the environmental fatigue evaluation, was one Fen applied to total usage in the reanalysis; multiple bounding Fens applied to each load pair in the confirmatory calculation.

MEMBER ARMIJO: So the more conservative treatment was in the reanalysis?

MR. STEVENS: For that step.

MEMBER ABDEL-KHALIK: How much do the material properties change over the temperature range let's say for the feedwater?

MR. STEVENS: I can't give you a specific answer, but generally speaking there could be 10 to 15 percent variation I the material properties over the range of temperatures we are looking at.

MEMBER ABDEL-KHALIK: And how is that accounted for in the analysis?

MR. STEVENS: In the reananalysis we picked bounding temperature properties. Because of the Green's function use, everything - you do one run and everything is constant. So we tend to take the bounding material properties and heat transfer coefficients.

In the confirmatory calculation the material properties are varied with temperature input to the finite element program as well as heat transfer coefficients.

And you are really touching on one key element here, if you take these - we have identified really just three bold spots where these analyses are different. We identified on an engineering level 20 differences in these two analyses, things like you just mentioned, material properties; they were treated differently. Heat transfer coefficients were treated differently. Twenty differences between the reanalysis and the confirmatory calculation really that were levels of conservatisms built in to the analysis, approximations using a simplified approach versus a very detailed approach.

So we did not go through exhaustively a parametric study to understand which of those 20 items caused the differences between the two. We were satisfied at the end that the final result we got was the same, usage factor less than one with margin.

MR. DREYFUSS: Do you want to move on to the results?

MR. CHANG: Before moving on, could I put in a couple of comments?

I think Gary have summarized what you call the reanalysis and what you call the confirmatory analysis very nicely.

But I'd like to bring out a couple of key points that can facilitate going right through the heart of the issue.

Actually applicant submitted two reanalyses. One was submitted by amendment 31 which is dated 9/17. The second refined analysis was submitted December 11^{th}; that was submitted by amendment 33.

So those two I call them just reanalysis. And then there is a final confirmatory - you call final confirmatory analysis submitted by amendment 34 on January 30, '08.

Now in our final SER, submitted to the ACIS and it was issues, we call that analysis as analysis of record for the feedwater nozzles. Why? That's the point I'd like to point out. Missing this phase, this is the opportunity, you may keep in mind, reanalysis, analysis of record, which is not the case.

The - now let's call that analysis of record. The analysis of record took all the unknowns out of the place. You use six components, stress, including sheer stress and nominal stress. Only thing is you approximate the header effects by a spherical header. That as Gary said is a very standard industrial approach. We buy that.

The difference comes that the reanalysis did not analyze every transient. From the base transient case, and finite element results, from that base case you project it to the other transient stresses by the Green's function.

I don't dispute the Green's function methodology at all; I love it. The only way is, how do you apply it? Now you apply it by six components, or you apply it by one-D virtual stress.

The reanalysis still have the one-D virtual stress there. But the analysis of record do not have that.

So let's for the time being call the analysis of record close to the reality. The outcome, you don't see it at the amendment 34. Because amendment 34 seems to indicate the analysis of record always give you a lower answer. That means the reference analysis is conservative.

But that is deceiving, because if you use the same Fen as you used in the refined analysis, the CUF will be higher. As I report it, as the staff report it in the final SER, that number, the CUF, will be .893. It's not .353 anymore.

So in other words the analysis of record gives you higher CUF for everything the same condition.

In other words the refined analysis can be conservative, can be not conservative; can be conservative by a factor of two; and also can underpredict by a factor of two.

For that reason we don't call that the refined analysis or analysis of record. But for Vermont Yankee the feedwater nozzle, the final analysis, additional analysis, or whatever you call it, still give you at least 10 percent margin to the code CUF limits.

For that reason I feel comfortable. Now as long as you make this as the analysis of record. For the future if you want to adjust anything you base it on that. You don't back to the refined analysis.

