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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

SUBCOMMITTEE ON POWER UPRATES

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TUESDAY,

NOVEMBER 29, 2005

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m.

MEMBERS PRESENT:

RICHARD S. DENNING, Chairman
THOMAS S. KRESS
VICTOR H. RANSOM
JOHN D. SIEBER
GRAHAM B. WALLIS

ACRS STAFF PRESENT:

RALPH CARUSO, ACRS Staff

ACRS CONSULTANTS PRESENT:

SANJOY BANERJEE, ACRS Consultant
GRAHAM M. LEITCH

NRC STAFF PRESENT:

ZENA ABDULLAHI, NRR
CHRISTOPHER BOYD, NRR
RICK ENNIS, NRR
STEPHEN HAMBRIC, NRR
CORNELIUS HOLDEN, NRR
TAI HUANG, NRR
JESS GEHIN, NRR
TOM MULCAHY, NRR
MUHAMMAD RAZZAQUE. NRR
VIKRAM SHAH, NRR
THOMAS SCARBROUGH, NRR
GEORGE THOMAS, NRR
JOHN WU, NRR
SAMIR ZIADA, NRR

ENTERGY/GE STAFF PRESENT:

ENRICO BETTI

ALAN BILANIN

FRAN BOLGER

MICHAEL DICK

MARGARET HARDING

JERRY HEAD

BRIAN HOBBS

KARL KUEHLERT

BRIAN MOORE

DOUG NEWKIRK

CRAIG NICHOLS

DAN PAPONE

LOUIS QUINTARA

I-N-D-E-X

P-R-O-C-E-E-D-I-N-G-S

(8:31 a.m.)

INTRODUCTION

CHAIRMAN DENNING: Good morning. The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Power Uprates.

I am Dr. Richard Denning, Chairman of the Subcommittee. Committee members in attendance -- well, Dr. Graham Wallis isn't quite in attendance. He would be here this morning. He was held up by the fog. That is not a typical problem of Dr. Wallis', being held up by fog. Dr. Tom Kress, retired head of Applied Systems Technology from Oak Ridge National Laboratory. Dr. Victor Ransom is not here yet. He will be here in a few minutes, who is Professor Emeritus, Purdue School of Nuclear Engineering; Mr. Jack Sieber, retired Senior Vice President, Nuclear Power Division, Duquesne Light Company. We also have ACRS consultants here today in attendance: Dr. Sanjoy Banerjee and Mr. Graham Leitch.

The purpose of this meeting is to discuss the extended power uprate application for the Vermont Yankee nuclear power station. The Subcommittee will hear presentations by and hold discussions with representatives of the NRC staff and the Vermont Yankee licensee, Entergy Nuclear Northeast, regarding these matters.

The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

Ralph Caruso is the designated federal official for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on November 14 and November 28, 2005. The meeting was also announced in an NRC press release issued on November the 18th, 2005.

Portions of this meeting may be closed to discuss proprietary information. In fact, they will be closed to discuss proprietary information.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard. It is especially important today for people to speak up into the microphones because this meeting is being broadcast via a conference call link. The conference call will allow stakeholders to listen to the discussion today and tomorrow, but we will not be taking comments over the telephone.

When it becomes necessary to close the meeting to discuss proprietary information, stakeholders on the conference call will begin to hear recorded music and a message explaining that the meeting is closed until we return to open session.

We have received several requests from members of the public to make oral statements today. And they will have the opportunity to make those comments tomorrow afternoon.

Other interested stakeholders can submit written comments to the ACRS and at the NRC's Washington, D.C. address or by e-mail to Mr. Caruso at the address listed on the agenda. These comments will be provided to all of the members before the meeting of the full Committee on December 7th, 2005.

This is the second of two ACRS subcommittee meetings that will consider the Vermont Yankee power uprate request. On November 15 and 16, the Subcommittee met in Brattleboro, Vermont. The full ACRS is scheduled to consider this application on December 7th, 2005 in Rockville, Maryland. And that meeting will also be open to the public.

We have a very packed agenda for these two days and a number of major issues to discuss. I apologize to the staff and the speakers in advance. At some point we are undoubtedly going to cut short presentations if it looks like those aren't the most relevant issues. And I also ask you to give us some help, too. If there's something that is straightforward and does not look like an issue, let's go through it quickly to save time for the discussion of the major issues.

We will now proceed with the meeting. I call upon Mr. Holden of the NRC staff to begin.

1. OPENING REMARKS

MR. HOLDEN: Good morning. My name is Cornelius Holden. I'm the Deputy Director of the Division of Operating Reactor Licensing in the Office of Nuclear Reactor Regulation.

The NRR project manager for the power uprate review is Rick Ennis. He will discuss the specific agenda in a moment. However, I would like to note that we plan to discuss the areas of the review not covered in the ACRS meeting held in Vermont two weeks ago.

As I mentioned at the Subcommittee

meeting, NRR just recently entered an organizational restructuring. This resulted in numerous changes to division branch names. Since the Vermont Yankee review was performed using the review standard RSO 01 and the standard is organized by the previous branch names, we decided to use the previous organizational names in our slides for the technical review branches.

During the meeting in Vermont, there were questions raised regarding the NRR staff, when the NRR staff was going to revise the safety evaluation, to reflect some recent supplements to the application that provided the licensee's risk assessment associated with crediting containment overpressure.

As I noted during the last meeting, there are no open items in the draft safety evaluation. On this issue, the staff made its findings based on its own assessment of the risk of crediting containment overpressure, as discussed in safety evaluation section 2.13.

However, the staff requested Entergy to provide its assessment based on generic discussion of this topic related to the proposed revision of reg guide 1.82. Specifically, during the October 7th ACRS full Committee meeting, Dr. Sheron stated that as part of the planned revisions to reg guide 1.82, the staff proposed to take a more risk-informed approach to determine whether or not credit for containment overpressure is acceptable. As part of this proposal, the staff stated its intent to request licenses demonstrate that crediting containment overpressure meets the five key principles in reg guide 1.174.

Entergy's supplements 38 and 39, issued in late October, provided the licensee's risk assessment of crediting containment overpressure using the guidance in reg guide 1.174.

The NRR staff has reviewed the licensee's supplements and issued a request for additional information on November 25th. The licensee has scheduled a response date of December 2nd. Although this would not give the staff time enough to revise the draft safety evaluation before the full Committee for ACRS on December 7th, we hope to have enough time to review the submittal and at least provide our findings verbally to the full Committee.

Any changes to the draft safety evaluation would further bolster our current finding. And it would be consistent with the ACRS letter of September 20th.

Unless there are any questions, I would like to turn it over to Rick Ennis.

CHAIRMAN DENNING: I have a quick question about this issue of 1.174. I notice in 39, the staff states that they are making a risk-informed presentation. And in RSO 01, in the older version there, it definitely says that these are not risk-informed applications.

Help me again. Is that a policy that is changing as far as the staff is concerned? And can they risk-inform a piece of it and not all of it?

MR. ENNIS: This is Rick Ennis, the NRR project manager.

I believe we discussed this a little bit at the meeting a couple of weeks ago. It's not the intent to risk-inform the entire EPU application, the overall EPU. For this specific subject, we said that if a licensee was going to request credit for containment overpressure, we would ask them to provide risk information on that aspect of the EPU but not the overall EPU.

CHAIRMAN DENNING: But that's quite consistent with what RSO 01 says about how to use risk information.

MR. ENNIS: Right, right.

2. INTRODUCTION

MR. ENNIS: Good morning. My name is Rick

Ennis. And I am the Project Manager for the Vermont Yankee EPU in the NRC's Office of Nuclear Reactor Regulation, NRR.

I would like to discuss the agenda for the meeting today and tomorrow. Today the first presentation will be a discussion by Entergy pertaining to issues associated with the steam dryer and reactor vessel internals.

And following Entergy's presentation, the NRR staff will provide a discussion of the review performed by the Mechanical and Civil Engineering Branch, as discussed in safety evaluation section 2.2. Much of that discussion will focus on our review pertaining to the steam dryer and potential adverse flow effects at EPU conditions.

Entergy will then follow with a discussion related to the analytical methods and codes used by their fuel vendor, General Electric, GE, as well as other reactor issues. The NRR staff will follow that presentation with a discussion of the review performed by the Reactor Systems Branch, as discussed in safety evaluation section 2.8. And a large portion of that presentation will focus on the GE methods issues.

Tomorrow Entergy and its contractors have four presentations planned. Each will be followed by an NRR staff presentation on related topics. The first Entergy presentation will be on flow-accelerated corrosion and pressure temperature limit curves. That will be followed by NRR's Mechanical and Chemical Engineering Branch's presentation related to the review of areas covered in safety evaluation section 2.1.

Next, Entergy will provide a presentation on station blackout and grid stability. And NRR staff will then present the review by the Electrical Engineering Branch, as discussed in safety evaluation section 2.3.

Entergy's third presentation will be on operations training, emergency operating procedures, operator actions, and operator time lines. The NRR staff will then provide a discussion on the review related to human performance, as discussed in safety evaluation section 2.11.

Entergy's contractor, Erin Engineering, will provide a discussion on probablistic safety assessment, PSA. The NRR staff will then discuss its review of its risk evaluation related to the proposed EPU, as discussed in safety evaluation section 2.13.

I would like to note that the staff's risk evaluation presentation will discuss the overall EPU and won't include the risk aspects of crediting containment overpressure since that topic was discussed two weeks ago up in Vermont. And, as Mr. Holden mentioned, the NRR staff will provide further discussion on the risk aspects of crediting containment overpressure at the ACRS full Committee meeting on December 7th.

Tomorrow the NRR staff will also discuss the impact of the proposed EPU with respect to plant systems, source terms and radiological consequences, and health physics.

Unless there are any questions, I would like to turn it over to Entergy for their discussion on the steam dryer and reactor vessel internals.

CHAIRMAN DENNING: One comment, and that is at some point there are going to be some additional discussions of debris beds. And I know particularly after Dr. Wallis gets here, I know the consultant has some questions about this. Where do you see those best fitting into this agenda?

MR. ENNIS: There is no real best place. It would probably be sometime tomorrow, and we'll have to take a look at the agenda. Maybe we could shorten up some of our other presentations and put that in there.

CHAIRMAN DENNING: Thank you.

MR. NICHOLS: Good morning. I'm Craig Nichols, the Entergy Vermont Yankee Power Uprate Project Manager.

Entergy would like to thank the Committee for this opportunity to continue our discussion about the Entergy Vermont Yankee extended power uprate. For today's first session, we will be discussing the steam dryer analysis, modification, and monitoring program.

I have with me Mr. Brian Hobbs, our engineering analysis supervisor; Mr. Enrico Betti, our senior structural engineer, who is the technical lead for the steam dryer analysis and monitoring.

Again, we appreciate the opportunity to be here today to continue our discussions. And, with that, I would like to turn it over to Mr. Hobbs.

3. STEAM DRYER AND VESSEL INTERNALS

MR. HOBBS: I'm Brian Hobbs, Entergy's supervisor of engineering analyses for the Vermont Yankee extended power uprate project. This morning, assisted by Mr. Enrico Betti, I will be providing an overview of Entergy's evaluation of the Vermont Yankee steam dryer structural integrity.

The topics I will present in this overview include industry steam dryer operating experience and regulatory oversight; Vermont Yankee steam dryer inspection results; Vermont Yankee steam dryer strengthening modification; the main steam vibration levels measured at Vermont Yankee and predicted for the future; structural integrity analysis of the Vermont Yankee dryer; and, finally, monitoring of the dryer during power ascension.

Entergy and our power uprate dryer team consisting of GE, LMS, Continuum Dynamics Inc., Fluent Structural Integrity Associates, Areva, JAR Engineering, and University Specialists, have put in a significant effort over the last 30 months on analyses, design modification, inspection, and monitoring to ensure continued Vermont Yankee dryer structural integrity and EPU operating conditions.

DR. BANERJEE: Do you have the documents available, the background analyses by Fluent and Structural Analysis Associates or whoever they are?

MR. HOBBS: Those were all submitted on our docket. So yes, those are available.

DR. BANERJEE: Okay. Can we have a look at those, Ralph?

MR. HOBBS: As a result of this effort, we have made major strides in understanding the forces acting on our dryer and sources of those loads. The key conclusions of this work are: number one, acoustic loads are the primary source of industry dryer degradation operating experience; number two, it is important to monitor acoustic loads to evaluate their effect on dryer structural integrity; number three, the acoustic circuit methodology used for Vermont Yankee and other BWRs can be used to project main steam system measurements onto the steam dryer; and, finally, higher steam flows at power uprate conditions can exacerbate flow-induced vibration vulnerabilities that exist at original license thermal power.

DR. BANERJEE: What do you mean by "acoustic loads"?

MR. HOBBS: Acoustic loads are loads that are created by acoustic excitation sources within the main steam system.

DR. BANERJEE: Which are what?

MR. HOBBS: For example, sheer layer instabilities caused by the flow across cavities in the main steam lines. For example, a safety relief valve or a safety valve or a branch line for a -

DR. BANERJEE: These are pressure waves arising out of turbulence, which then radiate?

MR. HOBBS: Yes. That can be a source of

acoustics.

DR. BANERJEE: So these are air acoustic instabilities of some sort?

MR. HOBBS: Right. And we'll be talking in some detail about acoustic sources and acoustic loads.

DR. BANERJEE: I'd be very interested to see how you calculate these.

MR. HOBBS: Okay. And measure them also.

DR. BANERJEE: Also, yes.

MR. HOBBS: Right.

MEMBER KRESS: Is this a resonance phenomenon?

MR. HOBBS: We believe it is.

MEMBER KRESS: So do you have to calculate the resonant frequency of the dryer itself?

MR. HOBBS: Yes. And we also calculate the resonant frequency of the potential excitation sources. So we'll be talking about those.

Industry experience shows that increased main steam and feedwater flow associated with power uprate results in increased flow-induced vibration. Flow-induced vibration causes fatigue of plant components, including steam dryers. And industry operating experience has shown that fatigue can cause flows potentially leading to component degradation, such as has occurred on steam dryers at several plans, some at pre-EPU conditions and some at power uprate conditions.

Results of a survey of 13 BWR units currently operating at EPU conditions showed that instances of significant dryer degradation occurred at 4 units and were attributed to operating at EPU higher steam flow conditions. The remaining nine EPU units reported no significant dryer degradation.

MR. LEITCH: Are you going to discuss your steam line velocities at Vermont as compared with the rest of the industry?

MR. HOBBS: We can discuss that, although steam line velocity is not as important a factor as we once thought it was. It's more important to look at the potential for acoustic excitation.

And we did look at specific velocities for Vermont Yankee relative to excitation frequencies for acoustic resonators. So we believe that it's possible to have excitation at velocities that, you know, may not be very high velocities but just happen to resonate a potential acoustic excitation source.

MR. LEITCH: But could you give me an idea of what are your velocities --

MR. HOBBS: Sure.

MR. LEITCH: -- compared with Dresden or Quad Cities, for example?

MR. HOBBS: Okay. The pre-EPU, the current rate of steam velocity at Vermont Yankee is approximately 139 feet per second. The EPU-rated velocity for 120 percent power at Vermont Yankee will be on the order of 168 feet per second. That value is approximately the original rated steam flow at the Quad Cities and Dresden units, approximately 168 feet per second.

Their steam velocity at EPU conditions for those units is slightly over 200 feet per second.

MR. LEITCH: Okay. Thank you.

MR. HOBBS: Entergy has been closely involved in industry efforts to evaluate steam dryer susceptibility to flow-induced vibration, including extensive operating experience, review, and benchmarking, development of a sophisticated computational fluid dynamics modeling tool to ensure diverse analytical methods, playing a key role in EPU BWR owners' group and actively participating in industry dryer meetings.

We have incorporated applicable operating experience into our analyses, conducted two extensive dryer inspections, proactively installed a dryer-strengthening modification, and developed a comprehensive power ascension-monitoring plant. These will be discussed in this presentation.

We have also responded to more than 150 NRC staff requests for additional information, which posed challenging questions and required thoughtful answers.

Let me briefly review the configuration of the Vermont Yankee steam dryer. The dryer is located at the top of the reactor vessel. On the outlet of the steam separator, it's a static structure made of stainless steel that provides final removal of moisture before steam flows down the main steam lines to the turbine generator.

MEMBER SIEBER: We don't have these slides. You will have to provide them for the record.

MR. HOBBS: Vermont Yankee has a BWR 3 square hood dryer design which is similar to other BWRs which have experienced significant degradation.

Next slide. The dimensions of the Vermont Yankee steam dryer are approximately 62 inches high, upper dryer height, and 201-inch diameter. The reactor steam flows through the five chevron dryer main banks with approximately 10 percent quality at the inlet of the dryer and greater than 99.9 percent quality at the outlet. The moisture is removed by internal drain pipes and ten drain channels.

Although this is not a safety-related component, the dryer is designed to withstand design basis event loads without generating loose parts. Dynamic flow-induced vibration loads have only recently been analyzed for BWRs such as Vermont Yankee's dryer.

A comprehensive visual inspection of all Vermont Yankee dryer internal and external locations was performed in 2004 in order to obtain baseline information on current material condition.

This was the first complete inspection of a steam dryer prior to operating at EPU conditions. Indications observed were either repaired or left as is justified by an evaluation, which concluded there would be no structural impact at either current license thermal power or EPU operating conditions.

Inspection of the dryer completed a recent refueling outage in 2005 looked at all the repaired and modified areas and indications left as is. The VY dryer-strengthening modification, which I will describe momentarily, was found to have no indications.

The indications found in 2004 were found not to have grown. We also performed an augmented inspection of the dryer vane bank endplates based on discovery of additional minor indications as a result of enhanced visual inspection techniques.

MEMBER RANSOM: You indicate where these loads that you're talking about are caused by vortex shedding. There are many opportunities in a complex configuration like this. I'm wondering, can you identify the major ones that are the cause of the frequencies that are of concern? Are they the lips or the dead regions or where are they?

MR. HOBBS: We developed a computational Fluid Dynamics model, which gave us pressure loading as a function of vortex shedding on the steam dryer. And we will be talking about that momentarily.

But what we find is that those hydrodynamic forces there are not the key contributors to structural loads on the dryer. We find that it is the acoustic loads in the system that are key contributors.

MEMBER RANSOM: The interesting thing is, though, the acoustic loads have to have a driver. Something has to cause the pressure forces to be created. Normally those are the vortices that are shed. And so the frequency of those normally will be consistent with the source.

MR. HOBBS: That's correct.

MEMBER RANSOM: And resonance, of course, is achieved when you have a matching impedance and a driver. I would be interested to know how well you have identified those sources.

MR. HOBBS: Right. And we will be talking about both the vortex shedding, hydrodynamic sources and the acoustic cavity sources momentarily.

MR. LEITCH: Could you say again what you did in the Spring of '04? I missed that. Was that just an inspection or --

MR. HOBBS: Yes. In the Spring of '04, we conducted a comprehensive internal and external inspection. And that's also when we installed the strengthening modification that I will be describing shortly here.

MR. LEITCH: Okay.

MR. HOBBS: So we did find some indications on the dryer. Those indications were identified primarily as being caused by IGSCC. And there was no way to tell since we had never done such a comprehensive inspection previously how long those indications had existed.

MR. LEITCH: There were no missing parts, though.

MR. HOBBS: There were no missing parts.

MEMBER SIEBER: I would like a little more detail about your inspection. This is an enhanced VT inspection.

MR. HOBBS: The 2005 inspection that was completed earlier this month was an enhanced VT1 inspection. And that's how we found additional minor indications on the dryer vane bank endplates.

MEMBER SIEBER: And so all of these indications would show up in a VT as surface cracks.

MR. HOBBS: Right.

MEMBER SIEBER: Did you do anything to characterize the cracks as far as morphology, depth, ligaments, that kind of stuff?

MR. HOBBS: Enrico, can you --

MR. BETTI: I don't think any of the cracks in the areas where they were deemed as not structurally tight are not significant to the structure. There was no follow-up evaluation in terms of the --

MEMBER SIEBER: Okay. So you didn't characterize any of these? Would that be a fair statement?

MR. HOBBS: We did characterize. Do you want to do that link there?

MEMBER SIEBER: Well, one way to characterize is to grind it out and repair it.

MR. HOBBS: Right, right.

MEMBER SIEBER: So that tells you something. What did it tell you in this case?

MR. HOBBS: Right. And here is some more detail about our 2004 indications. We did have two indications of cracks on the steam dams, which you can see on this diagram here are near the lifting lugs for the steam dryer. And we did grind those out and repair those indications. Those were two.

MEMBER SIEBER: Why did you choose those two and not others that might have been similar?

MR. HOBBS: We chose these 2 because they were actually different than the other 18 indications from 2004. And the reason we chose these is because these essentially could have been fatigue-related as a result of we think original manufacturing, the construction of the dryer. And because this was an area of potentially higher stress based on a load definition, we thought it was appropriate to grind these out and repair these.

MEMBER SIEBER: Okay. Now, the steam

dryer is not a pressure vessel. So it doesn't fall under the typical ASME pressure vessel code or piping or anything. It's just an entity that's out there. And so you don't have a standard to apply to it.

On the other hand, VT is not doing much as far as doing understanding what the conditions of that structural piece are because you don't know depth.

Do you think that -- and you'll have to tell me why you think it if you do -- what you're doing is adequate to determine whether this structure of the steam dryer will be strong enough to withstand potential fragmentation, shedding parts, degradation, distortion, or any of those kinds of phenomena that would hinder the operation of the reactor?

MR. HOBBS: Well, you know, I think that we did perform the most comprehensive pre-EPU inspection. I think that the approach we used, which was a visual enhanced inspection, is the best technique that is currently provided by the industry guidelines, such as GE 6.4 --

MEMBER SIEBER: Right.

MR. HOBBS: -- talks about recommendations for inspecting your dryers. But this is part of a comprehensive program for ensuring dryer structural integrity. And this is kind of a lagging indicator if we had structural integrity challenges.

We just want to make sure that the dryer today is in good shape. And we think as a result of the visual inspection, that it is. And certainly compared to inspections of other steam dryers that have been at EPU conditions, we believe that our dryer is intact for that.

MEMBER SIEBER: Without the sufficient characterization, you can't do the fracture mechanics, right, unless you make a lot of assumptions about it?

MR. BETTI: Enrico Betti.

But for a surface evaluation in the ones that we had seen and that we did evaluations on, the surface fracture was assumed to be through all cracks for that evaluation.

MEMBER SIEBER: Okay. So that's conservative.

MR. BETTI: That's conservative.

MEMBER SIEBER: Okay.

CHAIRMAN DENNING: These particular cracks that we see here, they're not normally in a load-bearing region? This is just related with the lifting of and replacement of the steam dryer. Is that your interpretation as to what the origin of those cracks may be?

MR. HOBBS: The interpretation relative to the origin is that the way that the dryer is put together at the site during its original construction, you know, you create stress because you take two pieces and weld them together.

We think the fact that these two indications are 180 degrees apart indicate that it was due to that joining together of the parts and welding those in the original construction that caused some residual stress that relieved itself during initial operation, most likely the dryer, and resulted in these indications at this location.

This is not a structural member, although the steam bands do need to basically channel the steam as it comes up out of the dryer vane banks. So they are important from a functional perspective.

MEMBER SIEBER: What material is used to build the dryer?

MR. HOBBS: Stainless steel.

MEMBER SIEBER: And it was not heat treated after well fabrication? That would be pretty tough to heat treat stainless steel, right?

MR. HOBBS: No, it was not.

MEMBER SIEBER: Yes. At the job site, I'm not sure how you could do it.

CHAIRMAN DENNING: Okay. Continue.

DR. BANERJEE: I have a couple of questions. How important are the CFD calculations to the case you forward? Are they just there as a sort of supplement or --

MR. HOBBS: Yes.

DR. BANERJEE: -- are they sort of central to understanding something?

MR. HOBBS: They are both. They are both the supplement and they are central to understanding the vortex shedding phenomenon that's occurring in the vessel. And we'll be talking about how we develop that CFD model and what we learn from it.

Basically the NRC staff asked the question about vortex shedding more than a year ago. And we said we needed a tool to understand what the effects of vortex shedding and hydrodynamic loads are.

DR. BANERJEE: So then let me ask you a supplementary question. There is a computational error acoustics set of benchmarks, which every code, which is sort of qualified to do these collocations. This is set up by NASA. Has this code been tested against those to see if it works, actually?

MR. HOBBS: The benchmarks?

DR. BANERJEE: Yes.

MR. HOBBS: The code we used is the Fluent code. And I would ask you when we get in that point of the discussion --

DR. BANERJEE: Somebody is going to tell us what this is --

MR. HOBBS: Right.

DR. BANERJEE: -- and how it runs and why you think it's right?

MR. HOBBS: Yes.

MEMBER SIEBER: Before you leave this picture, it seems to me that I recall that this dryer does not have the perforated mesh plates in it that lighter dryers have and that you intend to install them. Can you show me where those would fit on here?

MR. HOBBS: We do not plan to install perforated plates. We have a steam separator that is highly efficient relative to other BWR-free units. So our steam quality coming out of our separator is high enough that we can work without having a perforated plate.

MEMBER SIEBER: Okay. That is one reason why you would install it, is to improve the steam quality?

MR. HOBBS: Right.

MEMBER SIEBER: Another reason is as a

debris catcher. So you don't feel a need for that either?

MR. HOBBS: Right because our overall goal relative to dryer structural integrity is not to generate debris.

MEMBER SIEBER: That would be a good first step.

MR. HOBBS: Right, right. A debris catcher, again, would be sort of a defense-in-depth that we don't want to get to.

MEMBER SIEBER: Do you have something against defense-in-depth?

MR. HOBBS: No, no. I think defense-in-depth is very appropriate.

DR. BANERJEE: At Brattleboro, they said that -- I don't know how true this is -- in one of the Quad Cities, pieces of the dryer fell on top of the core. Is that true?

MR. HOBBS: That is not true.

DR. BANERJEE: Okay.

MR. HOBBS: The initial Vermont Yankee dryers flow-induced structural analysis combined with operating experience resulted in Entergy's decision to proactively modify the dryer at Vermont Yankee in order to strengthen it for operation at EPU conditions.

The VY dryer modification installed in April 2004 consisted of strengthening of areas adjacent to the main steam line nozzle shown here in the highlighted locations, which are vulnerable, as shown in other BWRs with square hood dryers.

The modification consisted of replacement of the original half-inch outer hood vertical plate, which you can see here is the area on the vertical portion of the front hood.

Also, we replaced the original quarter-inch-thick lower horizontal cover plate with five-eighths-inch-thick plate. We added 3 55-inch-tall gussets to the outer vertical plate and cover plate junction to increase stiffness.

We removed the outer bank internal braces, which were determined to concentrate vertical plate stress. And we replaced the tie bars that connect the dryer banks together with a more rugged design.

MEMBER RANSOM: Could you point out where the steam nozzles are relative to those?

MEMBER SIEBER: Yes, right there.

MR. HOBBS: Yes. The steam nozzles are just about adjacent to the gussets, those triangular shaped components there.

MEMBER RANSOM: What? There are two on each side?

MR. HOBBS: Two steam nozzles on each side, right. And that is actually when you end up -- you have a flat spot on the dryer there to allow the steam to come off the dryer and exit to the steam nozzles.

Next slide.

MEMBER SIEBER: And the steam flow at that point is down, --

MR. HOBBS: Yes, the steam --

MEMBER SIEBER: -- which aids in carrying the moisture, any remaining moisture, away from the steam line.

MR. HOBBS: Right. This is a photo of the modification being installed in 2004. And this shows the completed Vermont Yankee dryer-strengthening modification. Here you can see the new gussets and the new faceplate and the lower cover plate.

CHAIRMAN DENNING: When you talk about strengthening, basically what you're doing is you are limiting the vibrational mode. Is that what is really going on with this, that there is a vibrational mode? And I don't know if you're going to get into what these vibrational modes look like.

And you are limiting the amount of deflection that occurs in that vibrational mode. Is that what you're doing when you talk about strengthening?

MR. HOBBS: Yes.

DR. BANERJEE: Has this strategy been found to be useful in other dryers?

MR. HOBBS: Yes. Other boiling water reactors with square hood dryers have installed this same modification here. And it has been shown to improve the strength of the dryer.

DR. BANERJEE: Now, if you don't remove whatever is causing the vibration, this is going to continue to vibrate, right? And eventually it will crack again or not?

MEMBER SIEBER: Well, it will be different.

MEMBER RANSOM: Vibrate at a higher frequency, though.

DR. BANERJEE: Have you changed something which would actually prevent it from cracking? You haven't removed the excitation, right?

MR. BETTI: Well, I think we're making the assumption -- this is Enrico Betti.

This was a proactive modification. And we at Vermont Yankee didn't have any evidence, like some plants have that have had a lot of problems, of some high-amplitude resonance in the steam system in reactor domes.

So this modification takes care of some of the low-frequency excitations that typically can occur inside the domes themselves. And it moves the fundamental vacancy of this dryer face well above the standard frequencies, driving frequencies. So it keeps the structure coupling with the --

DR. BANERJEE: So you've changed the natural frequency response.

MR. BETTI: Right, yes, brought it up above --

DR. BANERJEE: Right.

MR. BETTI: -- what is typically the -- for most BWRs, what they see is a vibration signature in the steam systems.

DR. BANERJEE: Now, when this is done in other systems, has it actually proved successful? I mean, cracking hasn't continued after that. Has this actually proved successful in sort of reducing the problem after it's done and operated? What has happened?

MR. BETTI: Yes. There have been mixed

results with this kind of mod. Certainly if you were to have a system, say, that had 30, 40, 50 current vibration sources, this is a great mod. It means the resonance frequency above those functions. So this dryer design won't respond.

But if you were to have a resonance show up at higher steam flows that was in tune with one of the response frequencies of this modification, then the stresses could get large and you could have a problem with this modification.

DR. BANERJEE: So what has been the experience, actually? Where has it been successful? Where hasn't it been successful?

MR. HOBBS: This modification was actually first installed on Vermont Yankee and was subsequently installed at Dresden. Okay? And what was found at Dresden, which operated for 2004 and 2005, extended power uprate condition, is that they did find problems with portions of this modification. And that was partly due to the fact that their final element model incorrectly made the connections between this modification and the dryer. So they did find indications on portions of this modification here, but we addressed that specific issue for our modification.

And, in addition to that, Dresden and Quad

Cities both have high loads in their plants. Now, the Brunswick plant has installed a similar mod to this. And they have been operating at 120 percent updated conditions. And they have not seen problems with this modification.

So I think it is a combination of doing the modification right and modeling it correctly and also does your plant have high loads that would challenge this modification.

DR. BANERJEE: What do you mean by "high loads"?

MR. HOBBS: We have a slide coming up here, two slides, that show what our loads are compared to Quad Cities. And you will see --

DR. BANERJEE: But is it load in terms of velocities that you're talking about or what is the load here?

MR. HOBBS: Well, it's a combination of hydrodynamic loads due to vortex shedding phenomena. And it's also acoustic loads as a result of excitation from vortex shedding or from excitation of a resonator.

DR. BANERJEE: Well, we wait to see when you describe that.

MR. HOBBS: All right.

MEMBER RANSOM: Out of curiosity, you have frequencies associated with, say, the horizontal dimension of the plate that you stiffen and also the vertical dimension. Do you discriminate in terms of which one you were trying to stiffen and raise the frequency, I mean, the horizontal mode of vibration or the vertical flexing?

MR. BETTI: This is Rico Betti.

The modification had a few effects. The vertical plate that used to be a half inch is now one inch. The cover plates previously a quarter are now five-eighths.

MEMBER RANSOM: Right.

MR. BETTI: And so that thickness of material moves the resonant frequency between the gussets to well beyond what we see as signatures in our steam system.

MEMBER RANSOM: Right. The gussets were not there before, right?

MR. BETTI: Right. The gussets take care of the fundamental dishing motor that --

MEMBER RANSOM: Right.

MR. BETTI: They help raise that frequency up to about 80 units.

MEMBER RANSOM: Is that associated with

the horizontal dimension you mean or --

MR. BETTI: Not completely because it's a plate structure and the top plate there acts as a --

MEMBER RANSOM: Stiffener.

MR. BETTI: -- a wide stiffener, it's --

MEMBER RANSOM: Sure.

MR. BETTI: -- more of this structure is well-supported in normal to that vertical plate.

MEMBER RANSOM: Well, its fundamental mode would be like a drum head mode and just --

MR. BETTI: Yes.

MEMBER RANSOM: And, of course, the gussets will stiffen that.

MR. BETTI: And the skirt itself provides uplift resistance to those gussets; thereby, instead of having, say, -- you could have had a gusset that was maybe current and just working on the plate's fundamental mode, this GE design realized to bring some of the load down to the base of those gussets and to convert it back into the skirt.

MEMBER RANSOM: In a situation like this, the thing you would like to hear is that you were able to identify where the fundamental mode was coming from and that you stiffened it and raised that frequency to a high enough frequency that now it is coupled with whatever resonant phenomena exists in the rest of the system.

MR. BETTI: Right. We didn't have problems in this dryer in this area prior to the modification, but we based it based on what GE felt was a design that would take its fundamental frequency above what typically for BWR systems are the recognized frequencies of concern.

But what we'll show you a little later on is what we measure at VY currently to be our frequencies of concern and how we'll monitor for any changes in those frequencies in the steam system as we come up. And then we'll be able to evaluate the fact that those frequencies are in this dryer structure.

DR. BANERJEE: Adding those gussets, of course, gives you additional vortex shedding because the flow goes across them now. So you've added some additional sort of modes due to those gussets themselves, --

MR. BETTI: We did. And --

MEMBER RANSOM: -- acoustic modes.

MR. BETTI: Brian is going to present something that shows our evaluation of those loads.

MEMBER RANSOM: Okay.

MR. BETTI: But, in short, you're talking about local forces on a one-inch plate, five-eighths-inch plate. And the effect of those localized forces was not significant.

MEMBER RANSOM: Another source that was talked about initially is when you have two outlets that are close together, unlike these two. There's a stagnation zone that exists between the two. And oftentimes it itself will oscillate and cause, you know, frequencies.

And sometimes adding splitter plates or something like that has been a solution to that problem. So it's like what you've done in that regard.

MR. HOBBS: Yes. We'll be talking about that. So the bottom line, this modification was installed for a potential vulnerability at Vermont Yankee, not an existing vulnerability.

MR. LEITCH: Just so I'm clear, this was installed in '04. And you took a look in '05.

MR. HOBBS: Yes.

MR. LEITCH: And it's still okay?

MR. HOBBS: No indications, right.

MR. LEITCH: Okay. Thank you.

MEMBER SIEBER: This turns out to be a pretty complex geometry. And a calculation that you would do to predict all of these forces and resonant frequencies is not going to be perfectly exact because of that complexity.

MR. HOBBS: That's a very good point, very good point. And we are not here to tell you that we are perfectly exact in our measurements and predictions for --

MEMBER SIEBER: I don't see how you could be.

MR. HOBBS: Right. And that's why, actually, we couldn't tell you what our load definition will be of the EPU conditions. And that's why we have a very controlled monitoring plan to capture the data and do the monitoring to see if we have any vulnerabilities that pop up on our way up to EPU conditions.

MEMBER SIEBER: The ultimate engineering fix is to over-design with whatever corrective structure you're going to put in there so that you catch all of the potential failure modes and frequencies.

MR. HOBBS: Right. And we have --

MEMBER SIEBER: It sort of looks like that is what you have done.

MR. HOBBS: We have incorporated a lot of uncertainty into our analysis also and accounted for that to make sure we have a conservative --

MEMBER SIEBER: And how did you do that?

MR. HOBBS: We'll be talking about that.

MEMBER SIEBER: I will be eager to hear it.

MR. HOBBS: Okay. Good. The Vermont Yankee structural analysis relies on obtaining fluctuating pressure measurements on the main steam piping. For the VY dryer analysis of record, the measurements have been obtained from one strain gauge location on each main steam line and one reading from a high-speed pressure sensor installed on the main steam venturi flow instrument lines.

This measurement configuration was used to develop the dryer acoustic load definition applied in the current VY dryer stress analysis. To improve instrument measurement accuracy, we recently installed 48 additional strain gauges consisting of 6 gauges at 8 locations on each main steam line.

Four of the locations of the strain gauges, the newly installed strain gauges, are approximately seven feet outboard of the main steam line nozzles, seen here as location number one.

The other four locations are approximately

45 feet outboard of the main steam line nozzle shown here as the location two. These are optimal locations for measurements because they are close to the nozzle, which minimizes signal attenuation for vortex shedding and acoustic signatures.

Also, there are minimal acoustic sources in between these two measurements, which allows us to take these and apply them to our load definition. And also there is adequate separation between these measurement locations for collecting data.

The original strain gauge locations are shown here on this figure also. Those are the starred locations. And the venturi flow devices are also shown here in the vertical riser heading down the steam pipes.

MR. LEITCH: So, you're not abandoning the original ones. You'll still have the venturi high-pressure signal, high-pressure, high-speed pressure recorder.

MR. HOBBS: We don't intend to collect data on the venturis. The problem with the venturis -- and we'll be talking about those measurements here shortly -- is that they had high uncertainty. We were measuring fluctuating pressure at the end of an instrument line that was more than 100 feet long. And that instrument line had steam and water, so a two-phase mixture, in it.

And we found that the modes of that instrument line itself were basically interfering with our ability to accurately measure what was happening in the main steam system.

MR. LEITCH: Now, all of your sensors are on the reactor side of the MSIVs. I guess I've had some experience with high-speed fluctuations in the turbine control valves, which I think could be reflected back into pressure fluctuations in the main steam lines, I mean, very high-speed fluctuations in the turbine control valves. Are your turbine control valves steady or is there some fluctuation in that or have you looked at that?

MR. HOBBS: We have looked at that, and they are steady.

MR. BETTI: In 2004, we didn't really want to fill up this slide, but we put high-speed pressure trays down near the control valves. And then we also put them at the venturis. And we also had high-speed transmitters in the reactor vessel-level instrument system.

And we had strain gauges on the vertical risers because the industry at the time was making an attempt to define the signatures in these lines, find what was important and determine what to focus on.

As we went forward with industry experience and developed better technology for measuring these loads, we determined that, really, the best thing to do is measure this signal close to the reactor.

So even if there's a signal, say, that would emanate from the control valves and make it up through the venturi, the flow in the safety device and our restrictor, we'll be able to measure that signal, do a time record of it, and project that acoustic load back to the dryer because, I mean, our ETR MPRs do have oscillating signals that bounce in our steam lines.

And we have to damp those out for our regulator pressure control for pressure regular control. And when we put the devices down there to read those, we found signatures on those lines, like we did other places, and worked through coherence evaluations, et cetera, and say, "Well, how does this relate?"

There wasn't a lot of coherence between there and back at the vessel. The important thing now is that we've put in a refined system to measure the acoustic loads where we need a measurement.

So if we come a mile down the line or ten feet down the line, as long as we have two points of measurement on a clean pipe, we'll be able to measure and project those acoustic loads back toward the vessel.

MR. LEITCH: Okay.

MR. BETTI: So the first phase was to measure everywhere, try to learn.

MR. LEITCH: Yes.

MR. BETTI: And the second phase is now we understand the system, know how to calculate it. And so that's why we're concentrating on measuring the system up here.

The NRC has also asked us to look at the accelerometers and the like in parallel just to make sure that our strain gauges are not giving them different information. We have accelerometers on the same lines that we'll be talking about.

DR. BANERJEE: I take it that you can't directly install anything on the dryers until we move to the signal out.

MR. HOBBS: The Quad Cities unit 2 did install instrumentation on a dryer earlier this year, with a new dryer, right, this year. Instrumenting an existing dryer, such as that of Vermont Yankee, is a very high-dose effort. And we believe that this approach here is an adequate way to predict loads on the dryer.

DR. BANERJEE: What has been the experience? I take it that other people have done things similar to this to pick up vibrations in other power uprates. Has there been experience that would suggest that monitoring vibrations in the steam lines is indicative of what is happening in the dryers?

MR. HOBBS: Yes.

DR. BANERJEE: What evidence is there?

MR. HOBBS: We have an acoustic circuit model that we'll be talking about here shortly, which shows how you take those two measurements on each steam line and predict using a Helmholtz solution into the steam dome and onto the face of the dryer. So we have some detail about that.

DR. BANERJEE: Right. That's solving a Helmholtz equation for the pressure field.

MR. HOBBS: Right.

DR. BANERJEE: But I'm saying, are there any actual measurements which you will perhaps have in Quad Cities now that they have instrumented the steam dryer, which makes a correlation between measurements of what is happening in the steam dryer and in these lines? I think this is a crucial issue --

MR. HOBBS: Yes.

DR. BANERJEE: -- because if these monitoring locations are okay, then they should have been okay in the past.

MR. HOBBS: Right.

DR. BANERJEE: If that is the case, why is Quad Cities putting a monitor into the dryer now?

MR. HOBBS: Well, to answer your first question, yes, this measurement approach here was benchmarked against the instrumented Quad Cities 2 dryer. So the actual measurements on the dryer were compared to the predictions using this acoustic circuit methodology. So we will be talking about that and how that --

DR. BANERJEE: So the correlation already exists?

MR. HOBBS: Yes.

DR. BANERJEE: There is some backup for this other than just solution of a Helmholtz equation.

MR. HOBBS: Yes.

DR. BANERJEE: Because there are thousands of things that could be wrong with that.

MR. HOBBS: Yes. There's empirical data

to back that up.

MEMBER KRESS: And there is the solution that the Helmholtz equation will give you the right answer for those Quad Cities?

MR. HOBBS: It gives you an answer, and there is some uncertainty associated with that answer. And we have taken that uncertainty and applied it to our --

MEMBER KRESS: It normally doesn't couple the structural. And I think that could make a difference. How big are those exit pops, for example? And how thick are they?

MR. HOBBS: Those are 18-inch-thick interdiameter.

MEMBER KRESS: That's pretty thick.

MR. HOBBS: I'm sorry. Eighteen-inch piping. So it's interdiameter.

MEMBER KRESS: Okay. I was about to say you're not going to get anything.

MR. HOBBS: Right. No. The thickness of the pipe is not 18 inches.

MEMBER KRESS: How thick are they?

MR. BETTI: They're .9 inch pipes. And it's an 18 outside diameter pipe.

MEMBER KRESS: That might be sensitive to the frequencies you are talking about.

MR. HOBBS: Right.