On the same basis if this can produce results like this, the same or similar results can also be produced. I'm not sure, because I didn't do that analysis on the other two nozzles.

For that reason we asked them to perform similar analysis for the other two nozzles. When all this is completed, we have three analyses of record. Those are fully justified.

VICE CHAIRMAN BONACA: What I would like to point out, however, is that this calculation results seems to be consistent with the one that was in the SER. So we would like to understand it better.

In the SER you asked the licensee to use the same maximum Fen.

MR. KUO: Right, what we consider that is acceptable is what the applicant calls confirmatory analysis.

VICE CHAIRMAN BONACA: Yes, but here in the confirmatory analysis I see the result being 0.35, and you are quoting .893.

MR. CHANG: Eight nine three, we have both numbers reported in the SER, so it's on record that the analysis of record, using the maximum Fen, you will get .893. But you use 24 different values of Fen which is appropriate, you will get .353.

In other words, the .353 is not wrong; it's just compare the earlier analysis and the newer analysis. The earlier analysis may not be conservative. It depends on the final analysis which we know is right and conservative.

CHAIRMAN SHACK: What you are arguing is that his stress analysis could be nonconservative, and he covers that up by using a conservative Fen, but clearly his overall calculation is conservative but he's piling it up in different ways, and I guess the question is, is that always going to be the case? It's certainly true in these two situations.

MR. CHANG: Normally staff do not second guess what the future outcome will be. But since this feedwater nozzle, the CUF, is five to 10 times higher as compared to the others, I would imagine the other two nozzles when you complete your analysis give us a good foundation to work for the future. This number will also be good.

MEMBER ARMIJO: I'm a little confused. The mechanical analysis I think, the confirmatory calculations were done by the methods the staff was comfortable with and were done with a lot of conservatism as pointed out in some of these charts.

In addition they applied a more realistic Fen for different periods as opposed to the original reanalysis approach. But still conservative.

So I don't know, and there's a big difference in CUF, right, .35 versus .89, that's a very big difference. So what does the staff consider to be the official number for CUF for this nozzle?

MR. CHANG: .353.

MEMBER ARMIJO: Okay.

VICE CHAIRMAN BONACA: Because in the SER you state very clearly that any request of the licensee to use a maximum Fen, and you got the value of .89, okay, still using the confirmatory calculation now it ends out to .89, and you are saying because it is higher than what you calculated with the reanalysis which was .64, then the analysis of record has to be the one with the higher value.

So here we are talking about apples and oranges. I mean I'm trying to understand what is the confirmatory calculation result, and what is the basis for forcing them to use the highest Fen? I mean that's probably the best question.

MR. CHANG: As many people call the fatigue analysis, it's a black box. You can turn out different results depending on the level of sophistication that goes in there.

The first step we are trying to establish is, is the Green's function methodology or the confirmatory analysis methodology, which is correct.

We say the confirmatory analysis methodology is correct. That's the purpose of bringing the .893 up.

VICE CHAIRMAN BONACA: But you told me that 0.35 in the confirmatory analysis calculation is conservative; that's what you said.

MR. CHANG: They are realistic. Realistically speaking, the refined analysis do not have to use Fen equal to 11 to all the transient pairs. If you make every assumption the same, confirmatory analysis will get you lower results.

MR. KUO: Just like you said, Dr. Bonaca, comparing this two analyses here is comparing apples and oranges, because the numbers involved are different in terms of Fen.

For the reanalysis that they used, okay, they used a bounding Fen value for all transient pairs. But for the confirmatory analysis as they called it they used Fen, maximum Fen for each transient pair.

VICE CHAIRMAN BONACA: that is what I understood. And you said you have to assume the same Fen for both methodology if you want to compare results.

MR. KUO: If they were to use the same bounding Fen for all transient pairs, using the methodology in the confirmatory analysis, the number would have been .893.