DR. BANERJEE: The problem obviously is that Helmholtz equation is a far-fielded equation. So it doesn't have any near-field source terms in it, which have to come out of a turbulence calculation as a driver, right?

So when you go through this entrance region or whatever, you're going to generate turbulence. And there's going to be lot of near-field stuff there which you're not going to actually see in this Helmholtz equation.

So the expectation that it works is only correct in a situation where you have got the near-field noise well-characterized. So it's sort of unexpected that this will work coming through that entrance where there is a lot of turbulence.

MR. HOBBS: Well, that's right. And that's the reason we use the CFD modeling tool.

DR. BANERJEE: Unfortunately, I don't think any CFD tool that I'm aware of can do that calculation, but I am open to listening to how they did it.

MR. HOBBS: Right. Very good.

MEMBER SIEBER: Just one quick question.

Your coffin is that you are getting the right interpretation of the results of this has to do with the coherence of the signals, the paired signals, from one to the other.

And that's if you have coherence in the signals and then you say that they're in the same couplet and, therefore, I can rely on any spatial derivation from that, to what degree are you getting signal coherence? And how do you measure it?

MR. BETTI: We have a little bit of some of the new strain gauge signal data to share with you a little bit later here, but we're getting very good coherence in terms of the signal at those two points in the steam line. And there's been more --

MEMBER SIEBER: Same signatures.

MR. BETTI: Same signatures, yes. Yes. It's almost identical.

MR. HOBBS: Next slide. Okay.

So the measurements we have taken using our newly installed strain gauges are reflected in this figure here, which is representative of main steam line strain gauge power spectral density log-scale readings for Vermont Yankee and also for Quad Cities.

Vermont Yankee here is the blue line,

which is the see main steam line location number one measurement on the new strain gauge data acquisition system. This is typical of the seven other new strain gauge measurement locations of Vermont Yankee and demonstrates the very low vibration at current license thermal power with limited evidence of high-frequency acoustic excitation.

There are some peaks here on the Vermont Yankee spectra seen at 30, 45, and 60 hertz, which don't have significant structural impact in our structural model.

Now, the yellow line shows Quad Cities vibration levels at the same main steam line strain gauge location. You will note that Quad Cities has significantly greater high frequency acoustic resonance in their steam system, evident here, which is original license thermal power for Quad Cities.

Next slide. This figure adds the Quad Cities vibration data in log-scale still for operation at EPU conditions. And if you go to the next slide, this is on a linear scale.

So you can see that there is a significant increase in the Quad Cities acoustic resonance levels at EPU conditions in this figure here. And at Quad Cities, EPU exacerbated the previously existing acoustic excitation phenomenon, which resulted in their dryer failures.

DR. BANERJEE: So the yellow is without operate and the red is with operate?

MR. HOBBS: Yes.

DR. BANERJEE: But that's only sort of like -- the access there is linear or --

MR. HOBBS: This is linear.

DR. BANERJEE: Yes. So it's only a factor of two or something?

MR. HOBBS: Four.

DR. BANERJEE: Four?

MR. HOBBS: Right. But these high acoustic peaks here are what has been determined to have caused the dryer failures at Quad Cities.

DR. BANERJEE: But these are measured in the steam lines, right?

MR. BETTI: Right.

MR. HOBBS: These are measured in the steam lines, right

DR. BANERJEE: And are these the same as are being measured in the dryer, then, or not?

MR. HOBBS: There are measurements on the dryer at Quad Cities that correlate to these steam line measurements here.

DR. BANERJEE: The same frequencies?

MR. HOBBS: Right.

CHAIRMAN DENNING: Incidentally, your ordinate is a little bit strange on there. That is the one times 10^{-6} down there. Is that really zero?

MR. HOBBS: It's really zero, yes.

CHAIRMAN DENNING: Another comment. And that is now the frequency at which we saw in Quad Cities, this big peak, is way above the area that is related to where your strengthening occurred, right?

MR. HOBBS: Right, yes.

CHAIRMAN DENNING: So this wouldn't directly address that particular issue. I'm sorry. I mean, we don't know, of course, whether you have an issue with this high frequency, but, in any event, if you had, the strengthening that you did would not have helped against that?

MR. HOBBS: That's correct.

MEMBER RANSOM: Can you identify what parts of the steam lines correspond to the different peaks in that spectrum?

MR. HOBBS: Yes.

MEMBER RANSOM: I mean, is it the entire steam line or is it a part of it or --

MR. HOBBS: We'll be talking about that

here on the next series of slides, actually. So this strain gauge data that we collected from Vermont Yankee is converted using the acoustic circuit model to pressure loads on the dryer. And we'll be talking about that also momentarily.

Although there's no evidence of high-frequency acoustic resonance at Vermont Yankee today, we performed an evaluation of main steam branch lines for potential acoustic excitation. And the branch lines we looked at are the main steam safety relief valves, the spring safety valves.

We have a HPCI steam supply line; RPCI steam supply line, which supplied steam-driven turbines for emergency core cooling. And we also have blanked-off stub tubes on our main steam lines.

So back to this figure here, you can see the locations of the branch lines on this figure. The SVs, one on each main steam line, represent the safety valves. The RVs are the relief valves. You can see there are some blanks indicated here. The HPCI ten-inch steam supply line is on the B main steam line. And the RPCI is on the C main steam line.

Now, one thing to note about Vermont Yankee is that we have only one type of each cavity on each main steam line; whereas, at Quad Cities, they have more than one type of cavity on each main steam line. And those are in close proximity to each other.

MEMBER RANSOM: So the frequency is associated with the length of the branch?

MR. HOBBS: Yes, right. That's one factor, right. And we have a table, actually, coming up here. But our main steam line monitoring approach will detect all acoustic excitation that occurs in our system.

So here is our evaluation of potential acoustic resonation at Vermont Yankee. This shows the natural frequency of each of the cavities we evaluated. It shows the velocity at the onset of resonance, which we predict; also shows the velocity where resonance is fully developed.

And what this shows is that for the relief valves at today's rate of steam flow of 139 feet per second, we should be seeing the onset of resonance. And the relief valve frequency is 116 hertz. But we have no data that shows us that we're having that resonance actually occurring.

Moving up to EPU flow conditions, it shows that we may see excitation of the relief valve and the safety valves. The HPCI and RPCI lines are well below what we see at rated steam flows. And the blanks are well above. Their frequencies are quite high.

Next slide.

MR. LEITCH: I assume this evaluation is done with HPCI and RPCI not being in service, right? They're just static lines?

MR. HOBBS: Yes. Next slide. So this is just another way to look at this, which is on the *x*-axis here, we have main steam velocity in feet per second. On the *y*-axis, we have frequency of the cavities in our main steam system.

And you can see that for the rated current Vermont Yankee velocity of 139 feet per second, the relief valves have predicted onset of resonance and full resonance in that block there. And at EPU condition, you can see the safety valves would show potential onset for resonance.

So we know where to look. We know what our potential excitation sources are on our main steam lines. And we don't see today any indication of onset of resonance.

DR. BANERJEE: Just a question. At the entrance to the steam line and that cavity which is formed at the dryer, is there sort of potential for resonances there?

MR. BETTI: We'll have Dr. Bilanin. And

we'll talk a little bit about how we do the Helmholtz solution and how CDI backed figures what the source must be at that nozzle.

DR. BANERJEE: Okay.

MEMBER KRESS: Do you assume it's all steam when you do the calculation?

MR. HOBBS: Yes.

MEMBER RANSOM: All vapor?

MR. HOBBS: Right. Because the quality is greater than 99.9 percent, we essentially ignore the moisture.

CHAIRMAN DENNING: Now, we're about to enter proprietary information. Is that true? Is that where we are?

MR. HOBBS: That's true, yes.

CHAIRMAN DENNING: Okay. So that now we have to clear the audience of --

MR. CARUSO: People who do not have a nondisclosure agreement with --

MR. HOBBS: Continuum Dynamics.

MR. CARUSO: -- CDI --

MR. HOBBS: Yes.

MR. CARUSO: -- have to leave the room.

CHAIRMAN DENNING: And how are you going to determine that?

DR. BANERJEE: Let me ask you this while this is happening. You said that your venturi lines have sort of got steam water and condensation or whatever.

MR. BETTI: We have a condensate pot that is very close to the piping that puts steam over the water. That's the steam water. It's a short amount of steam.

DR. BANERJEE: Oh, okay.

MR. BETTI: And then it's all liquid down to the pressure transducer.

DR. BANERJEE: So what you are concerned with is that that pot damps the high frequencies? That's why you don't --

MR. BETTI: We modeled that. And we developed a transfer function for those lines, you know, looking at the acoustics of the sensing line, which is that as you go through resonance frequencies of the sensing lines, you have an --

DR. BANERJEE: Overlap of some sort.

MR. BETTI: -- or a lot has changed in the signal.

DR. BANERJEE: I see. So you can get the average pressure drops okay, but you can't get the true signal of the acoustic frequency fluctuations, the high frequencies.

MR. BETTI: You can get an idea of that large uncertainty. You may pick up a 70 percent uncertainty in values reading for that.

DR. BANERJEE: I see.

MR. BETTI: If you're close to a harmonic of the sensing system, it's going to be less reliable.

DR. BANERJEE: So the transducer is actually after a separation part or condensate part, which is after that. It's all liquid-filled to that line.

CHAIRMAN DENNING: We're not ready to start into this yet because Ralph still has to get the telephone line off here, but I do want to check and see exactly where we are slide-wise because I think that we've got a lot of slides to go still.

We're only scheduled for half an hour here, but we'll have some freedom beyond that and compromise other places. But I do want to let everybody know that we're going to have to move quickly.

So the question is, how many slides do you have? What's your projection on how much time you really need to go through that?

MR. HOBBS: We are approximately halfway

through our entire presentation right now. So I would expect that we should be able to complete that in an hour or less depending on the number of questions.

CHAIRMAN DENNING: And hour is too long. So we're going to have to make it less.

MR. HOBBS: Okay.

CHAIRMAN DENNING: So let's try to finish up in 45 minutes and try to get through it quickly. We'll come back and ask questions later if we have to. Okay?

MR. HOBBS: That sounds good.

DR. BANERJEE: I guess the issue, at least of concern to me, to get clarification is how one can monitor these signals in the steam line and get a good indication of what is happening inside so that when you go up in power and you're doing this monitoring, to make that connection and what evidence do we have.

So that is one of the issues. If you would address that based on how important you think the CFD calculations are and how much reliance you can put on them and why you think you can put reliance on them? There is a bridge.

I mean, if you have empirical evidence to that effect, that would be fine. I would find that much easier to --

MR. BETTI: We submitted empirical evidence to the staff. We submitted the empirical evidence to the staff. I mean, we did do it. On the Quad Cities dryer between GE's instrumentation on the dryer and the Quad Cities stain gauge installation, it was very similar to the one that we show here. They had four strain gauges, not six, at each location, at almost the same locations.

So, you know, we did compare aspects of the model, acoustic model, we used with the signals and their ability to predict loads at 27 locations on the Quad Cities dryer.

DR. BANERJEE: Maybe you could just summarize it in a slide here or something or put it on the board, what you saw. You know, that would be useful.

CHAIRMAN DENNING: Right. We're ready now to move into the proprietary phase of this.

MR. HOBBS: Okay.

CHAIRMAN DENNING: Proceed.

MR. CARUSO: The phone is muted at this point. I've got somebody checking it to make sure. Okay? And we're going into proprietary session. Thank you.

(Whereupon, the foregoing open session

was recessed and the hearing was reconvened in closed session from 9:46 a.m. to 10:00 a.m., at which time the open session resumed.)

MR. HOBBS: Next slide. The CFD analysis was used to capture again the hydrodynamic forces.

Next slide. This shows the CFD loads calculated at 100 percent and 120 percent power conditions. And this location here represents the dryer face plate adjacent to the main steam line nozzles for these two conditions.

Even though the CFD model was used to calculate hydrodynamic loads, we found that use of a compressible fluid resulted in the prediction of acoustic loads, which are shown here as the red lines or pink lines with peaks at 30 hertz, 45 hertz, and 60 hertz.

So these peaks were acoustic phenomena at EPU conditions, which we don't see today but the CFD model predicts will occur as a result of hydrodynamic forces creating acoustic energy in the system. And these three peaks here were used in our stress analysis and contribute a majority of the loads on the dryer in our structural analysis.

So these three peaks here are basically

the major components in our load definition for our dryer.

CHAIRMAN DENNING: Does the CFD analysis extend all the way into the steam line?

MR. HOBBS: Yes. We modeled the steam lines to the main steam header to see if there was any coupling interaction between adjacent steam lines.

MR. CARUSO: But you said these are the predicted value at your current rated thermal power level.

MR. HOBBS: Ralph, these are both current power, which is the blue, and EPU conditions. The CFD model we were able to calculate what the conditions would be at extended power uprate, which is basically what is the velocity at extended power uprate.

The acoustic circuit model, on the other hand, requires measurements as input to project loads on the dryer. So unless you have measurements, which we don't have for EPU conditions right now, we don't have an circuit model load at EPU conditions.

MEMBER RANSOM: So you do have an estimate of the frequency, the fundamental mode, of those lines, right? And they were up around 100 or higher in frequency?

MR. HOBBS: Right.

MR. BETTI: They wouldn't couple with these.

MR. CARUSO: But you're not detecting any of these.

MR. HOBBS: We are not detecting these. That's correct.

MR. CARUSO: So the analytical method is predicting certain phenomena that should be visible at current rated power that you're not detecting.

MR. HOBBS: Oh, I'm sorry. When you say, "detecting," you're talking about the blue line here, right?

MR. CARUSO: Well, either one, whatever is being predicted for current rated thermal power. Are you detecting what you predict is supposed to be there?

MR. HOBBS: Mr. Betti, can you --

MR. BETTI: Yes. I would like to talk to this a little bit. As Brian pointed out, we originally ran the CFD model to understand the hydrodynamic forces, the cortex shedding forces. And if we go back to the last depiction that Craig had, what this model showed us is what our people had seen in the dryer faces, that sometimes you get this little polished area where you get this vortex shedding load.

Often the question has not been what is the effect of these really strong vortices on gusset plates. The gusset, how will that impact the vortices? What will these vortices do to the gusset, that kind of question, the cover plate?

Now, the short answer to that, that blue stripe versus the red stripe, we end up with about a 19 psi if you do the pascal conversion as a vacuum on that front plate. And that kind of local forces on a one-inch plate, half-inch gusset, and that five-inch cover plate had negligible stress impact on the dryer. Okay?

I mean, this model, though, because we ran a compressible, -- we ran a compressible because we wanted a little better idea of the actual flow field in this region where there is a lot of velocity change. What we found is that the majority of the pressures that we were reading we determined that when we were starting to study the results were acoustic.

We knew that because basically you can say these modal responses of the dome, the pressures on either side of these gussets for the entire frequencies were the same. You know, we showed you the average pressure on a quadrant of that big plate. We found that these loads were acoustic.

Now, that CFD model was not built or expected to give us acoustic results. Unlike the acoustic model, we didn't get good acoustic boundary conditions set up, right absorption steam line that would be flat lying back.

It was never our intention to use this model to calculate acoustic loads because we have a benchmark methodology for acoustic model where we can measure loads in the steam line, project those back to the dryer.

What this model was for was to fill in the gap with acoustic modeling and calculate the hydrodynamic forces. So what came out of this model was hydrodynamic forces, plus some acoustic loads.

Now, it so happens that the frequencies in those bump responses that we see on this theoretical model do match the bumps that we see in the strain gauges on the steam lines. And they match some of the theoretical hand calculation frequencies and frequencies that we have looked at for the molds in the dome.

So what is coming out of this model is understandable, but the acoustic magnitudes just up over 30 hertz. This model was never set up to do an accurate job in that acoustic magnitude.

What you also have to consider is that all of these loads, although they're shown in this amplified region, are low. They're very low-pressure variations.

So what we're looking for here is some smoking gun. You know, is there a hydrodynamic problem that's causing dryer failures? And the absolute answer from that from a hydrodynamic standpoint is no. There's nothing hydrodynamically in either of these two cases that took us months and months and months to generate data for that should challenge the dryer.

Now, when we ran our analysis Brian will show out, we didn't strip out this acoustic. We basically double-dipped this acoustic. And that's hugely conservative. And we'll talk a little bit about that because --

DR. BANERJEE: I just have to clarify in my own mind what you mean by "hydrodynamic" and what you mean by "acoustic." If I understand it, acoustic is the pressure field. After all, sound is variations in pressure. Hydrodynamic, I presume you mean the flow field.

MR. BETTI: Pressure field.

DR. BANERJEE: But pressure and flow are

hand in hand. So why this separation between what is hydrodynamic and what is acoustic? Maybe somebody can explain this to me.

MR. BETTI: Well, my simple explanation is that we ran this as an incompressible flow problem.

DR. BANERJEE: It wouldn't matter. It's a low mach number anyway.

MR. BETTI: But it would matter in terms of you wouldn't be seeing anything in terms of signal after 25 hertz because when we started out running this model, we did look at it in --

DR. BANERJEE: Well, that simply depends on the resolution of the calculation. If you're doing a calculation, the pressure field comes out of a Pyson equation in terms of the hydrodynamics. I mean, the two are inextricably coupled. And at low mach numbers, whether it's compressible or incompressible is more or less irrelevant.

Maybe the Fluent people who are here can educate me on this.

MR. HOBBS: Actually, we have a question from Dr. Ransom here about boundary conditions as well. So I would like to ask Karl Kuehlert from Fluent to step up to the microphone here and see if we can talk about that.

Dr. Ransom, could you repeat your question on --

MEMBER RANSOM: Well, I was interested in what you use for the boundary condition in the CFD calculation at the wall.

MR. HOBBS: Can you talk about the boundary condition at the wall, Karl?

DR. KUEHLERT: My name is Karl Kuehlert from Fluent. We used a wall boundary condition with a wall function.

MEMBER RANSOM: What is assumed the wall?

DR. KUEHLERT: No slip.

MEMBER RANSOM: No slip?

DR. BANERJEE: You used a no slip condition at the wall? And you used what, a Smagorinski model, in the fluid?

DR. KUEHLERT: For the separate elements, yes.

DR. BANERJEE: But we know that the Smagorinski model going to the wall gives you the wrong results.

DR. KUEHLERT: Pardon me?

DR. BANERJEE: Is it Smagorinski all the way to the wall?

DR. KUEHLERT: We used a wall function at the wall.

DR. BANERJEE: What was the wall function?

DR. KUEHLERT: It's a standard wall function.

DR. BANERJEE: Which one?

DR. KUEHLERT: I'm not sure I understand what you're asking me.

DR. BANERJEE: What is the wall function that you used at the wall? Give me the name of it. There are many, many different wall functions.

DR. KUEHLERT: I do not know in detail what the wall function is based on. It's a wall function that is equally used for Reynauld Evers models through this ABS model.

DR. BANERJEE: I guess Professor Ransom's question is of concern because wall functions break down near separation points. When your sheer stress goes to zero, then wall functions are usually phrased in terms of a friction velocity, which require the wall sheer stress. So there's a singular point there.

So how do you actually predict separation?

DR. KUEHLERT: Well, in this particular case, we put more emphasis on the three sheer layers, as opposed to all friction, because the flow that we are seeing is going into the vent, coming out of the steam dome. And there is a lot of turbulence generated in the sheer layer, much more so along the wall in the boundary layer.

MEMBER RANSOM: The problem is you want to know when the flow separates and when it reattaches periodically. In order to predict the shedding of these vortices.

CHAIRMAN DENNING: Talk into the mike.

MEMBER RANSOM: You want to know when the flow separates and reattaches in order to predict the shedding of these vortices. And that is dependent on what you assume for the boundary condition at the wall.

DR. KUEHLERT: Well, in this case, unlike in a steady state simulation, we are generating localities all the time coming from the sheer layer. So there's no clear separation point defined. You can only see --

MEMBER RANSOM: So, as an example, if you have flow or river-facing step, where there is definite separation and reattachment, this is a classical problem. Is your code benchmarked against these kinds of data taken from --

DR. KUEHLERT: Yes. Again, I have to refer to two types of benchmarking, one set for steady state analysis using the steady state turbulence models and what we are interested in here, LES models. LES models are inherently unsteady. And separation point moves around all the time. And on a time-average basis, we can determine what the mean separation point would be.

To this effect, we have submitted benchmarks for simple geometry, such as flow behind the cylinder, square cylinder. And, in addition to that, one internal flow problem with coaxial swelling jets expanding into a chamber, which includes a facing step problem.

CHAIRMAN DENNING: Okay. I think we're going to have to move on except there is another question here which relates to pressures. How does one differentiate between what is an acoustic pressure and what is a hydrodynamic pressure, as we seem to be differentiating here?

MR. HOBBS: Okay. I would like Dr. Bilanin to help out on this.

DR. BILANIN: When we talk about an acoustic pressure field, we look at a pressure field that is proportional to the first power in velocity. So the pressure is typically proportionate to the density times the fluctuation in velocity times the acoustic speed. We talk about a hydrodynamic inner field. We talk about something that's an order mach number squared.

The pressure field then if you double the fluctuating velocity, the pressure goes up by a factor of four.

DR. BANERJEE: I have a much simpler view of this. There are conservation equations for mass, momentum, and energy.

DR. BILANIN: Yes.

DR. BANERJEE: Ultimately the pressure gets phrased into these equations.

DR. BILANIN: Yes.

DR. BANERJEE: If you take the energy, say the momentum equation, and take its divergence, the pressure is related to the velocity for a Pyson equation. And there is to me no understanding whatsoever of anything else beyond that. It just comes out of the momentum equation and the equation of state.

So when you start to distinguish between hydrodynamic pressure and acoustic pressure, I am completely confused. It may be that they have regions where near-field hydrodynamics gives rise to a pressure field, which is then perhaps describable away from a wall in terms of a Helmholtz equation, but those are simply approximations to the equations of motion at the end.

So I don't see what this -- you can say that I approximated the pressure by a Helmholtz equation and called it an acoustic pressure. And in the near-field, I calculated it by Fluent or whatever, which does a near-field calculation. And I called that a hydrodynamic pressure.

But I think that is the same pressure. Pressure is pressure.

DR. BILANIN: Pressure is pressure, but one can take the Helmholtz solution and then do an expansion in terms of mach number. And the zero mach number, the lowest order solution is proportional to the velocity fluctuation times the acoustic speed.

The next order expansion is the mach number squared. It's typically what's referred to as the dynamic pressure, what you feel on your hand when you put your hand out the window. Okay? That's a higher order effect. That's a lower pressure fluctuation than the acoustic pressures here, which are about an order of magnitude larger.

So in the first slide of this presentation, when the loads that are causing dryer problems are acoustic in nature, they are typically an order of magnitude bigger than the pressures you would calculate if you just looked at the velocity squared inside the dryer. The velocities in the dryer are very low, typically over entering the main steam line, go less than 50 feet per second

DR. BANERJEE: So these are just pressure fluctuations?

DR. BILANIN: Yes.

DR. BANERJEE: And they don't have the kinetic energy of the velocity taken into account?

DR. BILANIN: That's correct.

DR. BANERJEE: All right. I understand.

CHAIRMAN DENNING: Continue.

MR. HOBBS: The load definition for Vermont Yankee's dryer, which includes acoustic circuit loads and hydrodynamic loads, was evaluated for uncertainty. And we broke down the contributors for the acoustics circuit model load uncertainty into several categories: first of all, our signal uncertainty.

Secondly, we have an uncertainty relative to the frequency peak calculated by the acoustic model. We also have an uncertainty associated with the model technique itself. And, finally, there's an uncertainty associated with the location of your measurements for input to the model.

We determined that the acoustic circuit methodology in our analysis of record was 130 percent. A substantial portion of this ACM uncertainty value is a result of the signal uncertainty that we used from our original signal configuration.

The new data acquisition system with optimal locations of the sensors and model refinements of the acoustic circuit model will substantially reduce the ACM uncertainty and improve the accuracy of our acoustic circuit model loads.

DR. BANERJEE: What do you mean by "uncertainty" here? I mean, uncertainty in relation to what? Measurements?

MR. HOBBS: Predicated courses of action.

DR. BANERJEE: But how do you know? Oh, you have already used the Quad Cities data. The model uncertainty here is based on the measured versus predicted --

DR. BANERJEE: In Quad Cities.

MR. HOBBS: -- in Quad Cities 2 dryer loads, right.

DR. BANERJEE: Okay.

MR. HOBBS: The CFD model uncertainty was determined based, as Karl said, on bench-scale experimental comparison of a non-dryer Fluent methodology model. The bench-scale uncertainty was determined to be 15 percent. Factoring in a frequency uncertainty of 4 percent, we ended up with a total hydrodynamic load uncertainty of 16 percent. Uncertainty for --

DR. BANERJEE: But these experiments that they did were extremely simplified.

MR. HOBBS: That's correct. We also compared the CFD model results to other data from previously instrumented full-scale boiling water reactor dryers. And what we found looking at those four BWR dryer measurements is that the 15 percent uncertainty bounds those data sets by 80 percent on average.

And there was one exception of a single instrumented dryer location where the CFD model under-predicted. But in general, we found that our CFD model came close to the readings on the instrumented dryers from these BWRs.

CHAIRMAN DENNING: Now, you're not talking about acoustic loads now, are you or are you?

MR. HOBBS: We're talking about our CFD model.

CHAIRMAN DENNING: You're talking about your CFD model. And CFD models that were used for these others, were they compressible or incompressible flow?

MR. HOBBS: These other BWRs did not have CFD models associated with them that I was aware of. We just took the measurements off of those. So it's a somewhat coarse comparison.

DR. BANERJEE: And you took the ones from Quad Cities 2, right?

MR. HOBBS: Yes, right. We looked at their low-frequency loads that they measured And we compared those to what we predicted. And even though the new Quad Cities dryer is a different configuration than ours, it's got a slanted hood on it to reduce some of the vortex shedding loads, you know, we feel that it's in the ball park. It's representative.

You know, the NRC safety evaluation for our power uprate questions the Entergy perspective on CFD uncertainly. We think it's important to share with you our perspective on why we believe this uncertainty assumption for CFD is appropriate.

First of all, operating experience demonstrates that hydrodynamic loads are not as critical as acoustic loads when assessing dryer structural integrity. You can see acoustic loads that cause the structural challenges to the dryers.

Secondly, the total Vermont Yankee load definition is relatively insensitive to hydrodynamic uncertainty, as reflected by the fact that if you double the CFD uncertainty, it increases our total load uncertainty by less than five percent. So it's relatively insensitive to the CFD model uncertainty.

And, finally, the CFD loads, including their acoustic content, are conservatively added to the stresses from the acoustic circuit model, which results in double counting of acoustic loads. So we believe that our uncertainty for the CFD model is appropriate.

MEMBER RANSOM: Just a point of clarification. Since all of these are hydrodynamic loads, when you say "acoustic loads," I guess you mean loads that are produced by coupling so resonance is involved, right?

MR. HOBBS: Right. And we apologize for the confusion about some of the terms we're using here.

DR. BANERJEE: Okay. One is a higher frequency than the other.

MR. HOBBS: That's a very simplified way

to look at it. The loads calculated by the acoustic circuit model and the CFD model were input into a General Electric finite element model of the Vermont Yankee dryer using ANSYS methodology.

All components of the dryer were included in the finite element model. Also, the finite was shared with a third party by the --

DR. BANERJEE: May I just interrupt one second? ANSYS has built in today a Fluid Dynamics calculation called CFX. Why didn't you just do this integrated calculation, instead of doing this sort of thing with Fluent and then going to ANSYS?

MR. HOBBS: Well, we had our finite element model developed by GE. And Fluent was developing the CFD model loads. And due to time --

DR. BANERJEE: Coupling of those two is quite difficult, I would think.

MR. HOBBS: Well, it is difficult, yes.

DR. BANERJEE: Yes.

MR. HOBBS: And I guess if we had to do this all over again, we would probably look at that feature and take advantage of it.

DR. BANERJEE: Okay.

MR. HOBBS: The finite element model for the VY dryer was shared with a third party by the name of JAR Engineering. This provided an additional review of the model's adequacy and resulted the changes which corrected errors in the model, such as the connection between the front hood gussets and the horizontal cover plate and dryer support ring.

So this is an error which also existed in the Dresden finite element model. And we took action to correct that in our version of the ANSYS model. So the CFD and the acoustic circuit model pressure time history loads were run separately through the finite element model as a transient analysis. And the resulting stresses were combined by square root, some of the squares. And the loads applied to the same grid locations to ensure consistent results.

The peak alternating stresses calculated by the finite element model were compared to the fatigue limits in the ASME boiler and pressure vessel code and the primary plus secondary stresses to the applicable ASME code service-level limits.

The results of the stress analysis are shown here. I would like Mr. Betti to discuss these, please.

MR. BETTI: Thanks, Brian.

First I would like to just discuss the general nature of these equations and how we developed peak stresses from finite element stresses. The finite element model is a plate model, isopermetric shell elements. We had some solid elements for the ring girders and others.

We actually ran multiple ANSYS time history analysis. You know, we looked at frequency, plus or minus frequency, shifts to evaluate the sensitivity of the frequency.

For the CFD modes, as you talked, you know, we had, if I remember, roughly 140,000 vectors coming out of the Fluent model, which we spent a lot of time making sure we fed those right into our ANSYS model. We ran two sets. We had a 120 percent power set and the 100 percent power set.

We ran each of those through our ANSYS model. And then we looked at that model for frequency shifts to see what was most limiting.

DR. BANERJEE: What was the CAD package there? Was it step? How did you go and --

MR. BETTI: We wrote our own processes.

DR. BANERJEE: You like punishment?

MR. BETTI: Yes, I like punishment. I would like to talk about this a little bit because remember I said that here we are. We're using this model to calculate our low frequency, what I call the non-acoustic effects.

We didn't really want to be double counting acoustic effects. We didn't build this model for acoustic boundary conditions or write damping values, et cetera.

So when we calculated these stresses from this model, we went back. And then we filtered out what we believe to be acoustic effects that this model already would capture correctly based on measured acoustic responses in the steam system.

This stress right here, as we said in slide 24, would drop down to 167 psi if it didn't have this double counting method in it, these acoustic responses in the model.

So we had talked to NRC about this. And we all at the time wanted to maintain conservatism. So rather than change 1,000 psi to 167, we kept this load the same after we had looked at it and filtered it. All right?

Now, we looked at all critical components of that big dryer finite element model. This particular summary is only showing you one point that turned out to be most limiting from the standpoint of peak stress or fatigue assessment.

Then what we do is we didn't get to the

sophistication to take out a lot of conservatism. So we take the ANSYS plate stresses. And GE has a method where they have a Weld geometry factor they developed from finite element analysis, which, say if we have a penetration weld that's seven-eighths on a one-inch plate, they have a conservative geometry factor for a step increase in stress and multiply that times the ASME code SIF factor for that weld geometry. And we come up with basically a combined stress concentration factor of 4.61.

So the stress that we used from the CFD analysis is this number times this number. And that's what we determined to be our conservative CFD stress in this analysis.

Now, other plants aren't using anything near this conservativism. The only reason we do this is because we don't have a lot of loads out there, and we can afford to do that.

So I just don't want you to think that this is a realistic assessment of our CFD stresses. If anything, it's seven, eight times lower than this. And there is a very conservative stress concentration, maybe 10, 12 times lower than this number here.

Then what we did is we took our signals from our existing instrumentation in our acoustic model. And we ran those through the finite element analysis. And this combined location with stress concentration factors, et cetera, this location turned out to be critical.

So, again, we take the 403 psi stress times the stress concentration geometry factor. And we end up at that location with an 18.57 stress.

This slide is not that great because here is the combination that we did. We basically are taking the combination, the CFD loads that should be squared, times the load factor ACME, that factor squared, and that whole thing to the square root.

So we're taking the square root sum of the squares combination of the CFD loads quote and the acoustic loads quote, multiplying those times our geometry factor and stress concentration factor. And we're making sure that's less than a code limit of 13,600. All right?

If we had rearranged that equation, we were trying to determine now what would be the allowable increase in our acoustic loads to stay within the code-allowable limit using these conservative stress assumptions. So we just rearrange this equation, solve it for load factor, and we end up with just this equation as a function of the factor that we can multiple our loads times.

Now, if you go above right here, what we had done is we had come out with those two stresses that we saw on the loads that we looked at. We would have an ability to increase our acoustic load, our system-measured acoustic load. If it came up literally everywhere, we would be able to withstand a factor of 6.8, 6.78 times the current acoustic-measured loads in our piping system.

Based on the conservative uncertainties we have applied in this value, if we look at the load factor in terms of the load uncertainties, that drops this number down by 3.91. So we come up with a very conservative acoustic load factor of 2.87.

Next slide.

DR. BANERJEE: Does this mean that you don't expect your dryers to crack?

MR. HOBBS: If we stay below our limit curve, which we'll show you momentarily, which takes into account this load factor, we expect that the dryer will maintain its structural integrity.

DR. BANERJEE: Now, if you did this analysis on something like Quad Cities before it cracked, what would you have come up with?

MR. HOBBS: With this kind of conservatism on it, there's no way that the Quad Cities would be acceptable under our methodology. In fact, our next slide will kind of show you a picture and show you that.

CHAIRMAN DENNING: I would like you to finish up in ten minutes.

MR. HOBBS: Okay.

MR. BETTI: We'll do that.

MEMBER SIEBER: I think that it's a mistake to assume that this analysis would demonstrate that you aren't going to get cracks. I think the analysis demonstrates you aren't going to get a failure, which to me is different.

MR. BETTI: I guess I have touched on all of these things right here. We will combine by the squares method. Briefly, we do that because the frequency responses of the structure for the two loadings were completely different. So there are no closely coupled frequencies from the two results.

We used the maximum stresses from the two CFD cases. And, again, we conservatively used the CFD loads that included these high-acoustic forces that we think are very conservative.

MR. HOBBS: Okay. So we have just two more slides to go, and then we'll conclude.

This figure demonstrates a Vermont Yankee dryer structural integrity limit curve based on linear extrapolation of the acoustic circuit analysis input and measures relative to the most limiting component stress margin, as Enrico just described.

The green line is the VY level 1 limit curve. This curve will be applied during power ascension to ensure that the VY steam dryer structural integrity is maintained; in other words, that the fatigue stress limit is not exceeded.

This limit curve is very low, especially when you compare it to the Quad Cities spectra, where it's yellow here for original license thermal power, Quad Cities, and red at EPU conditions. If you applied our green limit curve to Quad Cities, you could see that, even at original license total power using our limit curve, they would have exceeded our ceiling for stress limit.

DR. BANERJEE: Why is that curve so much higher than yours?

MR. HOBBS: Why is their curve?

DR. BANERJEE: Yes. What is the physical reason?

MR. HOBBS: Well, the difference between our blue curve, which is our measured values on our main steam piping, and our green curve is 2.87. That's how much we can tolerate in the way of an increase in loads.

Now, when we go through our power ascension program, if we see a resonance out at a frequency that challenges that green curve, we will go back and reanalyze. We run the acoustic circuit model. We run the stress analysis. And we'll have a different green curve here, which may have a peak at that point because if we determine that we can tolerate some resonance in that high-frequency region, then we will adjust our limit curve.

CHAIRMAN DENNING: I think it is a different question. So ahead, Sanjoy.

DR. BANERJEE: I was just saying if you take the yellow curve before Quad Cities went up and the blue curve, they look somewhat similar below, say, 65 or 85 or whatever.

MR. HOBBS: Right.

DR. BANERJEE: But, then, there is a pretty large difference in the higher frequencies.

MR. HOBBS: Right.

DR. BANERJEE: What is the reason for it? Do we understand the reason for that?

MR. HOBBS: Right. The reason for it that has been determined is that there are relief valves on the Quad Cities mains steam lines. And there is more than one relief valve in each main steam line. Those cause acoustic excitation and coupling between the two cavities, which are in close proximity to each other.

So those have been determined to be the causes of these high peaks out here at 140-167 hertz for Quad Cities.

DR. BANERJEE: And those are the peaks which are causing the failures, you think?

MR. HOBBS: Those are the peaks that caused the failures of the original Quad Cities dryers. Okay?

DR. BANERJEE: Okay.

MR. LEITCH: So what does level 1 mean in power ascension? Does that mean you hold where you are and just analyze or back down to original full power level or what is the definition of level 1?

MR. HOBBS: That's a very good question, and we're leading into that next.

MR. LEITCH: Okay.

MR. HOBBS: This shows our dryer monitoring and test plateaus for power ascension. The power ascension monitoring will include power increase steps and test plateaus at each five percent of current license thermal power.

Data will be collected hourly for power increases and within one hour of reaching each test plateau. And that data includes strain gauges for all eight strain gauge locations. It includes moisture carryover data. It includes plant parameters which might be indicative of potential dryer failure and accelerometer data.

In accordance with the NRC license condition, if the level 1 limit curve criterion is exceeded, power will be reduced to the previously acceptable level within two hours and an engineering evaluation performed to document continued dryer structural integrity.

So that's the purpose of that green line there, that if we exceed that, we back down within two hours to a safe condition.

CHAIRMAN DENNING: If you don't mind, we can read the other viewgraphs. Can we end at this point?

MR. HOBBS: Sure.

CHAIRMAN DENNING: Okay. Well, let's do that, then. We will take a 15-minute break and be back at 10 minutes before the hour.

(Whereupon, the foregoing matter went off the record at 10:34 a.m. and went back on the record at 10:52 a.m.)

CHAIRMAN DENNING: We are still in closed session. Mr. Scarbrough, would you pick up?

MR. SCARBRUGH: Yes, thank you.

My name is Tom Scarbrough and I'm with the Engine and Mechanics Branch in the Office of Nuclear Reactor Regulation. I'd like to talk to you this morning about our compren and valuation portion of the Vermont Yankee proposed EPU amendment.

MR. CARUSO: Wait just a second. Are there members of the public here who are not able -- you do not have a Disclosure, Non-disclosure Agreement signed under Other Action?

(NO RESPONSE.)

MR. CARUSO: Anyone here? Have you signed a Non-Disclosure Agreement yet?

PARTICIPANT: No.

MR. CARUSO: The meeting is closed at this point and we'll have to ask you to leave.

CHAIRMAN DENNING: Ralph, when is it likely to be reopened, do you know?

MR. CARUSO: We don't know because they're going to be talking about proprietary information for a while.

CHAIRMAN DENNING: Probably through the morning?

MR. CARUSO: Mr. Applicant, do you have a Non-Disclosure Agreement signed with contractors for Vermont Yankee?

MR. APPLICANT: I will do that now.

MR. CARUSO: If you don't, I'm going to have to ask you to leave.

Is there anyone else?

(NO RESPONSE.)

MR. CARUSO: This is a proprietary session. All visitors who don't have an agreement, a Non-Disclosure Agreement, at this time, you are requested to leave.

MR. SCARBRUGH: Good morning. What I'd like to do this morning is talk to you about the Compren evaluation areas that we did in the Vermont Yankee EPU Amendment Review.

The areas included the pipe rupture locations, the anemic effects, the pressure retaining components and supports, the nuclear steam supply system piping, components and supports, the Balance-of-Plant piping, components and supports, the reactor vessel and supports, the control rod drive mechanism, re-circulation of pumps and supports, the reactor pressure vessel internals and core supports, safe weighted valves and pumps, seismic and dynamic qualification of equipment, and potential diverse flow effects. And what I'd like to do is I'll move briefly through the other components and get to the C Dryers, since that seems to be the most area of interest.

The scope of the review included the methodology and calculated loads for the constant pressure power uprate. The stresses and cumulative achieved usage factors, the acceptance criteria, code additions and addenda, the functionality impact on the safe related pumps and valves and the piping over pressurization, and acoustic and flow-induced vibration loading and monitoring.

MEMBER LEITCH: Was operating experience a factor in deciding which areas you should evaluate?

MR. SCARBRUGH: Absolutely. In this case, the steam dryer, since we've had so much poor performance for that, we focused on that quite a bit. And also, the review for the rest of the REC coolant components was straightforward. It was very similar to what we've done in the past for other power uprates. It's a constant pressure power uprate so that it simplified the review. So in that area, it was more straightforward and similar to what we've done in the past.

MEMBER LEITCH: But there were some other areas of operating experience where there were problems other than the steam dryer, perhaps not as well publicized and more minor issues like, I think, main steam isolation valve drain lines and some pressure switches associated with -- adjacent to the main steam --

MR. SCARBRUGH: Absolutely. We've looked at those as well, and we emphasize to the licensee the monitoring program that needs to take effect for those, and ensure that those components are capable withstanding the higher flows from the steam lines. So, yes, we did look at those as well. That was also part of the operating experience.

MEMBER LEITCH: Okay, thank you.

MR. SCARBRUGH: In terms of the reactor plant coolant pressure boundary and Balance-of-Plant piping, we evaluated those. There was no significant increase in the temperature or flow for the reactor coolant pressure boundary piping, with the exception of the main steam and fee water flow systems. There were some limited -- limiting issues relating to pipe supports. There were a couple of pipe supports that had to be replaced. The other piping was less significantly affected and they all met the Vermont Yankee Code of Record, the ANSI B31.1 1967 edition.

With respect to state-related pumps and valves, we looked at those components within the scope of the ASME Code. The review focused on the functional performance, and we based our review on acceptance criteria for the design, general design criteria, since this is a draft general design criteria plant, and also 10 CFR 50.55(a)(f) for in-service inspection of those components.

With respect to motor-operated valves, we had previously reviewed the MOV program at Vermont Yankee under Generic Letters 8910 and 9605 and they were found acceptable by the staff at that time. There were only minor system and ambient temperature changes from the EPU related to MOVs. During Engineering Inspection Number 2004-008, there were some weaknesses found in the MOV Program related to validation of the motor control serve testing and the lack of formal trending of the results of the testing. In Supplements 16 and 32, the Licensee addressed those weaknesses and specified that they would correct them. And in September, there was a regional inspection, which verified that those commitments were being implemented and those were documented in Inspection

Report 2005-006.

Next, I'd like to get into the Prevention Adverse Flow Effects Review that we did. As we've talked about, boiling water reactors have a steam dryer, which is used to remove moisture. It has no specific safety function, but it must retain its structural integrity without release of loose parts into the reactor vessel or steam system.

Quad City Units 1 and 2 experienced significant damage to their original square-hood steam dryers during plant operation, in 2002 and 2003, for Quad City 2 and also in November 2003 for Quad City 1.