VICE CHAIRMAN BONACA: Okay, that's why you are talking about -

MR. CHANG: Dr. Bonaca, Robert Schu, who used to be on my staff and is fairly involved on this topic, he may supplement some of the points.

VICE CHAIRMAN BONACA: No, I understand now. But go ahead.

MR. SCHU: May I say something? Because basically when you are doing the fatigue analysis you've got to calculate the stress. And right now the stress implemented by the applicant is not correct. Compare - it's not adequate, because everybody believe the ANSYS result is adequate. So we asked the applicant to compare their methodology with the ANSYS analysis. The result, there is no way they can match.

So from that analysis record point of view, their Green's function, any time they do a Green's function analysis, they've got to redo the traditional ANSYS analysis.

And actually the traditional ANSYS analysis will create the correct results and that's NRC accept.

MR. CHANG: The traditional ANSYS analysis will create reasonable results. That result could be higher; it could be lower. But that's reasonable. That's correct. That's why we think our - that's will be our future basis.

We want something to be correct.

MR. DREYFUSS: Garyk if we could summary?

MR. STEVENS: Okay, let's forget abou8t the sixth box here, which is the environmental fatigue, and let's look at the fifth box, which is, we've got the stress history. We calculated fatigue. And let's write some numbers down and put everything in perspective.

CHAIRMAN SHACK: That is the CUF in error if we just quite at the fifth box.

MR. STEVENS: We will compare apples to apples here, which is CUF from each analysis prior to an application of environmental factors.

Okay, the top box, the CUF for 60 years from the reanalysis was .064.

The bottom analysis, fifth box, the CUF for 60 years was .089. The difference between .025.

If we applied the same environmental factor to both fo those numbers, the difference in the magnitude would be identical to comparing those two numbers. So if I decided the environmental factor is 11, and I applied them to both, the ratio of the two would be the same.

So comparing apples to apples here, the confirmatory calculation, .089 versus the reanalysis of .064, as I mentioned before there were 20 some odd differences built into these two calculations, any one of which could have contributed to that difference.

The use of a single stress intensity history could be one. The material properties varying with temperature could be one. The heat transfer coefficients varying. Any of them. We did not do exhaustive analysis to determine which one contributed how much.

So I think what the staff is saying is that that increase is what has led them to the license condition for the other two nozzles.

MR. CHANG: You are correct.

MR. DREYFUSS: This is what took from September or so up to this point, going through this and trying to address staff questions on it.

It became clear to us that a simpler approach is to go with the confirmatory approach. That is why we did that for the feedwater nozzle, and we do have that license permission.

MR. CHANG: when all the three nozzles were done, the three confirmatory analyses would become three analyses of record; that's important.

MR. MANNAI: This is Dave Mannai, licensing manager. I'd like to make one point, because I did sense a little bit of concern on the part of the staff, the ACRS committee. The bottom line is, we agreed with the NRC in their request to make the confirmatory analysis the analysis of record.

When we had performed the calculation and then subsequently the NRC staff had ordered that calculation, they looked at our methodology, and they did not disagree with the fact that for the confirmatory analysis that the maximum Fen factors had to be chosen for each transient, but that was a more realistic use of that calculation that was wholly appropriate as Dr. Chang said a month ago.

And so if you stop in the middle of it

you'd say oh there is this big difference. But as the analysts went through and our own folks reviewed that and then subsequently the NRC staff reviewed it, there were no concerns with the use of that calculation or those assumptions that were used.

MEMBER ARMIJO: Okay, so there is no disagreement with the staff on the use of bounding Fens for each transient pair as the right way to go; correct?

MR. MANNAI: Right.

MR. KUO: It is more realistic. The reason that we want to make this so-called confirmatory analysis as the analysis of record is to prevent future readers getting the wrong impression. The original reanalysis is still the right reanalysis that we accept.

MR. CHANG: If you only read this analysis result once, you want to read the right one. You can skip all the intermediate steps.