In early 2005, Exelon replaced those original steam dryers at Quad Cities with an improved design and installed instrumentation on the Unit 2 steam dryer to measure the pressure loads and that collected data is now being used to assess the accuracy of the analytical methods that we talked about -- the ones we talked about this morning, the 2-circuits model.

Entergy modified their square hood steam dryer at Vermont Yankee to improve its structural capability and you heard about those modifications a few minutes ago. In terms of the cracks that were found at Vermont Yankee in the fall of 2005, they were addressed in Supplement 42 of the EPU Amendment and we did analyst that those should not propagate any further. Also, in terms of the recent cracking at Dresden, we have reviewed that, discussed that with the Licensee, and as you heard this morning, part of the problem at Dresden was the Finite element model did not adequately map out the gussets on that square-hood dryer at Dresden and that weakness was corrected at Vermont Yankee earlier this year. So they had --

MEMBER BANERJEE: Can you explain how a Finite element model doesn't map out the gussets?

MR. SCARBRUGH: Well, what happened was when they modeled -- you used to find an element model to model out the gusset. They assumed in the model that the gusset went all the way to the support frame. Actually, it stopped at like that far short of the support frame. And that's -- that's exactly where the toe of that weld there, where the gusset came, is where the crack at issue at Dresden, and then it grew around the gusset until it got to a point where it relieved the stress.

MEMBER BANERJEE: So if they had done this right, the finite element, what would they have done to the gusset?

MR. SCARBRUGH: They would have seen that there was a weakness there. What they've done at Dresden is they've installed -- for shoes underneath the gusset at Dresden and also at Vermont Yankee. At Dresden, because they have that higher load, they've installed what I call "over-shoes" on top of those shoes to extend, physically extend the gusset to the support link and then weld it to the support link to latch it there. Dresden Quad Cities have much higher loads they have to deal with than what we're seeing at Vermont Yankee, so they have a much more difficult problem to deal with.

MEMBER BANERJEE: So when you set up a planned element model, what sort of QA is done to make sure that it is actually taking the important phenomena into account?

MR. SCARBRUGH: In that case, they -- the cracking that occurred earlier at Quad Cities and Dresden with the gusset was up around the top of the gusset and everybody focused on that, and they just didn't -- and we just didn't notice that they had not gone all the way out to the end of the support link.

MEMBER BANERJEE: So how did that get by?

MR. SCARBRUGH: It's jut part of --

MEMBER BANERJEE: I mean --

MR. SCARBRUGH: -- it's part of the

review. You ask questions and you think it's modeled and it wasn't.

MEMBER BANERJEE: So are there other things, which can get by like that?

MR. SCARBRUGH: There's always that possibility. That's why we've established this team to look at that type of review to try to look at all the possible areas where there could be significant weaknesses in the model.

MEMBER BANERJEE: So then you feel there are none now?

MR. SCARBRUGH: In terms of what we've done now, in terms of Vermont Yankee, what we see is that the loadings are very low at Vermont Yankee. And that's part of what the analysis is going to be involved as they go up in power, to monitor that load. As long as the loading stays very low, the uncertainties and such that we talked about, we do not have a concern with.

MEMBER BANERJEE: What is the physical reason the loading is low?

MR. SCARBRUGH: They're not giving the excess --

MEMBER BANERJEE: Are the velocities lower?

MR. SCARBRUGH: The velocities were lower, that's true.

MEMBER BANERJEE: How much lower?

MR. SCARBRUGH: Two hundred feet per second at Quad and about 168, something like that, at Vermont Yankee. And what they're seeing is, when you look at the traces from the main steam line strain gage data, they're not seeing really any -- the excitation of any of the resonance in the steam lines, and so they're getting very low load going back to the dryer. As long as that stays low, that's part of the conditions in the safety evaluation is that as long as it stays low and they don't have any resonance that jump up and start to approach that limit curve, the resonance and the loads are very, very small.

MEMBER BANERJEE: The theory is that the dryers are failing due to something that's happening in the steam line rather than the flow of themselves. Is that your hypothesis?

MR. SCARBRUGH: Right, right. What we've seen so far is the loads from the -- the shedding coming off the dryer itself are very low compared to the tremendous peaks you see at -- for example, at Quad Cities. And that's why they ended up replacing their dryers, because they couldn't withstand that type of resonance feed. And even though they had modified their dryer to put in these same types of modifications, it still wasn't capable of handling that strong peak that they were seeing at the EPU condition.

MEMBER BANERJEE: As they said, this was due to the relief valves, right?

MR. SCARBRUGH: They think -- they're nailing it down, but they think it's coming from the safe relief valve resonance, right, where the flow causes a resonance across that relief valve and it couples with the dryer itself.

MEMBER BANERJEE: And the staff agrees with this?

MR. SCARBRUGH: Yes. So far, that's what we see as well, but the entire review is not complete on Quad Cities, as to exactly where it's coming from. That's one of the questions we have for them, is that they're working on is nail down exactly where it came from. They have a testing program in place where they are modeling doing small-scale modeling to look for exactly where that resonance peak is occurring and what to do about it.

MEMBER BANERJEE: Okay.

MR. SCARBRUGH: Okay. The next step we'd

like to do is go ahead and introduce the team that NRC assembled for reviewing this complex problem.

First, Dr. Christopher Boyd, who has over ten years of experience working with CFD issues and he's worked in this area since joining the NRC in 1996. Dr. S. S. Chen, with an Argon consultant, helped us with the review of Vermont Yankee 2004. Dr. Stephen Hambric is head of the Structural Acoustics Department at the Applied Research Lab at Penn State, an associate professor in the graduate program to Acoustics, and has worked with the Naval Surface Warfare Center and has directed many numerical and experimental flows -- experimental flow in structural acoustics research and development programs for the Navy and the U.S. industry. Dr. Hambric helped us with the acoustic loading in evaluating acoustic loads. Dr. Mulcahy has 20 years experience in flow-induced vibrations with Argon National Lab, primarily in the Liquid Metal Fast Reader Reactor Program and he's performed experimental analytical research, developed loading functions and identify excitation sources.

We have Dr. Vik Shah. He's a mechanical engineer with Argon National Laboratory and he's been involved with safety evaluations of the Boiling Water

Reactor Vessel Internals Program project on weld repair for vessel internals, and he's worked for 20 years prior to joining Argon in aging management of nuclear power plant components with field experience at Idaho National Laboratory. And Dr. Shah serves as the principal investigator for the Argon team. And then we have Dr. Samir Ziada, who's Chairman of the Mechanical Engineering Department at McMaster University. He's has 18 years of industrial experience in dealing with flow-induced vibrations and acoustic resonance and he's performed numerous vibration measurements in power plants and he's designed and performed small-scale model testing, including small-scale testing of a BWR steam dryer.

So that's our group. We are very proud of the team we assembled to look at this complex issue. In terms of --

MEMBER BANERJEE: When was the team assembled?

MR. SCARBRUGH: We began last year, before we did the first review of the Vermont Yankee Steam Dryer Analysis when we did -- and I'll give you a little background.

MEMBER BANERJEE: And this is specific to Vermont Yankee or does it include the whole program?

MR. SCARBRUGH: The team also -- most of the team, Argon assists us also with Quad Cities and Dresden reviews as well and so they're also involved with that. So there's some overlap.

MEMBER BANERJEE: Were they -- did they review Dresden before this recent finding of the --

MR. SCARBRUGH: Dresden was not reviewed in as much detail by the team. We did not use them as much for the team for Dresden.

MEMBER BANERJEE: How much detail was attributed?

MR. SCARBRUGH: In that case, it was not a significant amount of detail in terms of the finite element analysis because, at the time, for Dresden, the -- Dresden had been operating for over a year or two at EPU conditions and not seeing significant problems, even with the old dryer, you know, even with the original dryer. And so when they beefed it up and made it stronger, we didn't feel we needed to look at it in detail at that time because they were adding more strength, but as we found every step of the way along this problem, you know, every time we find something new as we get into it. And eventually, Quad Cities replaced their dryer and there's discussions about possibly replacing the dryers at Dresden as well.

MEMBER BANERJEE: Is there any problems with the replaced dryers in Quad Cities?

MR. SCARBRUGH: No. And right now, they've been operating at Quad Cities, both units, since the spring. They come down -- one of the units comes down in the spring of next year for an inspection. They're been monitoring the pressure sensors and strain gages on the Quad Cities Unit 2 Plant in comparing that to the acoustic circuit model and we still have issues with them in terms of the exact uncertainty assumptions for that model, how well it matches, and that's -- they're currently providing information to us as we speak.

MEMBER BANERJEE: Now, if you say that the main problem is coming from the steam line, is more or less what I understand --

MR. SCARBRUGH: Yes.

MEMBER BANERJEE: -- why did Quad Cities change their dryer design to reduce vortex shedding within the dryer itself? This is not a problem, from what you're saying, right?

MR. SCARBRUGH: Right, right. They designed that dryer a long time ago in terms of our -- the knowledge level where we are. It was a year ago

-- over a year ago that they began designing that dryer, and we've learned quite a bit in just a year's timeframe in terms of where these loads are coming from and what the sources are.

So they designed it -- it's much stiffer, it's much more bulky, much heavier -- because they were intending to -- wherever this load was coming from, whether it's vortex shedding loads, or acoustic loads, they were going to beef this up strong enough that they wouldn't have any problem whatsoever. So they intended to over-design it for all possible ways to try to improve it. So it's an improved design overall, in it -- because it more closely matches the more recent steam dryer designs of the curved hood and slanted hoods that came out later. So they sort of used that same philosophy in terms of designing this new dryer as well.

MEMBER BANERJEE: Okay. Did they ever do a CFD study?

MR. SCARBRUGH: No, I do not think they did a CFD study. The loads that they saw have been significant, up in the 150-Hertz range or so, much higher than where they expected to see anything from a CFD review. So they focused on the acoustic area.

In terms of the modifications, you all

went through them earlier, so I won't repeat them.

CHAIRMAN DENNING: You didn't actually tell us what this review team, what their mode of operation was, how big an effort it was. I mean, what did the Argon people, for example, do with it? Any independent analysis or just what did the review team do?

MR. SCARBRUGH: Okay. In terms of the review, the -- there's a whole series. Let me jump to -- let me jump to the next slide. There was an audit that -- the review team assisted the staff last October, October of -- I'm sorry, August of 2004 at the General Electric office in San Jose, California. There, we went over the calculations, the analyses, the -- we observed some of their modeling on their computers. We monitored what they were doing in terms of the scale model testing, that General Electric was doing. That was for close to a week, the timeframe of the review team.

Following that review, the staff determined that there were a number of concerns regarding the -- that original analysis of the steam dryer. It had been based on a combination of data from -- actual collected data from various plants and then it was overlapped and it was extrapolated, and there was a number of issues resulting, that we had concern for that original analysis.

Okay, as a result of that, there was an audit report which indicated that the staff did not accept that steam dryer analysis, and we indicated that Entergy could resubmit an analysis. They did that in the spring of this year, in Supplements 26, 27 and 29. The Argon team and staff took that information, reviewed it, and conducted an audit at the General Electric office in Washington, DC where, in June of this year, where we discussed with the Licensee the analysis, the acoustic circuit model, fluent modeling and such. And they also submitted the fluent actual data file, which our staff, Dr. Boyd, ran permutations of that to get a feel for that.

At the same time, in parallel to this, the team also has been assisting the staff with the Quad Cities review, in parallel, and so that we've been interacting with Quad Cities on the acoustic circuit model, which is very similar. It's the same contractor that developed that. So they've been assisting us with that review as well in reviewing the finite element analysis and acoustic circuit model and such, for Quad Cities as well.

And then in -- as based on that June

$15^{th}/16^{th}$ audit, the staff prepared Requests for Additional Information that we provided to Entergy, and that was assisted by Argon, with questions. Then in August of this year, Entergy submitted the REI Responses. In August of this year, August 15^{th} and 16^{th}, one of our staff, John Wu and Dr. Ziada, audited the GE scale model test facility in San Jose to evaluate the use of the scale model facility to validate the acoustic circuit model and then, in August -- later in August, August $22^{nd}/25^{th}$, the NRC staff, with the whole team, conducted an audit of the REI Responses and all the supporting documentation in more detailed discussions with the Licensee on the 2-circuit model and the CFD model for Vermont Yankee.

In September of this year, Entergy submitted supplements in response to that audit and the staff reviewed that and came up with a proposed draft Safety Evaluation, which we developed and provided to project staff on September 30^{th}. So that was the -- Argon team, and NRC team and Dr. Ziada have performed detailed review and interactions with the Licensee on their analysis, their basis for their analysis, their assumptions in their analysis, and the results analysis. So, it was probably more in-depth than I can remember any review being done by the staff in terms of the expertise that the staff brought into this problem. Because we met with ACRS before, a couple of years ago, we just weren't there. We just did not have a good understanding of what was going on with these dryers. It's because of that we decided it was time to bring in experts, and so we were able to find people who really understood this issue in much more depth than we did.

MEMBER BANERJEE: So what is the new understanding that you have now?

MR. SCARBRUGH: It's -- in terms of where the sources are, we have a much better understanding of what's driving these loads on the dryer and what's causing the weaknesses in the dryer and where they are. Where we don't have a good feel for how to extrapolate that information from the main steam line strain gates data, up to a precise value for the loads in the dryer. We know --

MEMBER BANERJEE: But that's the issue at hand, right?

MR. SCARBRUGH: Exactly. And that's why it's very important --

MEMBER BANERJEE: So, do you feel that it's okay to do what they are saying?

MR. SCARBRUGH: That's what -- we're going to get to all that. We're going to get to all that. There's lots of slides, lots of slides. I'm jumping -- I'm stepping on all my contractor guys' words. But --

MEMBER LEITCH: The Safety Evaluation Report, I think, is around Page 301. I don't know if it's right in front of me, but it says that pre-PDPU, there will be three -- the following three refueling outages that will inspect the dryers.

MR. SCARBRUGH: Yes.

MEMBER LEITCH: But there's a table there that seems to suggest that it's only two. Which is it? Is there a commitment for three inspections or two inspections?

MR. SCARBRUGH: Well, they should do -- probably in 2007, they should do three.

MEMBER LEITCH: Well, that's just a -- you don't really need to answer that question right now. I don't want to take the time with it, but it seems to be just a difference in the verbiage versus the table. I think the date for one of those pre-EPU inspections has already passed and, obviously, it's one of those post-EPU inspections. The date has already passed.

MR. ENNIS: This is Rick Ennis. I think if you -- you're looking at the Commitment Table, and

I think if you look at some of those commitments, they should that at various times, in supplements, they had made a commitment and later on , it was either overlapped or superceded by another commitment. And that's some of the comments. I think, as far as visual inspection of the dryer, if you look on Page 306, it's Commitment Number 23, Visual Inspection of the Dryer, and we've got that in Refueling Outages 26, 27, 28, and 25 is the one that they just finished. So it's three.

MEMBER LEITCH: Okay.

MR. ENNIS: Right. Those were -- if you look at some of the comments, it says, "Commitment Modified by Letter. See Commitment 23."

MEMBER LEITCH: Right.

MR. ENNIS: Do you see the comments there on the right? So those were some of the earlier commitments they made in some earlier letters and then later on, it was superseded or overlapped with another commitment. So as far as the latest, if you'd look at Item 23, and that's the next three outages from now.

MEMBER LEITCH: Okay, so there are three?

MR. ENNIS: Yes.

MR. SCARBRUGH: It's something that an overview of the steam dryer analysis -- you've heard this, but just to summarize it. Entergy evaluated the potential steam dryer pressure loads for a combination of CFD and acoustic circuit model analyses to see if these focused on the lower frequencies for both the current licensed thermal power and EPU conditions. The acoustic circuit model calculated acoustic pressure loads at high frequencies, but only for the current licensed thermal power.

Then the stresses for individual steam dryer components were calculated using a finite element model and from pressure loads from both the ACM and CFD analyses, and then the peak stresses were compared to the peak limits and the ASM pressure was also tested.

In terms of the scope of the review, the team looked at the validation of the CFD and AC analyses, the uncertainty of the analyses and their inputs, the fundamental frequency and damping assumptions, the calculational methodology used in determining the stresses, the combination of the stresses, the stress limits that were used, the margins of those limits, and then the Licensee's plans for monitoring steam dryer loads and overall performance.

So, next I'd like to ask Drs. Boyd and

Ziada to talk about the CFD analysis and the initial validation of the ACM.

DR. DR. BOYD:: I'm going to speak first about the CFD review, which is the only review that I did and then Dr. Ziada, who reviewed the CFD work and the ACM can follow-on.

I'm in the Office of Nuclear Regulatory Research and we're supporting NRR and the team with the CFD review. The NRR team provided us with reports, computer files with the model itself and data that they received from Entergy as well as background information. What we did is, we did a fairly careful review of that and we participated in the audit and produced a set of Requests for Additional Information that were answered, and then we participated in an additional audit to follow-up on those questions and then we received supplemental responses, which we also reviewed. And we felt pretty comfortable that we understood what was done and how it was done and could make a pretty good review of it.

The basic finding is that we believe there is a significant uncertainty surrounding the CFD predictions and that the 15 percent suggested uncertainty is kind of under estimated for this particular problem. That was our basic finding. And we have a lot of background information that can support that in various ways.

And the second issue that came up in a supplemental response was the comparison to plant operating experience. There is some specific test data. And we tried to take a look at that and what we found is that the CFD predictions were lower than -- I'm sorry, were higher than much of the plant data, but the plant data came from different geometries, taller dryers with slanted hoods, some of it in locations like the skirt, and we didn't feel like it was applicable.

One point was given to us. It was on the horizontal cover plate and, in that case, the CFD model was about 33 percent too low. That was one of the better points, I guess, for comparison.

We didn't feel like you could get a lot out of that comparison with those single point measurements on unrelated dryers with unrelated conditions, comparing it to the CFD model.

MEMBER RANSOM: What was the uncertainty in, the loads that were actually predicted or frequency of the loads?

DR. BOYD: On the CFD model?

MEMBER RANSOM: Yes. You --

DR. BOYD: Well, the suggested uncertainty is 15 percent.

MEMBER RANSOM: But in what?

DR. BOYD: On RMS values.

MEMBER RANSOM: RMS value of the forces or RMS value of frequency?

DR. BOYD: I believe they were RMS of the pressure fluctuations in the model, not forces. That came from a paper that was submitted along with the work for a large eddy simulation of confined swirling coaxial jets.

MEMBER RANSOM: Okay.

DR. BOYD: So the 15 percent uncertainty came from basically a two-meter-long test section of a 2-inch pipe that expanded to a four and a half or 4.8-inch pipe and it had some swirling things in it. From that, downstream, they had some measurements of pressure, RMS fluctuations, and they compared them with the LES simulations and they got this 15 percent value.

MEMBER RANSOM: Was there any attempt to compare the frequencies that are predicted? It seems like that's what is important in terms of coupling with the rest of the system.

DR. BOYD: I would have to -- I don't

believe the frequencies were compared in this model.

MEMBER BANERJEE: I don't believe so.

DR. BOYD: Mean axial --

MEMBER BANERJEE: I think it was only for the RMS fluctuations.

DR. BOYD: RMS on axial velocity, RMS on things like that.

Our concern would be -- when we looked at the model, the main source of uncertainty, we felt like the geometry was reasonable and the modeling assumptions were reasonable, but the solution procedure was -- is basically a big challenge. So, what they found on this 2-inch pipe, is they found that it was very important to match the upstream region as well. And in the paper, they used the quotes, "the RMS fluctuations were grossly under predicted, with 2.7 million cells." What they did is they packed an additional 4 million cells just in the upstream region along the walls, and then they improved the resolution. So they ended up with about a 6-million-cell case that was more accurate.

Now we're talking about 4.7 million cells on an entire operating BWR, including the main steam lines, down to some -- it's just a totally different scale. In their test model, across an integral length scale to turbulence, they used 10 to 20 cells. In the upper dome of the steam generator model, they used less than one cell. The cell size was -- the integral length scale was larger -- I'm sorry, the cell size was larger than the integral length scale. So there's, you know, a big difference in resolution.

In the inlet region where the major concern was, they used about two to three cells across an integral length scale. So the -- and the problem is just the scale of the problem is enormous. This pipe flow problem was at one meter per second on a small scale and we're comparing it to something that's much, much bigger.

So we didn't feel that the uncertainty from this pipe model was applicable to our BWR problem and we were concerned that the wall modeling, for instance, was relatively inadequate and we had concerns, you know, along those lines. The entire upper dome is very complex. The jets are coming out and they're dancing around and they're interacting with each other, and there's a large tetrahedral mesh up there that's significantly larger than what would be required to resolve the turbulence. So the flow coming across the step, down into the inlet plenum, would not be expected to have the correct turbulence as a sort of a boundary condition coming in to the vertical and horizontal faceplates.

MEMBER BANERJEE: Do you think that there could be excitations in this region, which are as important as those coming from the relief valves? I mean, that might be missed because of the inadequate resolution or something?

DR. BOYD: That was a concern. I mean, it's hard to predict with these equations without some experience on very specific geometries like this. One concern I had was the shedding can be impacted by the upstream turbulence coming in and the sheer layers, and none of that was really adequately modeled upstream.

MEMBER BANERJEE: But could the shedding frequencies get up into these regions, which they think are causing the damage? You know, they --

DR. BOYD: I would say probably not.

MEMBER BANERJEE: -- a couple of hundred Hertz, right?

DR. BOYD: Yes. I would think probably not. But we just don't know. But just looking at the CFD, in a focused look at the CFD, the concern we had is that that uncertainty estimate was too low.

CHAIRMAN DENNING: You know, it sounds

worse than that to me, and I'd like to know whether it was the impression of any of the people who had experience with CFD, whether one should totally discount that CFD analysis, say, 15 percent? I mean, I think that's extraordinarily low relative to the uncertainty. Is it so gross an approximation -- my own experience with CFD in a much smaller problem, was I saw tremendous sensitivity in pressure differences to nodalization and I just wonder, is -- was it the impression of some people that one should just completely discount the fluent analysis?

DR. BOYD: Yeah, there is a train of thought that it's more qualitative. The Office of Research was asked to do that calculation a few years ago when Quad Cities, you know, first started having problems. And we looked at it for about six months and did some preliminary things and we considered it an untenable problem, given our resources. And so that's what they face. They tried to -- it's a very difficult problem.

MEMBER BANERJEE: Probably, the overall gross structures that you see seem reasonable.

DR. BOYD: I think there are things to learn from the CFD model. I wouldn't totally discount it. Again, my concern was this -- our concern was the uncertainty estimate.

MEMBER KRESS: But the qualitative expectation is that the vortex shedding loads and frequencies are small compared to the acoustic on downstream. That's a qualitative thing that comes out of the CFD.

MEMBER BANERJEE: That is the issue, though. I've been missing something.

DR. BOYD: Hydro-acoustic coupling comes to mind as something that would be a concern if there's possibly some standing waves in the dome. And there was -- the time step would not be as suitable for that type of modeling and there are other issues with that also. But, you know, there is that thought that something -- there are those kinds of concerns.

MEMBER BANERJEE: That would be more the concern, in the sense that even qualitatively, is there something being missed in this analysis, which could be of importance and coupled with the acoustic wave? So is it really understood well that the problem is due to rather high frequencies or failures that are occurring rather than low frequencies?

MR. SCARBRUGH: Well, I would think it was what they had seen from Quad Cities, where they actually installed a number of pressure sensors on the steam dryer. They are not seeing much happening down in the lower frequency range, but they're seeing a tremendous peak up around 150 Hertz, the higher frequency range. So, now it is a different designed dryer, but they're not -- they're not seeing the sort of activity, you know, the actual measurements from the dryer. And when they did their scale model testing, they're not seeing that much either from General Electric. They're not seeing that much happening at the lower levels. But, you know --

MEMBER BANERJEE: Are these scale models -- excuse me for interrupting you. Are these scale models giving results, which are in correspondence with the full-scale, and could they be used to understand things better?

MR. SCARBRUGH: That's what General Electric is doing right now. They're taking the data from Quad Cities and going back and matching it, correlating it to find out -- where the scale model didn't see that really high, super high peak there, you could see some, but you couldn't see it in -- as high as it was. And so they're going back and trying to decide, okay, why did it not pick up that high peak? But in other areas, it's matching pretty well. In the lower frequency ranges and things like that, it's matching pretty well. But -- so they're having to go back and re-look at that. So that's part of GE's ongoing program.

MEMBER BANERJEE: I guess the issue which I'm concerned about, and why I wanted to ask Chris about this, is if there are phenomena within this -- let's say, the dryer area rather than in the pipe itself, in terms of failures, then it may be hard to detect them by looking at censors along the pipe and not having one on the dryer. So the real issue is whether such frequencies, which are of interest, would be generated within the dryer or not, and whether the CFT analysis might miss these completely, in which case, we might say, okay, you know, it looks like the CFT analysis indicates there's no problem. It only shows low frequencies there, which are not of concern, based on our experience base. And now we put all these sensors on the pipes and we expect the problem to come from relief valves or whatever, you know, so that we really think that's an adequate measure to take instead of putting some instrumentation in the dryer actually to look.

MR. SCARBRUGH: And that is something --

MEMBER BANERJEE: And that's really the issue?

MR. SCARBRUGH: Right.

MEMBER BANERJEE: How much confidence can we have in that?

MR. SCARBRUGH: Right, and we have talked about that with the term. We've asked that question ourselves. Is, you know, by monitoring main steam lines, if the loads get such that there could be damage to the dryer, would the main steam line sensors be able to pick up that higher loads that are generated. One of the areas that we did was, we asked -- and as part of the licensed condition -- is that they have to monitor not only that, but the accelerometers, to look for lower frequencies for excitation. Anything that's in the lower frequency range that might below the sensitivity level of those main steam line strain gages. So that's part of what we're monitoring as well.

MEMBER BANERJEE: Would the main steam line strain gages see excitations, which originate at the dryers themselves? The high frequency due to flow and resonances within these cavities and things like that? Then pick it up on the main stream line?

MR. SCARBRUGH: That was one of the questions we asked in terms of if you start to see such high turbulence and problems in the dryer that you're starting to get to a damage level, would that be reflected down? And that -- I'm not an expert in this area, but my understanding was that you would start to see some sort of interaction, something happening downstream, that you get that much turbulence and excitation going on in the dryer, in the dryer and reactor pressure vessel that you would, between the accelerometers and the main steam line strain gage, you would start to see something abnormal happening.

MEMBER BANERJEE: The problem, though, is that I was talking to a gentleman who had been involved in, I think, this acoustic circuit modeling, and he was saying that the main effect in the boundary condition comes from the mass flow, not from the pressure fluctuations. So, I mean, there may not be mass flow fluctuations coming through, so you might get a lot of action in the dryer, which is not so apparent. Maybe this can be cleared up, but let's put the question in a direct way. Imagine there was a lot of activity due to turbulence and so on. Within the region of the dryer cavity, would this be detected by the sensors, which are currently planned? I think that's the question that should have a clear answer.

MR. SCARBRUGH: Right, and that's why

we're jumping over from CFD into acoustics and -- but we have a different team of people --

MEMBER BANERJEE: Yeah, but a CFD is relevant because, I think, what CFD could address is whether there could be this possibility --

MR. SCARBRUGH: Exactly.

MEMBER BANERJEE: -- or not, within the --

MR. SCARBRUGH: Yeah, I know. And that's why I'd like to turn this over, and we have the wrong guys up here, but for this question, but Dr. Hambric is right behind you and I'll let him speak now because he's been trying to get my attention on this issue.

MEMBER BANERJEE: Sure.

DR. HAMBRIC: Yes, this is Steve Hambric from Penn State. Actually, Entergy, this morning, showed some data that they've collected from strain gages installed on their main steam lines. And the new data clearly shows acoustic peaks that are associated with resonances within the fluid inside the dome itself, very low frequency resonances, that get excited by the turbulent flow traveling over the dryer and into the main steam lines. All that turbulence lights up those modes. So it is showing evidence at current licensed power conditions of those peaks, so if the amplitude of the excitation increases and the peaks crank up, you will see that as they go up to the higher power levels.

CHAIRMAN DENNING: How do you know for sure that's right? I'm sorry. How do you know for sure that's where they're originating? I understand you're seeing them out there. How do you know that they originate from the dome?

DR. HAMBRIC: They've done finite models and scale mode testing and the CFD models and looked for the acoustic resonances of the cavity itself, and they're pretty consistent. The frequencies are plus or minus a few percent, but you see the shapes of the modes pretty clearly and it makes sense --

CHAIRMAN DENNING: Okay.

DR. HAMBRIC: -- if you just do quick calculations of length and speed of sound.

MEMBER RANSOM: Would you see rather high frequencies?

DR. HAMBRIC: Yes.

MEMBER RANSOM: From strain gage measurements?

DR. HAMBRIC: I'm sorry?

MEMBER RANSOM: Were they pressure or strain gage measurements on that?

DR. HAMBRIC: It's an integrated strain

gage signal that captures the breathing of the pipe.

MEMBER RANSOM: Right, right.

DR. HAMBRIC: So what you're seeing is the acoustic waves emanating from the dome, traveling into the pipe, and going in the other direction, down toward the turbans. And so you'd pick up that signal.

MEMBER RANSOM: Would you see that at high frequencies as well?

DR. HAMBRIC: Oh, yeah. Yeah.

MEMBER RANSOM: So this is not -- so the pressure, with this coming into the pipe, and somehow you're able to sense this down the pipe?

MRMBER HAMBRIC: Right.

MEMBER RANSOM: The things that are going on in the dome?

MRMBER HAMBRIC: Right. So what the dome is doing is it's kind of breathing and it's pumping energy into the steam lines, and so it causes the steam lines themselves to expand in response to that. And you can pick that up --

MEMBER RANSOM: What is the basis for that? I mean, there's a little pipe and there's a big dome here.

DR. HAMBRIC: Right.

MEMBER RANSOM: Why are you going to be

able to see that inside this pipe?

DR. HAMBRIC: The coupling isn't perfect, but it is measurable.

MEMBER RANSOM: It's weak at higher frequencies?

DR. HAMBRIC: Right. Oh, it is weak, but you will see it. Now, at high frequencies, we suspect the main sources are going to come from valves that are downstream.

MEMBER RANSOM: Well, that is the assumption, right?

DR. HAMBRIC: That is the assumption, right.

MEMBER RANSOM: Yeah. If there were high frequencies generated within the dome, would you see them? That was the question.

DR. HAMBRIC: Maybe is the answer.

MEMBER RANSOM: Okay.

DR. HAMBRIC: Some of them, you would. Some of them will probably be filtered out.

MEMBER RANSOM: It didn't look that certain to me, that you would be able to.

DR. WU: In order to -- this is John, John Wu. I am one of the reviewers. I've been involved in this, you know, for quite a while, for the last couple of years.

In order to answer Sanjoy Banerjee's question, that is the same question we've been asking ourselves. We've been asking it at Quad Cities and at Vermont Yankee about, how about a coupling between acoustics and, like a vortex shedding and turbulence within the cavity, providing you can expand the vortex shedding within the cavity? For some reason, quite recently, we looked at the Quad Cities internal matrix, which also shows the peak at high frequency. That's from their shedding mentioned, also from the pressure sensor measurement, supposed to show the high frequency. Which is a complete, quite consistent with the loads, so that's why we say, how to reserve this, you know. Acoustic can, you know, to -- well, hydro -- downloading within the cavity. Something like that.

But we need -- up to now, we believe we just see the measurement data and that we pretty much think that, you know -- the high frequency occurs from the incidents. So we believe that, you know, high frequency exists in the pressure on the trial.

MEMBER KRESS: This issue could be resolved if we had string gages on the steam dryer itself.

DR. WU: We do. We do have that, yes.

MEMBER KRESS: You have those on both the new and --

DR. WU: On the QC, on the Quad Cities, too.

MEMBER KRESS: On Quad Cities? That's a different steam dryer.

DR. WU: Right. It is.

MEMBER KRESS: Well, is it that difficult to put gages on the Vermont Yankee side?

MR. SCARBRUGH: The dosage is very, very high.

MEMBER KRESS: It's a dose issue application?

MR. SCARBRUGH: Yes, yes. That's really where it is. I mean, they've been modifying it quite a bit. So they've modified it. They can do the modification, but the dosages would be quite a bit just to run those lines out.

CHAIRMAN DENNING: Okay. I think we ought to move on to the AMC validation.

MEMBER KRESS: Before you go on, I'd like to hear a little more about that last bullet. What are the Licensee conditions that are going to address this thing?

MR. SCARBRUGH: What the intent was, because of the uncertainties regarding the CFD, was in terms of the monitoring of the main steam line strain gage data that now will go down to a rather low frequency level and the monitoring of the acoustic -- of the accelerometers on the main steam lines, looking for low frequency lows that might be significant, so that's part of what they're going to be monitoring. Now, the uncertainties is that, in terms of the limit curve, the limit curve where they operate now, with what their sensors are reading, are very far away from where the limit curve is. If any peak hits a resonance and strikes that limit curve, they have to stop. That stops them right there. The analysis was that the whole -- all of that frequency spectrum goes up and hits the limit curve. But the condition is much more stringent on that. If any peak hits it, they have to stop, and they have to stop at -- whenever they're monitoring, they have to monitor hourly, and at 5 percent, 10 percent, 15 percent of the original licensed power, there is a commitment also, that as part of the NRC staff review, if we have a safety concern with what's happening with that actual operational period, then they have to stop and resolve those issues.

So, if they get to a point where any excitation starts to occur, they have to resolve these uncertainties and that stops the power increase. And so that's the condition that addresses it.

MEMBER KRESS: On the one basis, did you decide what level that limit ought to be?

MR. SCARBRUGH: The limit curve?

MEMBER KRESS: Yes.

MR. SCARBRUGH: What they did was, in terms of how far it was away, that there was like a hundred percent -- if you look at the weak link and there's a slide later on that, on the limit curve, but if you look at the weak link, it's still -- even if you assume the calculations that they did, they're still twice as much, a hundred percent, margin up to that level for the overall. And that's the curve that they establish. And what we did, we said on top of that, not only would the entire curve go up there, but if any peak hits that, that's where we stop. So that's how we added that additional conservatism into monitoring of the actual strain gage data, is that if they see any peak go up and hit that, they have to stop. Because --

MEMBER KRESS: The weak link you are talking about is on the dryer itself?

MR. SCARBRUGH: On the dryer itself, yes, sir.

MEMBER KRESS: So the assumption is that we will basically get no attenuation of that downstream as it goes through the exit plan and --

MR. SCARBRUGH: Well, they have to monitor -- in terms of things happening downstream, they have to monitor the piping, the components, walk downs, inspections, all that has to be done during every 5 percent power level. They have a series of walk downs they do, and accelerometers, monitoring acceleration of all the components. And Quad Cities did see these high peaks start to occur in their accelerometers when they started to have problems. So, they're going to be monitoring all of that information at each hold point and then presenting that to the staff and if there are any excitation issues, then they're going to have the holdback.

MEMBER KRESS: Thank you.

MEMBER LEITCH: Is there any commitment to monitor quality, other than just upon first reaching each plateau? In other words, months or a couple of months downstream, are they required to monitor the quality?

MR. SCARBRUGH: Oh, the motion carryover?

MEMBER LEITCH: Yes.

MR. SCARBRUGH: Yes, sir, that's part of the ongoing -- the criteria -- they have calculationals that they do based on the main steam line gages, and also the moisture carryover. Both of those. But we want to catch it before it gets to a moisture carryover issue.

MEMBER LEITCH: Sure, but what I'm saying is there is a requirement to do that upon reaching the 120 -- upon reaching each plateau?

MR. SCARBRUGH: Yes.

DR. MURPHY: But I'm saying what about downstream of that? In other words, upon first reaching it, the moisture carryover is high, but what about a month, a year downstream? Is there a commitment to --

MR. SCARBRUGH: Right. We expect them to continue the monitoring of moisture carryover, like most plants do, just like Quad Cities and Dresden do, continuously. And any time they see -- just like Dresden, we've had a couple of cases in Quad Cities where the moisture carryover has gone up after a rod, control rod movement. And that same type of evaluation would be conducted here. If they start to see an increase in their moisture carryover, they need to evaluate what's causing it. Sometimes it's caused by something, you know, as straightforward as a control rod movement, or at Quad Cities, they had cases where they actually had dryer fail and then they saw them go up.

MR. SCARBRUGH: But you could have the dryer failure and not have it affect the moisture carryover.

MR. SCARBRUGH: If you have a crack, yes, sir. I mean, once it wasn't releasing -- you know, and then they have to come -- and then they do the detailed inspections, you know, at the next three outages to find that. And if they find that, that's going to put them back to Square One because they shouldn't see any. With the low loads they're seeing, they shouldn't see any cracking at all in terms of this type of fatigue-type cracking.

CHAIRMAN DENNING: Okay, let's move on to the ACM delegation.

MEMBER CARUSO: Do you believe that the failure at Quad Cities was triggered by a rod pattern change?

MR. SCARBRUGH: No, no, no.

MEMBER CARUSO: It just happened at that point?

MR. SCARBRUGH: No, no. They've had moisture carryovers at increases at Quad Cities for a number of different reasons. They've had them for a stream dryer failure and they've had them for a rod change.

DR. ZIADA: My name is Samir Ziada. My part on this team was to look at the scale model tests and the validation of the ACM method on scale model tests as well as helping FISK with the CFD.

Perhaps I can say something very brief about the scale model tests. Actually, if you look at the results of this capabilities, you see that you have the high frequency and low frequency components. In the scale model tests, you see the low frequency citation, which is -- what we say, the higher dynamic, and see at low velocity, and it goes up, the low velocities with dynamic tests, and it exists at every flow velocity. Whereas, the high frequency component, the resonance of it, they become initiated at high velocity volume, and the winds become initiated, it becomes very steep. The altitude decreases with velocity very steep. This seems to correspond to the measurements in Quad City. Actually, if you see the Quad City here, you see that the measurements of vibration and strain and pressure at high power starts going very steep which really compares well with the model of this. So the evidence we have now does indicate that most likely it is the high frequency component that we need to worry about at the moment.

Having said that, the scale model test was used to validate the ACM and at this time, what they did is they tried to put the pressure conceal sites at the same locations as the old locations at VY, Vermont Yankee and what happened is in the scale model test, you have the microphone, the sensors are very good because they are flush-mounted to the pipe. You have no -- the uncertainties are very small. You know, the speed of sound, the volume conditions are well defined, so you have really perfect conditions to test the validity. The results of this was really not very good.

MEMBER RANSOM: The scale models, are they just geometric scales or did you scale the fluid also? The testing of air as opposed to steam?

DR. ZIADA: The validation test is being done on whatever model it is. The model is actually a Quad City model. It's not a VY model. But the objective of the validation of the acoustic model is to -- because you could measure the pressure distribution inside so that the test was to validate the method rather than model the VY. So they had two microphones in every pipe and they tried to circulate it, this whole modification, to, I believe the distribution, and then compare it with the measurements that's done on this smaller model. Okay?

So, as I said, I would have expected that that should really have all the test results for this case. I would call it a simple case compared with the planned larger effort.

The trend was to find, to show that the results balanced -- the predictions balanced the measurements and that this brings a lot of uncertainties because you just try to adjust some factors to adjust it. So I would say that the validation in the smaller scale model was really about heating.

MEMBER BANERJEE: Why was that, do you think? The measurements were good, right?

DR. ZIADA: Yes.

MEMBER BANERJEE: So is the model bad?

DR. ZIADA: You have so many sources, you have a lot of precipitation in the piping, and certainly the method can be improved.

MEMBER BANERJEE: How big is the pipe?

DR. ZIADA: I would think -- correct me if

I'm wrong -- maybe the pipe, maybe one inch, one inch or less.

MEMBER BANERJEE: And what is the velocity?

DR. ZIADA: The velocity was the same map numbers, so the velocity should have been --

MEMBER BANERJEE: 160 -- 200 feet per second.

CHAIRMAN DENNING: We have a comment from --

DR. BILANIN: In fairness, the validation was done blind.. The best parameters were estimated --

CHAIRMAN DENNING: Hold on one second. I don't think you're speaking into a mike. I think it fell down.

DR. BILANIN: In fairness, the validation was done blind. And the best parameters were estimated for a true speed and other damping factors from the subscale model. One calculation was done, and that was supplied for the valuation, so there was no model tuning done whatsoever for that comparison.

MEMBER BANERJEE: And what were the parameters that were estimated beforehand?

DR. BILANIN: Various things, such as

acoustic speed, the amount of losses that occur at steam/water interface. That is modeled in the calculation, but the radiation condition is downstream of the pipe, how much damping is in the speed dome and acoustics of the speed dome itself. So there were several parameters in the model.

DR. ZIADA: So, again, the other aspects of this validation actually is that the tests were done at very relatively low flow velocities and the model which does not correspond to 100 percent of VY conditions. At these conditions, the relief valve were not excited, so this, I think, brings additional uncertainties. Seeing that the noise ratio is a very important factor when you are doing this and when you run this with a low speed flow, it means that you have less turbo participation, as well as loud speakers were used. I recall that the loud speaker volume was turned up pretty high. It means that the noise to signal ratio is also very -- the signal to noise ratio is politically good.

So, all this, I would think that one would have expected better agreement, and that before, I think, the team concluded that the validation base was not really successful on this small scale model. And we started focusing on a more appropriate condition, which would be similar to Vermont Yankee and that's when we started looking at Quad City validation and doing something similar in VY as well.

The validation of VY, of Quad City, I think, the next team will talk about that.

CHAIRMAN DENNING: Oh, that's going -- we're going to have a presentation on the validation against Quad City 2 later? Is that what you just said?

MR. SCARBRUGH: Actually, right now.

CHAIRMAN DENNING: Right now, okay.

MR. SCARBRUGH: And so we're going to ask the other members of the team to come up and we'll switch out, so they can talk more about the acoustic circuit model now.

MEMBER BANERJEE: Blind tests are very good. I remember that when these were done for LOFT, every time we did a blind test before and then we did the experiment, they never agreed. But after that, they always did. Every time we did a new test, we had the same problem. So these methods seldom have any predictive fodder.

MR. SCARBRUGH: Next we're going to have Doctors Hambric and Shah and Mulcahy walk you through our review of the acoustic circuit model analysis and also the ACM input on certain issues.

DR. HAMBRIC: By the way, in the Navy community where I work, we have a term -- maybe other people use it, but we compare "predictions" versus "post dictions" and it's just as Sanjoy pointed out, post dictions are always better.