MR. DREYFUSS: Okay, next slide.

These are the results, we've talked about them. And the next slide.

I'll speak a little bit about the license condition. As discussed, the confirmatory analysis for the feedwater nozzle is complete. It is the calc of record.

The reanalyses performed for coarse spray and reactor recirc outlet you can see the CUFs adjusted for environmental factors here. The .17 and .08, we fully anticipate that as we perform the confirmatory calculations, that we will again be below one with plenty of margin, and that in fact the feedwater nozzle is the controlling nozzle for us.

The license condition itself is, we will perform the confirmatory analyses for coarse spray and recirc outlet no later than two years prior to going into the extended period of operation.

MEMBER ARMIJO: If you are already tooled up for this analysis work, why don't you just do it?

MR. DREYFUSS: There is some additional work to do, there's resources, there's modeling work that needs to be done. We will be getting to work on that. We just don't have those analyses complete yet.

Our intention is that we will be working on these during the course of this year, and getting that work complete.

VICE CHAIRMAN BONACA: Thank you for the presentation. It was clear, and we begin to understand what's happening here. And now we go to the staff presentation, right?

MR. ROWLEY: Good morning. My name is Jonathan Rowley, and with me I have Dr. Kenneth Chang. And we will discuss the environmental fatigue issue as it pertains to the Vermont Yankee safety evaluation report.

Next slide. I'd like to give you a quick recap of this discussion from the February 7th, HRS meeting. We talked about the resolution of this concern, and the included license renewal, the license condition that we have applied to Vermont Yankee.

Next slide.

As you can recall Vermont Yankee revised their application to use the fatigue model for their management of fatigue for the extended period of operation. The corrective action element of that program allows them to do a reanalysis of components. They submitted those reanalyses to the NRC that included incorporated environmental fatigue on September 17th, 2007.

We performed an audit of those reanalyses on October 9th and 10th. We asked six audit questions during that audit. One was not answered to our satisfaction, so we made that an RAI; we sent that on November 27th, 2007.

The response to that RAI came back on

December 11, 2007.

We had some discussions about this RAI. There were some differences in nomenclature and other things that we couldn't quite work out, so we decided to have a face-to-face meeting on January 8^{th}, which was a public meeting on January 8^{th}, 2008, at that time they agreed to submit a confirmatory analysis of the feedwater nozzle. Next slide.

That analysis was to include benchmarking for the Vermont Yankee's feedwater nozzle using axi-symmetric on that element model, taking full care of all stress components of the nozzle using ANSYS code for all defined transients; demonstrated that Vermont Yankee specific benchmarking calculations bound the coarse spray and the recirculation outlet nozzles, calculated fatigue usage factors were done by ASME code Section 3, and they can compare the results to the previous calculations to determine if they were conservative or not. Next slide.

On January 30^{th} Vermont Yankee submitted those what we called - a terminology change - updated analysis, which is one and the same with the confirmatory analysis. They proved to us that they used the same parameters, same data, methodology, as agreed upon.

And the last slide, what was stated during the January 8th meeting; determined that the CUFs were the safe ends and then rated lower than the previous analysis.

Next slide please. Supplemental information was submitted to us on February 5th to demonstrate that the updated feedwater analysis bounds the recirculation outlet nozzle, and it described how the water chemistry effects were accounted into this analysis.

Next slide. We performed an audit on February 14th, Valentine's Day, and we discussed the things listed here. And I would like Ken Chang to talk about what we did at that audit.

MR. CHANG: I will not follow these slides. Instead I will go through the process of how we performed the audit.

The audit, the main purpose to address the concerns expressed during the previous ACIS meeting. So really it's the chemistry, effect of chemistry on this EF analysis.

So we spent a good time of the day reviewing the absorbed oxygen content, the strain rate, the temperature, the surface content, those parameters that they used in the confirmatory analysis or the analysis of record.