I'm going to talk about the acoustic circuit model analysis review. We've looked at a whole lot of information from CDI, as well as from General Electric and Entergy, as well as Exelon with the QC people. So I just want to reemphasize that all of us are working on the QC, as well as the VY reviews, and that's helped us immeasurably as far as understanding what we think is going on there.

But just to refresh your memory, the acoustic circuit model relies on measured inputs. It's not trying to predict from first principles what's going on inside the dome and the main steam lines. What it does is it takes measured pressure waves or pressure amplitudes and phases at two locations in each steam line and then tries to infer the weight amplitudes going left and right. They then couple those main steam line one-dimensional models with the three-dimensional dome model to try to get the couple analysis of what's going on everywhere and what pressure loads are on the steam dryer.

Those inputs are synchronized time series and so everything they're doing is in the time domain. And as we pointed out a moment ago, the scale model tests were not all that useful as far as validating the ACM. And so what we used instead was Quad Cities 2 measurements. For the instrument in the dryer, they had 27 pressure taps mounted to the outer surface and in the inner surfaces of the dryer. And they looked at the broadband pressure levels, as well as the spikes that you saw at around 150 Hertz and we spent a lot of time discussing what the errors and uncertainties are.

Let me also, before I get into that, kind of point out that the main goal of Entergy and Exelon is to use these models to come up with conservative bounds on what the loads are. It's not, can we get the pressures exactly predicted? It's, are we above, are we conservatively above the pressures that are actually impinging on the dryers. So that was our main focus in the review, is are we conservative and, if we're not, what is the bias error? What is the uncertainty that they ought to apply to these predictions in order to tell them whether there's a chance that the stresses in the dryer might be over the allowable limits. So, that was our main focus.

It says on the vu-graph that they used a specific ACM version. So you had heard Dr. Banerjee refer to a few parameters that they use in the models. The parameters are damping in the main steam lines, damping within the dome, and lots of other damping parameters and sound speeds. So what Entergy did was they froze the ACM version that they were using and the froze it to the Quad Cities 2 originally licensed power condition, 790 Megawatts. So there are measurements at that condition. There are predictions at that -- blind predictions at that condition. And they are basing uncertainties on those comparisons.

Based on all that, they came up with 100 percent uncertainty and that's an amplitude. There was a question earlier about frequency and amplitude uncertainties. The AMC isn't going to shift frequencies. Whatever peak frequencies you see in the steam lines, those are the peak frequencies you're going to see in the dryer. So that 100 percent uncertainty is under the amplitude of the load.

Even after applying that, they presented in submission to us, a comparison of spectral density plots in frequency and also RMS overall amplitude plots and added that 100 percent uncertainty to the

ACM predictions and they compared that to the actual measured data. And there were still under-predictions.

And the other predictions that we've mostly been focusing on are at the toe ends that you see at 150 Hertz and so the valve singing frequencies in QC. Because our main concern is one of those valves is going to light off and start causing acoustic waves at very high amplitudes to travel down the steam lines and hit the steam dryer.

And so when we talk about uncertainties, we're mostly looking at those peaks because that's what we think is driving PC dryers, the old dryers in the failed unit.

So even after the 100 percent uncertainty, they're still under predicting, okay. And that under prediction is addressed in the license conditions that Tom Scarbrough just mentioned as far as monitoring what's going on. At any peak, challenges on limit curve, we're making them go off and do pretty much all the analyses over again and they have to convince us that the uncertainties that come up are realistic and fair and that they're really not challenging the integrity of the dryer.

MEMBER RANSOM: Steve, do you know what

kind of coupling they use between the dome, the steam dome and the line?

DR. HAMBRIC: Sure.

MEMBER RANSOM: For example, if you use just continuity a coupling agent and assume a just continuous change in area, you get one answer, but another one is a fairly new type entrance effect, and I forget what the acoustic term is for that, but it's a circle in the holograph point that you use for the boundary condition, you get quite a different answer.

DR. HAMBRIC: Yeah, they are using a ladder. They are assuming a fluctuating head loss across the joint.

MEMBER RANSOM: Well, very little head loss with the brewery-type entrance.

DR. HAMBRIC: Right, but it's a fluctuating, right. So they're including that term in their coupling between the main steam line 1D acoustic model and the 3D dome model.

MEMBER RANSOM: Okay.

DR. HAMBRIC: And they don't have to calculate that fluctuating head loss to get the answer on the steam dome, but they can. And they've done that in some of their submissions.

And they also enforce continuity of

particle velocity. That's supported --

MEMBER RANSOM: I was just wondering if that was maybe part of the reasons that there's such high uncertainty.

DR. HAMBRIC: There's that. A lot of the damping parameters are probably giving you a higher uncertainty. Some of the things we're looking at for Exelon now for QC, get into what the actual damping out to be of the steam froth, they call it, at the kind of the floor, the water versus steam --

MEMBER RANSOM: Compliance.

DR. HAMBRIC: All of that tuff, right. So I think there are a lot of parameters that need to be fine-tuned, but the point for Entergy is that the froze their ACM model, one particular model, one set of parameters, and based on the blind comparison of measurements, came up with their uncertainty, which we believe is low. We don't believe that's conservative enough. But based on that, the fact that we don't believe it's conservative enough, we applied a lot of conditions in the license plan.

DR. MULCAHY: I'm Tom Mulcahy from Argon. I'd like to talk to you about another uncertainty, and that is that they have to measure -- this is not a -- the ACM is not a predictive technique. You have to measure the pressures in the pipe, in the main steam line in order to come up with the pressures on the dryer. So there's uncertainties involved there.

But before I get into that, I'd like to put a little perspective onto this that maybe I carry that others don't, and that is of all the review papers that I wrote in the 1970's and 1980's and all the conferences I attended and that, this particular kind of problem has not been seen before. My current thinking is that it is the valves singing. They're the excitation source, and I look at it a little bit different than acoustic people, but essentially you have acoustic modes, which are both in the piping and -- the same mode is in the piping and in the steam dome itself. And so if you get to the unusual circumstance where you have a valve singing at an antinode of an acoustic mode and you've got another antinode inside the steam dryer, you can excite the steam dryer. It baffled me how you could get energy up from these valves which are often 50, 60, 70 feet down the steam line until I saw some of the acoustic model analysis that was done with regard to the small model tests.

So, now not only do you have to have this coupling, this acoustic coupling with the excitation source, but you also then have to have a frequency on the structure, which responds to this. So it's a rather -- in my view, it's a rather unique situation that you can get all of these parameters to come together.

MEMBER CARUSO: Can I ask you a question? Are you saying that it's the main steam isolation valves are resonating because they increase flow through them or resonance is off the branch line?

DR. MULCAHY: It's -- there's vortex shedding going across the branch line where the valves are.

MEMBER CARUSO: Right.

DR. MULCAHY: So the vortices are the same part of this thing, as we've all heard from wires and that sort of thing.

Another way to look at it is that just because you have a loud noise, it doesn't mean that you're going to have structural damage. You have to have a structure which responds to that. I mean, all the musical instruments don't fall apart as they're using them. So I think it's a rather unique situation.

Now, to get back to the -- and it may be Quad Cities and Dresden because Quad Cities and

Dresden have the high velocities in the main steam lines. Quad Cities goes through, what? It's 70 or 80 percent, you see a blip. Quad Cities -- I mean, Dresden has actually higher velocities, smaller pipe diameter than Quad Cities. So it may be that it's just those particular variances of reactors. All the other reactors have different scale between their main steam line and their reactor dome.

Getting back to -- I might also add if this steam dryer had been declared a safety item, we probably would have been working on this a long time ago because they had to instrument it and at least at Dresden you would have seen these peaks coming up either from a pressure measurement on the dryer or pressure measurement in the main steam line.

Getting back to measuring the pressures, these guys were really -- this is a daunting thing to do is to measure the pressures in the main steam line and they started out with the available parts, the instrument lines, close to the reactor, and then you have to put a pressure transducer at the end of this long line, which has two -- has air boundaries in it, has water boundaries in it, and you've got to get a transfer function between that transducer all the way up to that. And this -- the uncertainty just builds and builds and builds in these things. So when they started, they were just using these instrument lines with pressure transducers at the end of them and they -- the uncertainty was so large that you couldn't really even make heads nor tails out of it. They then started to add strain gages to the main steam line. In the case of VY, I believe it was one strain gage on each main steam line and now you get into the issue of, well, what are you measuring with one strain gage in the circumferential direction on a steam line. Both Steve and I have had lots of experience in this area and you've got to eliminate pipe vibrations and everything like that.

So now we've got Quad Cities up to four -- on four strain gages, 90 degrees apart, in order to eliminate some of the overling modes in the piping, and they've actually already are glad that they did it, although when we asked them to do it, they weren't so glad. VY is now, I was just told when we came in by Rico, that -- or somebody -- that they now have six around the circumference of this and the circumferential direction, which you now only eliminate the first mode, but can eliminate maybe the next two modes. And the idea is to deal with the modes that are in the frequency range of zero to 200

Hertz in the piping.

So that's where they're at now and I don't know if they showed that data that we've been given, but they've already had to use essentially these strain gages to eliminate some of the over predictions that they've been seeing. What they're doing is they're lowering the uncertainty of the measurement technique. It's not absolute now, but the uncertainty has gone way down because what they were relying on before was so -- was so -- had such high --

MEMBER RANSOM: Why didn't you just use flush-mounted transducers?

DR. MULCAHY: You know, if there had been a safety issue, to start with, they would probably have had ports in there to put in flush-mounted transducers. But to go into a main steam line in -- this is an old -- this is a three-year-old plant, right? It's so hot that -- and you've got to penetrate the steam boundary and I don't know who you'd get to okay that.

They've done almost everything besides -- first of all, the main steam line is not the world's greatest transducer. I mean, you're essentially trying to make a transducer out of a steam line or an instrument line. That's not an easy thing to do. The strains are low, so they would've had to get -- they would've had to update and upgrade their instrumentation in order to resolve these small strains that they're seeing. And they'd do bench tests to see if they could do it. They obviously can't simulate what's going on in the reactor, but they do as much as they can, or they've done as much as they can.

CHAIRMAN DENNING: Okay. Thank you. Continue.

MR. SCARBRUGH: Okay. The next slide, I'd like to talk a little bit about the limit curve margin and we've talked somewhat about this. And Entergy showed that this morning. They have a limit curve that they've established from zero to 200 Hertz frequency and using the physics circuit and such, and part of what we did was we indicated to them, during their audit in August, that the importance of that limit curve and that you will still maintain structural integrity of the steam dryer if you get up toward that limit curve. And that's where they did an analysis which showed that the stresses, the combined stresses that they had were from their calculations, and you saw a little bit this morning about how they calculated that, was 7,400-psi at their weak link and the fatigue stress limit from SME is 13,600 at that point. So even if they did rise up to that level and hit that, they would still have almost a hundred percent margin there.

But also, as we talked about, any peak, any single peak can end up affecting that little curve and makes them stop and -- from the license condition, and evaluate the uncertainties. So that's how we added our additional conservatives there.

So overall, our findings regarding the steam dryer stress is that, although as we've discussed, there's significant uncertainty regarding the calculation of the stress and the mouth of that uncertainty, that the current steam line instrumentation suggests minimal excitation of the pressure frequency spectra in the main steam lines at the current licensed conditions.

So, it's apparent that the flow in these stresses are not significantly challenging the fatigue stress limits from the ASME Code for the dryer.

MEMBER BANERJEE: What are the cracks in the dryer at the moment due to?

MR. SCARBRUGH: Most of them were -- they were IGSCC, okay, and tomorrow you can have the Chemical Engineer being brought in. They can talk more about that.

MEMBER BANERJEE: But they're all those?

MR. SCARBRUGH: They did have some small fatigue ones down where the end plates fit into the drain trough and that's a sort of a natural flexing point, which isn't even -- the weld isn't even really necessary because the end plate fits in there and it doesn't move.

MEMBER BANERJEE: And those are the only cracks related to this?

MR. SCARBRUGH: Well, they had a few others, but they're very small. None of them -- they inspected the areas where the loads are on the outer hood, and the gussets and modifications, and they don't see -- they don't see any --

MEMBER BANERJEE: Now, they saw a lot of new cracks when they did some -- the inspection just before we were in Brattleboro last.

MR. SCARBRUGH: Those new ones that they saw were the ones that were on the end plates inside the vein beds and it's where -- and that's the IGSEC cracking where they have a -- It's a channel shaped 8-inch end plate for those channels. And where the inlet side comes in, they saw -- they saw some cracks a couple of inches long. They weren't sure where they went, but they didn't see them on the other side. So they -- they were assuming that they just stopped or maybe that they were there all along, and they just hadn't seen them before, but they ones that they had seen previously in 2004, they were still where they were and they still didn't see any on the outlet side.

So, that's where they're getting a little bit of IGSCC crack in there, it appears, but they're not getting any fatigue cracking on the vertical welds there or anything of that nature.

CHAIRMAN DENNING: IGSCC is stress and cracking?

MR. SCARBRUGH: Inter Grainger of Stress, Corrosion and Cracking.

MEMBER BANERJEE: Oh. Oh. Did you have that in Quad Cities, too?

MR. SCARBRUGH: Most plants, when -- we've been sort of monitoring the inspections of all the steam dryers and all of them see a little bit of IGSCC during these outages. And they see --

MEMBER BANERJEE: But there's no coupling between these two cracking modes?

MR. SCARBRUGH: No, it looks like there was not --

MEMBER BANERJEE: IDSCC crack doesn't grow due to vibration or anything?

MR. SCARBRUGH: No, it just gets to a point where it relieves -- and you see, you see it in a lot of the dryers where they get a little bit of IGSCC from the cold working that occurred in the past and then it occurs and it relieves itself and then it stops. But anytime like that, they monitor that because that's something that they want to make sure doesn't grow any further.

So that's -- what all this does is it emphasizes the importance of monitoring. And that's part of our -- the next slide is the monitoring plan. And they -- Vermont Yankee described the steam dryer monitoring plan and defined their unacceptable steam dryer performers where they could get a generation of loose parts, and these little cracks or tears that would allow excessive moisture carryover because all these dryers see little, small, little indications every time you inspect them. It's just is the nature of the beast.

And then they have a step process where they go up in power, 2.5 percent steps, and 5 percent steps, and then they have performance criteria based on moisture carryover and the steam line data where they evaluate the data hourly to make sure they're staying far below the limit curve.

Now when we did our review of the monitoring, we found that there were a number of areas that needed to be strengthened regarding the monitoring plan. We needed to -- we wanted to be provided with the plant data and also actions -- hold points where we could interact with the Licensee in discussing these safety concerns. They needed to resolve the uncertainties. If they hit the limit curve, and even if they don't hit the limit curve, within 90 days after EPU issuance, they have to resolve these uncertainties.

They have to monitor the plain instrumentation for low frequency excitation because that was one area we thought -- we haven't seen any excitation in the low frequency areas significant from the scale model casting or from the Quad Cities instrument and dryer, but we wanted to make sure that the Licensee was monitoring that in case there was something that we missed.

And also, we wanted more details regarding the start-up test procedure and so we provided that to areas we like to see. Because our experience with Quad Cities start-up, there were certain areas that we wanted to make sure were monitored as they went up in power. So we used that Lessons Learned from Quad Cities for their power start-up after replacing the dryers and put that into the License Condition.

So, the bottom line in terms of our development of the Licensing Conditions was we wanted to provide a slow and deliberate power assention with lengthy hold points and data evaluation. We wanted to formalize the plans for improving the strain gage limitation and we've heard, it's already been installed and being used now. And there were other activities that we wanted to formalize that the Licensee had mentioned in their Supplement 33. We wanted to specify the contents of the start-up test procedure. We wanted to go ahead and incorporate Entergy's License Condition that they had regarding the long-term implementation of the monitoring plan, and we wanted to provide for detailed interaction between the Licensee and the staff during the power assention so we could discuss the plant data, the valuations, and inspections, just like we did for Quad Cities when they came up in the spring with their new drives.

We sent this out to the Licensee and they accepted it. They had some minor clarifications which we didn't consider to be significant to our overall goal and we put those into the draft's evaluation.

In the next few slides, I have -- I summarize the License Conditions, and I'll just very briefly, just go through them for you. In terms of -- the first part is the requirements above 1593, Original License for Thermal Power. They have to monitor the newly installed strain gages hourly. They have to have hold points for 24 hours at 105, 110, 115 percent to collect data and they cannot increase the power above that point for 96 hours after receipt of their evaluation of that -- our receipt of that evaluation of that data. If a frequency peak from the strain gage data exceeds the limit curve, they have to return the facility to a power level where the limit curve was not exceeded and resolve the uncertainties. And provide that to the staff prior to any further power increase. They have to monitor the reactor pressure vessel water level or maintain line piping of accelerometers, hourly, and this also -- well, we talked about looking for a low frequency or something that the main -- a few main strain gages might have missed --

CHAIRMAN DENNING: Why is that an "or?"

MR. SCARBRUGH: Oh, because when we discussed this with them, their water level experimentation just isn't able to give you reliable data based on what they have. And based on our experience with the Quad Cities main steam line pipes and accelerometers, they did pick up excitations at various levels across the frequency spectra. So we thought that would be a reasonable way to do it. It could be either/or. We were focusing on what was in the lower frequency range, what could give them something to supplement that.

But we wanted to -- in discussing it with them, they didn't think the water level would give them any reliable data. So we thought, well, rather than have them do something which doesn't tell them anything, we just focused on the accelerometer. So that's why we did the "or" in there.

MR. SCARBRUGH: Just to clarify, the water level there is considered not reliable for these purposes. For the purposes for which the water level instrumentation was put in there, which is a safety purpose and feed water control, it is satisfactory.

MR. SCARBRUGH: Yes, thank you for that clarification.

MR. SCARBRUGH: Just so that it is clear that we don't have something hanging out there that says that.

MR. SCARBRUGH: Exactly right, thank you. That's a good clarification. Yeah, for this purpose, they didn't think that they could anything reliable for monitoring steam dryer excitation from the frequencies, monitoring the frequencies, and so they suggested that -- they were asked if they could do either/or and we were agreeable to that. As long as they do something that looks for sort of a back-up, sort of a safety net there just to make sure that the steam line strain gages -- if they see anything else happening, that they'll be alerted to that. And if they do, then they have to respond to that. And if they see any resonances start to occur in those accelerometers, then they need to address that with us.

CHAIRMAN DENNING: Okay. Continue.

MEMBER LEITCH: Under "B" there, should it not also say "120 percent?" I realize increasing beyond that is not applicable, but you still do the -- all the analysis and --

MR. SCARBRUGH: Right, because when it gets to 120 percent -- and I think it's on the next page -- yeah, we have it on the next page. When they get down to 20 percent, they have to reevaluate everything.

Then the following, Item (e) there is that following the start-up testing, they have to resolve the uncertainties within 90 days. So they have that provision there.

On the next slide, this were the areas that Entergy had mentioned in their Supplement 33 and we thought these were important to formalize as part of License Conditions. Installation of the strain gages, they challenged the limit curve. They reevaluate -- after they reach 120 percent, they have to reestablish or establish the fatigue load margin, update the stress report, and reestablish the limit curve. So they had to redo all of those things once they get there. If they do have to do an engineering evaluation, they need to evaluate the frequency uncertainties, plus or minus ten percent, and any peak responses within that uncertainty band, they have to revise the monitoring plan to reflect the long-term aspects, they have to submit the final report upon completion, so once they get to 120 percent, they have to submit their final load definition and then they have to submit the appropriate proportions of the EP start-up test procedure prior to power assention. So they have to do that for us.

Then the next slide. We list out what we wanted to see in the start-up test procedure. This is what we used as part of the Lessons Learned from Quad Cities starting up in the spring, the limit curve, the hold points, the parameters, the inspections, walk downs, the trend and methods they're going to use to trim, the acceptance criteria, the actions if they don't need those acceptance criteria, and the verifications of the commitments and the planned actions.

CHAIRMAN DENNING: When do you expect to receive that procedure?

MR. SCARBRUGH: I'm sorry?

CHAIRMAN DENNING: Have you received that procedure from them yes?

MR. SCARBRUGH: No, I have not received it.

CHAIRMAN DENNING: When do you expect to receive that from them?

MR. SCARBRUGH: Prior to power assensions and with sufficient time for us to review it. So, we don't know.

CHAIRMAN DENNING: So you're going to issue another SER?

MR. SCARBRUGH: No. No. We don't think we need to issue another SER. This will be handled the same way we did handle the Quad Cities start-up where we reviewed the start-up test procedure prior to them going up, and taking our actions with them on that, and as they went up in whole points, and interacted with them that way. So we were going to follow the same approach we did for Quad Cities.

MEMBER BANERJEE: Wasn't the instrumentation at Quad Cities similar to this?

MR. SCARBRUGH: Yes. Quad Cities actually has a four main steam line strain gages at each location. In quadrants here, we just learned that they've actually put six. Because of the potential for one failing, this way, they always have a back-up.

MEMBER BANERJEE: But when you had Quad Cities go up in power, did you follow exactly the same procedure here, as here?

MR. SCARBRUGH: Yes, exactly as -- I would say very close. I mean, this -- we modeled this exactly -- we've got the same guys working on the other as this, and we did the same -- that's why we used the same approach. They went up faster and they actually had a different sort of start-up.