Those parameters were properly used, like the dissolved oxygen is average plus one standard deviation. And then we asked about whether any excursion was there, the excursion happened during the heat up. During the heat up process we found that the feedwater nozzle don't have any significant transients, although it doesn't bound the oxygen level during the heat up, so that doesn't really matter.

And we also looking at the strain rate, a low strain rate to bound the value, to bound the Fen value, was used all along.

And the temperatures, we assumed using 550 degree Fahrenheit for the nozzle, which is also bounding.

For the surface content, for stainless steel, surface content is not one of the parameters evaluated by NUREG CR 5704. But for the carbon steel, .015 percent was used to have the maximum impact on the Fen.

We also look at how they performed this confirmatory analysis. The confirmatory analysis and the reanalysis use the same model, the axis-symmetric finite element model, for which the branch site is exact. You find the axis of symmetry. You do a revolution around it. But on the header pipe, on the header side, you can only simulate with either the flat plate or with a sphere.

Normally people do simulate the header effects by using a spherical header. The right way to do is to use two times the actual radius for the sphere. That way you simulate to accurately predict the pressure stress.

For Vermont Yankee there was a model using 1.5 radius already done, so I don't dispute that, since they adjust the pressure stress by another factor of 1.33, four thirds. Now four thirds times three halves, that's a factor of two. That is a typical number being used by the ASME stress analysis simulating the 3-D effects.

We also look into what Fen value we used. That has been already discussed in quite detail. I really fully endorse them of using 24 training pairs to come up the total CUF, and 24 Fens were calculated, one for each training pair. That is the most complete analysis I've seen so far. I hope we can make this as analysis of the future, as a general case.

Now, the - another question was asked during the early meeting was how was film coefficient calculated? The film coefficient was calculated correctly even including the gap between the thermal sleeve and the nozzle wall. They estimated how does the gap open or close, and calculated some film coefficient to simulate inside of thermal sleeve, between the thermal sleeve and the nozzle wall, and after the nozzle wall. So that analysis was quite accurate, and even by today's standards it's still very good.

Other transients: the two analyses use the same transients; otherwise you cannot compare. Transients got to be the same. Cycle got to be the same. Same training curves. Same number of cycles was used in the refined analysis and in the confirmatory analysis.

External piping loads, here is a little deviation from the traditional MD 3200 analysis as compared to this. Although Vermont Yankee did not apply the external piping loads in a 3-D way, but they calculated a stress intensity based on the external load.

And that external load was added, that stress intensity was added, to the stress intensity calculated for the thermal transients. After that stress intensity was calculated add on top, that is known to be conservative.

K sub e, ASME code requires elastoplastic cycling penalty factor. In old analysis normally people have K sub e equal to one. We look into it, and for the feedwater nozzle, K sub e the worst combination K sub e equals to 1.115. So in other words this 11.5 percent penalty on that underlying stress before you go into the -- allow the cycle to stress to the allowable cycle curve. That is also appropriate.

Young's modulus, ASME curve, the fatigue curve, is based on certain Young's modulus. When you are performing analysis you have to adjust your Young's modulus to the ASME code value. That was done also properly.

Six stress components, although it's not a true 3-D analysis, but six components was used. For the thermal transients, those components, in particular the unit stress giving small or big is included in their confirmatory analysis. That is, to us that's acceptable.

Seismic loading, seismic is one of the transients. Seismic, you cannot put on the 3-D analysis and put in six components, because you don't even know what it is. However, the seismic loads are small compared to similar transient loads. And seismic loads, when seismic load occurs, the strain rate is high, Fen is low. So by not considering the seismic load in the combination, produce conservative results.

Cycles: the two analyses use the same cycles, the same transient cycles. That is appropriate.

So based on these descriptions we felt through deeper review and through the cooperation of the applicant, by bringing two suitcases of material into NEI, downtown office, we reviewed there; we are very satisfied.

If you can make this as analysis of record for the feedwater nozzle, we say, we have no further questions.

On the same basis there are two other nozzles, could result in a similar way. So we say, if you perform this kind of confirmatory analysis as described above, then you heard it twice already. You heard it from the applicant; you heard from me. If you do that kind of analysis for the two additional nozzles, our confidence level also goes up for those two nozzles. So the whole issue will be resolved.

Now I really want to thank the applicant for performing this analysis, because this, let me remind you, yesterday we talk about whether on the nozzle, they are one location or two locations or three locations which you need to study.

This nozzle, the plan radius is not at the safe end. Yesterday you hear about safe end. You've got to evaluate your pipe to the nozzle well, you've got to evaluate the safe end. You've got to judge whether you have similar sleeve or not. You've got to evaluate the plan radius.

It happens to be for this nozzle the plan radius is the highest to CUF location. Did you see that yesterday? I don't. That's why we insist on performing similar analyses for similar kind of conditions and terrains.

That concludes my presentation.

VICE CHAIRMAN BONACA: Could you go to page nine?

MR. CHANG: Page nine?

VICE CHAIRMAN BONACA: Here you are talking about previous analysis. Is this the reanalysis?

MR. CHANG: Previous analysis means the reanalysis. The September 19 and December 11.

VICE CHAIRMAN BONACA: Okay. We got an explanation of what we meant by reanalysis and confirmatory analysis. So the October analysis now is the confirmatory analysis.

MR. CHANG: One and the same.

VICE CHAIRMAN BONACA: That's what I thought.

MR. CHANG: Updated analysis, the confirmatory analysis, and the analysis of record, those three are equal right now.

MR. SHUN: I am sorry, Ken, why do you say these three are equal? I thought they are different. Reanalysis is reanalysis; normally reanalysis is - they are not equal.

MR. CHANG: What Jonathan call is update analysis, and what applicant call as confirmatory analysis, we call them analysis of record.

MR. KUO: I would personally suggest, let's not confuse the issue. We, at least from staff's point of view, we stopped using the term, confirmatory analysis. We have the analysis of record.

MR. CHANG: I agree.

VICE CHAIRMAN BONACA: Are we disagreeing with the previous statement, that previous analysis means reanalysis?

MR. ROWLEY: No.

MR. CHANG: For the feedwater nozzle, there is only one analysis of record; that is submitted on January 30, '08.

VICE CHAIRMAN BONACA: Still it says, the confirmatory analysis which now has become the analysis of record.

MS. FRANOVICH: If I may, this is Ronnie Franovich, the reason that this has been such a strong view by the staff is that we are establishing a new licensing basis for license renewal, and so being very clear on what the licensing basis is for this issue is really important for the future regulation of the facility.

I wanted to answer one question by the gentleman, why wouldn't they do the analysis now for the other two locations. The end of the current - the period of extended operations really begins in 2012, and so two years before that would be 2010. So it won't be but for another couple of years th8at we will get that analysis in for the other two locations.

Just wanted to clarify that too.

MR. ROWLEY: All right, next slide please.

Our conclusion is that the feedwater analysis is the analysis of record, as performed in accordance with ASME code Section 3, the coarse spray and the reactor circulation nozzle analysis will be performed according to the fourth condition which is, next slide, that the licensee perform and submit to the NRC for review and approval an ASME code analysis for the reactor circulation and outlet nozzle and the coarse spray nozzle at least two years prior to the extended period of operation. This analysis shall be the analysis of record for these two analyses.

VICE CHAIRMAN BONACA: Now on the conclusion on the second bullet, did you say that the CUF was calculated in accordance with ASME code Section 3. But the analysis was also in conformance with the ASME code Section 3?

MR. ROWLEY: The entire analysis - the entire updated - well, confirmatory analysis, yes.

VICE CHAIRMAN BONACA: Yeah, the claim was made that the original analysis was also conforming to ASME code Section 3.

MR. CHANG: to be precise, that should be performed according to the ASME code without using Green's function methodology.

VICE CHAIRMAN BONACA: Yes, okay. They stated the same thing. So that is not the distinguishing attribute

CHAIRMAN SHACK: Well, just to defend the poor Green's function here for a second, poor Mr.

Green, the Green's function is fine. It's how they combine the stresses after the use the Green's function that is the problem.

MEMBER BLEY: Calling that the Green's function method is not right.

(Simultaneous speakers)

CHAIRMAN SHACK: I did have a question, if I could ask Gary Stevens, this came up.

Does the location of the maximum fatigue usage change when you do the individual transients, decay Fen? You find that the actual location of maximum usage has shifted? You didn't look at that?

MR. STEVENS: We did. I'm trying to figure out the best way to answer your question without confusing the whole room.

The answer would be no, but what location we looked at we built into this going into the analysis. And there were several considerations.

First and foremost would be looking at what the original design analysis tells us about where the high usage location is. And that's an appropriate technique -

CHAIRMAN SHACK: Well, no, when we say high usage location, I mean are we talking nozzle or are we talking finite element location, et cetera.

MR. STEVENS: I'm not sure I understand that question.

CHAIRMAN SHACK: You get a different usage factor for every finite element in this whole axis-symmetric model, and I'm assuming the number you are quoting here is the highest usage factor for any given element that you are looking at.

MR. STEVENS: That's right. We based our selection process on really three things: maximum stress, which is going to give us high usage factor; we also need to look at different materials. Some of these nozzles have stainless steel safe ends and low alloy steel nozzle forgings which have different Fen factors associated with them. And we also have to look at chemistry, as in water chemistry.

An example there would be the feedwater nozzle where the incoming feedwater stream, the oxygen content is significantly different than it is in the vessel. So the environmental factor for the safe end would be drastically different than it is for the nozzle forging.

All that was built together, and that's why for each of these nozzles we take two locations, the limiting location in the safe end, and the limiting location in the nozzle forging. And that is a composite of all those factors going together, that collectively this gives us - between the two locations we've covered the maximum possible usage factor for the whole component.

If I - I would come up with a different conclusion if the chemistry was constant for all locations, the material was constant, I might pick one location in a safe end, in a PWR for example, especially where stratification loading is present, and it drives you back to the safe end.

In this situation here, with different materials and different chemistry, we chose to evaluate two locations to bound it.

MR. CHANG: Dr. Chang. If I may supplement what Gary says. You vary two locations, but when they say safe end, actually they evaluate three locations in the safe end; the pipe end, the pipe to nozzle weld; and the transition. Consider, next to that transition there is a thermal sleeve which can change temperature diffusion pattern.

So one location covers three areas which they did not advertise. I just tried to clarify.

MR. ROWLEY: So that ends our presentation unless there are more questions.

VICE CHAIRMAN BONACA: Thank you for your presentation. And are there any questions? Or further comments?

I guess not, so I'll give it back to you.

CHAIRMAN SHACK: Gentlemen, I think we can break for lunch until 1:15. And again I'd like to thank the licensee and the staff for very interesting presentations. It did help clarify an issue that was quite confusing.

(Whereupon at 12:04 p.m. the proceeding in the above-entitled matter went off the record to return on the record at 1:15 p.m.)

CHAIRMAN SHACK: We can come back into session.

Our next topic today are some selected chapters of the SER associated with the ESBWR design certification applications. And Dr. Corradini will lead us through that.

MEMBER CORRADINI: Thank you, Mr. Chairman. I'll just give a short reminder to the Members about where we are in this. So the purpose of this portion of the meeting is to review four chapters of the design certification document and the associated SERs that we have talked about in subcommittees. Those chapters of the SERs are chapters 9, 10, 13, and 16, with open items related to