MEMBER BANERJEE: But they saw vibrations and stuff like that, or acoustic modes?

MR. SCARBRUGH: Yes, they did, as they

went up.

MEMBER BANERJEE: As they went up.

MR. SCARBRUGH: And each one had to be evaluated as they went up. And so there was times where they held, when they held and had to reevaluate what they were seeing in the strain gages. So that process happens. As they go up, there is almost constant interaction between the staff and the Licensee as they go up in terms of what the agent has seen.

MEMBER BANERJEE: So now, this was before the problems with Quad Cities, or after, with the new trail? When did you have these tests?

MR. SCARBRUGH: Oh, this was all in the spring of this year, or after --

MEMBER BANERJEE: So this was when they put their new dryer in?

MR. SCARBRUGH: New dryer. And they actually had instrumentation on Quad Cities Unit 2 on the dryer itself. So we were actually looking at the actual loads on the dryer. And then Quad Cities 1, they had the main steam line strain gages similar to here, and we monitored those as they went up. And so we had the same issues, that whenever there was an indication of a resonance or a peak, those were very carefully looked at and we had phone calls and interactions with them before they went further up in power.

MEMBER BANERJEE: And what did you do when Quad Cities went up first?

MR. SCARBRUGH: Oh, the first time?

MEMBER BANERJEE: Yes. How did you monitor that?

MR. SCARBRUGH: That was before I was even involved in this project. I think they just -- I think they just monitored -- there were no strain gages on steam lines, so they probably monitored moisture carryover in the standard way. This was a surprise to everybody. No one expected these dryers to have any problem when they went up, and so it was quite a shock that they failed.

MEMBER BANERJEE: I thought a member of this Committee did, at one point. It was -- he sat about here, right?

CHAIRMAN DENNING: Yeah, he's no longer with us. He had other things to do.

MEMBER BANERJEE: So it was predicted?

MR. SCARBRUGH: Yeah. Well, we know a lot more now than -- at least we know a lot more now than we did then.

CHAIRMAN DENNING: Go ahead. Continue.

MR. SCARBRUGH: Okay. Then there was -- the next slide was, 4, 5, and 6, were processes that Entergy proposed for implementation of the plan, about what they could change in the plan without NRC approval, and what they can't, and they have that. Those items --

CHAIRMAN DENNING: On Item Number 5, after the next three refueling outages, is there -- wouldn't we want to periodically -- not at every refueling outage, but wouldn't we want to periodically be again inspecting visually, or is that part of a normal --

PARTICIPANT: It's part of the VIP.

MR. SCARBRUGH: Yes, it's part of the -- yeah, BWO and VIP, there's a B139 Report, and there's also a General Electric SIL, Service Information Letter, 644, which talks about, you know, ongoing -- you know, this is an ongoing project. So they would follow those after they finished this more, you know, stringent thinking. And then they have to report the results of the inspections within 60 days after -- following each start-up, and submit the results of the overall plan within 60 days after this initial power assention.

So then, 7 and 8, you know, they continue on for these -- unless they see a flaw, and then they have to reassess what caused that flaw and they continue. And then there's an expiration after they've satisfied all the 5, 6, and 7 issues.

MEMBER LEITCH: Should I draw some comfort from the successful operation at Brunswick? Or are the Brunswick dryers so different than the Vermont dryers that it's just not applicable?

MR. SCARBRUGH: Well, they're different. I don't know if they're a slanted or a curved hood, but they're -- they're slanted. They're different. And plus, as we've heard, it seems to be just the combination of hitting the resonance, you know, with the branch lines, and acoustic -- as the resonance frequency of the dryer, I mean, you get that combination. And Dresden seems to have passed through it on their way up to EPU. So there seems to be, you know, there's a lot of luck involved here. So I wouldn't rely on, you know, say that just because Brunswick is okay, I wouldn't say Vermont Yankee is going to be okay. That's why I think we should monitor it very closely as they go up.

CHAIRMAN DENNING: Okay. Continue.

MR. SCARBRUGH: In terms of the regulatory commitment, this was a commitment Entergy made to provide information on the data and the evaluations and walk downs, inspections, at each home point and then if there were any safety concerns identified, they would not increase power above that and we would not consider the License Conditions to be satisfied.

So, in conclusion, regarding the overall comprehend evaluation, we feel that they will continue to meet their draft, design criteria following implementation of the EPU. They provided reasonable assurance that the flow induced effects are not causing structural problems at the current license conditions, and we have a series of monitoring conditions which will ensure that there is careful evaluation of the data as they go up in power, and so that if there's any adverse indications from that data, that we will stop and require Licensee to evaluate before they continue to power any further.

So that basically is our presentation.

CHAIRMAN DENNING: Let me make a little comment and see whether anybody has anything they want to say relative to it. And that is, it looks to me like you really have covered everything very well, unless we really don't totally understand what's going on, that a problem initiates within the dryer region, and within the dome, and we really can't see it propagate. We really can't see it on the steam lines. And I think that Mr. Hambric has the feeling that the chances are good that even if that were the case, that we would monitor it out there. But I haven't heard any strong positive statements yet that, if that were the case, we'd really be able to monitor it. Do you have any comments along those lines?

MR. SCARBRUGH: Yes. I'll just say that, you know, in terms of what we've seen so far, in terms of this, the scale model testing that GE did and the general -- the Quad Cities Unite 2 instrument dryer and the CFD, for what it's worth, and the acoustic circuit model for taking data and projecting it back, we haven't seen that in terms of something occurring that we didn't pick up. We have matched pretty well in terms of what has been the significant piece. We have seen them in the acoustic circuit -- I mean, model. I mean, we've seen resonance start to occur. The main steam line strain gage data show us that there was something happening there, some resonance was being hit. We haven't seen something that, like, for example, in the scale model testing, where there might have been some peak, that was measured on the actual dryer, the scale model dryer, that wasn't picked up downstream. We haven't seen anything like that, but it's true. That is one reason why we want to monitor the accelerometers very carefully, you know, to see if there are any resonances that might occur. But that is an area that, you know, we just haven't seen it and that's why we want to take a slow, deliberate process.

MEMBER BANERJEE: It would be more comforting if you had a peak in the dryer region and showed that you saw it on your monitors on the line.

MR. SCARBRUGH: What?

MEMBER BANERJEE: All you have is very negative information.

MR. SCARBRUGH: Right. We haven't seen any, that's correct.

MEMBER BANERJEE: So if you could initiate one, either in your scale model or somewhere else, and see it in the way you're monitoring it on the steam lines, that would be more comforting.

MR. SCARBRUGH: Now, I know they -- in the scale model, did initiate ones downstream in the pinging, to pick it up in the dryer itself. But I don't know if they initiate anything in the dome itself and see if that could go the other way.

MEMBER RANSOM: Right, that would be --

MR. SCARBRUGH: That's a good question and we can relay that back.

MEMBER RANSOM: -- good if you could do that.

MEMBER SIEBER: The ultimate back-up indication is moisture carryover. You know, all the theories and all the measurements have nothing to do with moisture carryover performance and so you can say that if I see an increase in moisture carryover, that I've got a problem with the dryer, whether anything else shows up or not.

MR. SCARBRUGH: Right. If they start to see moisture carryover increase, you know, they have conditions where they will have to shut down and evaluate.

CHAIRMAN DENNING: Are there other comments or questions?

(NO RESPONSE.)

CHAIRMAN DENNING: No?

(NO RESPONSE.)

CHAIRMAN DENNING: Okay. In that case, we are going to adjourn until 1:30 p.m.

(Whereupon, the above-entitled matter went off the record at 12:37 p.m. and resumed at 1:31 p.m.)

CHAIRMAN DENNING: You may go ahead and start.

MR. ENNIS: Good afternoon.

This afternoon's session we will be talking about nuclear analysis methodologies. The lead presenter for this will be Jerry Head, manager of nuclear analysis, nuclear engineering analysis for Entergy Nuclear Northeast.

We also have up at the table Mr. Fran Bolger, who is the manager of the LOCA (phonetic) analysis for General Electric, and Dr. Moore, who is the manager of nuclear and thermal hydraulics.

Now I'd like to turn it over to Mr. Head to start the presentation.

MR. HEAD: Okay. I'm using a lapel microphone. That seems to be working correctly, right?

All right. The following presentation, I'm going to be providing an overview of the nuclear analytic methods that were used and reviewed in the BY extended power uprate efforts.

This is going to include a short background discussion to explain the manner in which the VY core will produce the extended power uprate power levels that we're looking to go to.

I'll also explain a little bit about some of the things that were going on in the industry at the time that affected the review, and our interaction with the staff on some of the issues that are going on.

Finally, I'll explain what was proposed by Entergy to address those concerns that came out of the other issues that were going on in the industry at the time, and provide a brief description of the resulting nuclear analytical methods and safety analysis results reviewed for VY.

We can go past this. First off, let's talk a little bit about the power uprate. Constant pressure power uprate is what we are going for for VY. This is a docketed methodology, pretty straightforward requirements as far as its analysis required to support it.

There have been questions that occurred in the last ACRS meeting VY, about how we get there. And so I wanted to touch a little bit on that.

There are two ways to get more energy in a core. One is, increase enrichment. The other is to raise the batch fraction, the number of bundles we put in in each cycle.

Typically it's a combination of both of those. The speed limit, if you will, or the limits on a particular bundle, are defined by the thermal margins, the thermal limits that we have established in those – in the analysis that supports it.

So what you do with a bundle is limited already. So what we do in this power upgrade basically is to put more bundles to work. We spread the power distribution out further. It's a flatter radial power distribution.

And so when you look across the population of the core, you don't see any one bundle doing a significant amount more work than had been done in past reload designs. You just see more of them.

Next.

MEMBER SIEBER: In the process you end up putting more effluents to the vessel walls?

MR. HEAD: That is correct. And that is one of the things that is on the topics – is that on the topics for tomorrow? It is on the topics for tomorrow.

So not only on the vessel walls, but the internals as well. Those are part of the things that you deal with when you go through this process.

DR. BANERJEE: Does flattening the core affect stability? Are you going to talk about that?

MR. HEAD: We'll talk about that a little bit. You do see some effects. We'll discuss that a little bit later.

As I mentioned before, I wanted to talk a little bit about what was going on in the industry at the time that affected this EPU review.

Prior to the initiation of the power uprate project, GE had developed an additional extension to the BWR operating domain. That is, the power flow map, how you actually operate one of these plants.

The purpose of that extension of the domain was to provide additional operating margins. It also was to provide – it would support power uprates, although it wasn't necessary specifically for V1.

This particular product was under review by the staff at the time, so there were a number of questions on this product that were what we call the generic docket. It was not specific to VY, but it was being handled at the same time.

And due to the concurrent review of VY and this product, it was apparent to us, we were getting confused as well as the staff in a manner, in how we could separate questions from this operating domain docket, and the VY EPU.

The net result of all that was that the staff performed probably a more extensive review of previously approved computer codes and methods used for establishing the core operating limits. Most of the staff questions and concerns in that area focused on fuel power uncertainty; the effects of void history; things like that.

So they were good questions, and like I said, sometimes it was difficult to separate them from the power uprate and from the operating domain expansion.

As a result, in the difficulty we were seeing in resolving generic issues, Entergy proposed what became known as the alternate approach. And this resulted in a license condition in which the safety limit minimum critical power ratio would be conservatively adjusted by a factor of .02.

This margin increase was shown as part of this review to be sufficient to balance staff concerns that they had so that no additional open methods issues remain for VY EPU.

And what I show on the slide here is basically a quote, and what's in the SER, the draft SER right now. If we go above current license thermal power, we will impose a .02 additional margin on the safety limitation.

DR. BANERJEE: What was the reason that you did this? I mean, why was the staff concerned about the uncertainty? What led to that?

MR. HEAD: Well, there were a number of different factors that led to it. But what drove us to go to the .02 was to get final resolution on the staff questions was going to take a significant amount of time. There were additional measurements that needed to be made in the industry and things like that that would be needed to put it to rest for good.

And so what we looked at, and worked with the staff on, was trying to bound the impact of all these additional uncertainties that might be out there, and come up with something that would clearly show we would be conservative; clearly give them a path to reach success there from the standpoint of --

DR. BANERJEE: But what were the uncertainties? I mean the fuel design was essentially one which looked similar to what you were using.

MR. HEAD: That's correct.

DR. BANERJEE: Was it enrichment profiles, or what as it?

MR. HEAD: It was power distribution uncertainty, both local and bundle to bundle power distribution.

And also you would see, and it will be discussed later, there were issues about void history, and the void history effects on power distribution.

DR. BANERJEE: So it was related to your flattening of the core?

MR. HEAD: It's hard to say if it was or not. It was just --

DR. BANERJEE: What was it related to, then?

MR. HEAD: The fact that the real crux of the issue was, when you look back at all of the methods that have been developed over the years, when the 10 X10 fuel product line had been introduced, it had been introduced in a manner that we believe was consistent with the expectations from the regulators at the time, but there was not specific gamma scan measurements of that fuel product type. What had been done prior to that was, 8X8 or 9X8 fuel product lines, and even in that data you didn't see a significant dependency on the lattice type. But there was no specific 10X10 data available.

DR. BANERJEE: It wasn't specific to you. Anybody that used 10X10 would face that problem?

MR. HEAD: That's correct. That's correct. That's why we said, it was more of a generic versus an EPU issue. We were already running a 10X10 fuel.

MEMBER SIEBER: Someday that problem will be solved. And someday you will come in and want a little mini increase probably.

MR. HEAD: Well, what we'll want to do is come back and take out the .02 additional conservatism we put in place, because we needed it at the time to get the issue resolved on a generic basis.

MEMBER LEITCH: So how will that be

implemented? Is that going to be in the tech specs, the safety limit?

MR. HEAD: That's correct.

MEMBER LEITCH: It will actually be .02 higher?

MR. HEAD: That's correct.

MR. LEITCH: Than the number that appears in the tech spec presently?

MR. HEAD: Yes, and no. The tech specs are a cycle-specific calculation. And if you look at the history of VY over the past few years since even before Entergy bought them, we had – cycle 22 became a significant departure I guess would be the best way to describe it, from an equilibrium cycle design.

Then we went to power uprate. So the safety limit calculated for VY has changed every cycle. The actual calculated value for cycle 25 right now is 1.05. What is in the tech specs right now, which is the number from the previous cycle, was 1.07.

So we will impose a .02 penalty, but it's not going to physically change the number in the tech specs. We just – it's there.

And oftentimes, it's been our experience in the industry that if you have a cycle design in which the safety limits calculated for that cycle actually becomes less, if it doesn't penalize you from operations, as far as operating maneuvering room, it's not worth the hassle for us and staff to go through and actually change it to go back down, because then subsequently in a cycle you may have the need to go back up again.

All right, when you look at the safety limit MCPR, and what we were proposing to do here, and even what the staff had reviewed up to that point in time, there were a number of fundamental factors that needed to be reviewed as part of this effort, and those are listed here.

The focus of the staff review from the time of the alternate approach proposal was to make sure that that approach was sufficient to bound any additional uncertainty they thought might be present in these particular areas.

And so I'm going to talk about each one of these separately. The staff will subsequently discuss the ones that count most here, but I've got a presentation that touches on each one of them.

The first one is the safety limit MCPR. That is the obvious one.

For background, safety limit MCPR is a limit that ensures that during normal operation, and during anticipated operational occurrences, 99.9 percent of the fuel rods in the core do not experience transition boiling.

Built into the development of the safety limit MCPR are process and power distributional uncertainties. The original power distribution uncertainties that were established years back used Monte Carlo techniques. In fact it was a Monte Carlo in particulate MCMP calculations to determine what power distributions that we had in the bundles.

And these were in part confirmed with gamma scans. Which goes back to your question earlier about what is driving this. These gamma scans were performed on the earlier vintage fuel, and that data didn't show a significant dependence on lattice height.

However, we had not done 10X10 with the same scope of work. And so because gamma scans of the

10X10 aren't available, then there is at least some degree of issue with respect to the uncertainties that we carry forward.

The way we address that, we went back and looked at the original statistical treatment of the uncertainties that went into the safety limit MCPR, and the original process was to use one sigma values for the uncertainties and the things that were measured. And when we expanded that to two sigma, we found that in that particular case we're going to a higher statistical certainty on the value that we use for the uncertainty that if you took that work and the independent code comparisons that we have performed, that we showed that the .02 was going to be sufficient to bound anything that we think we might find in gamma scan data on 10X10 when it actually occurs.

And right now that work is actually going on. We're getting data from overseas, and that work is going on right now to look at what the 10X10 product line shows.

All right, next slide. The next of the critical power base limits is operating limit MCPR. The GE methodology takes safety limit inquiries as kind of a baseline. I mean you look at the anticipated operational occurrences, and the change in CPR that you see in those occurrences to determine what the operating limit is. It's additive.

I've got a follow-up slide here, if you want to click on that little background slide. This gives you sort of a graphical representation of what we have.

Minimum critical power ratio of one. It means you've got some transition boiling. We back off that by processing power uncertainties, as I discuss in the safety limit. We back off that further to handle the AOOs, and that gives our operating limit.

So somewhere down below that is the allowed operating range. Typical operation of our cores, we typically have between five and 10 percent margin to the operating limit. That gives us comfortable margin in the way we operate the plant. It doesn't restrict the operators.

So if we could go back to the original.

Because there were questions with regard to the power distribution uncertainties, that question gets carried forward in the delta CPR calculation as well.

So what we had done there was, we explored that further with the staff. We looked at what coefficient – which is another one of the issues that was out there. We looked at exposure effects on the fuel, and we performed additional analytical work to show that.

While these uncertainties that we have in there historically have been actually quite large. For instance, with voice coefficient, we've got a significant uncertainty in there from a void coefficient standpoint. It's like 15 percent, two sigma. And the sensitivity to that parameter is not that great.

So we went through the analysis, worked with the staff to show them what was the – what the results of that actually were.

The conclusion of that was with the safety limit MCPR already conservative by the .02, that no additional penalty was going to be required for the operating limit.

Next slide.

Limits related to local power – there's a couple of those that we need to talk about. Linear heat generation rate is the first of these.

This protects the fuel from the things like fuel centerline melt. One percent cladding plastics strain. Fuel rod internal pressure. And there are a couple of other things that go into the thermal mechanical limit.

And again, because the staff is concerned with the uncertainties that you may have in the power distribution, we needed to go through and demonstrate that the uncertainty treatment within this methodology already was sufficient to bound what we expected to see in the future.

DR. BANERJEE: Excuse me, what computer code do you use, or is it experiment, for CPR?

MR. HEAD: The CPR is the correlation.

DR. BANERJEE: It's a correlation?

MR. HEAD: That's correct.

DR. BANERJEE: It's just a correlation?

MR. HEAD: That's correct. Fran, is there additional discussion we need there?

MR. BOLGER: The critical power is

predicted with the GEXL correlation, which is based on quality. So that has been, that correlation was developed based on test data from the Atlas test facility.

DR. BANERJEE: And it includes 10X10?

MR. BOLGER: Yes, it does.

DR. BANERJEE: And this somewhat mechanical deformation or whatever, do you use a code for that?

MR. HEAD: There's fuel performance codes. I forget now what exactly they're called.

MR. BOLGER: The fuel rod analysis performed with the Jester (phonetic) mechanical code.

MR. HEAD: And again, that is docketed and licensed methodology. And buried in that methodology is already a statistical accounting of uncertainties in power distribution, et cetera.

And so we went through the efforts with the staff to demonstrate that the uncertainties that were already included in that methodology, and the conservative assumptions in that methodology, were sufficient so that it would be bounded by the existing methodology.

DR. BANERJEE: Now, this CPR correlation, is that steady-state data mainly? Or is that some transient?

MR. BOLGER: The CPR correlation is developed based on steady-state data. However, there are transients that are formed with the Atlas facility which demonstrate the performance or the correlation in a transient condition.

DR. BANERJEE: What sort of transients?

MR. BOLGER: The transients are turbine trip type transients. Also, oscillation-type transients. And I believe also a pump trip type transient.

DR. BANERJEE: So are they relatively slow transients?

MR. BOLGER: The turbine trip transient is a relatively fast transient. It has a flux peak that's with a width of approximately a half a second.

DR. BANERJEE: So this CPR is more for dry out or DNB?

MR. BOLGER: Dry out.

DR. BANERJEE: Just dry out? And so the transients with a time scale of about a second or two, it works.

MR. BOLGER: That's correct.

DR. BANERJEE: You wouldn't expect it to

work for all transients, would you?

MR. BOLGER: Well, it's a quality based correlation, and the mass flux profile, the blend, is very much nonuniform. So you may expect there to be some deviation.

But we find that it performs very well for various transient types.

DR. BANERJEE: So if you have relatively fast transient, there would be no need for this, right?

MR. BOLGER: Yes.

DR. BANERJEE: So how would you get it to work in that case? What quality would you define?

MR. BOLGER: I would expect that for a very fast transient, you've got a time constant of the fuel rod itself that comes into play there. It takes time for a fuel rod to produce additional power, and the heat flux to go out to the clad.

So I would expect at some point that you're going to be limited by fuel rods --

DR. BANERJEE: But the fluid dynamics moves faster than that.

MR. BOLGER: I agree.

MR. HEAD: In a transient application the local quality conditions used in the correlation.

DR. BANERJEE: So how is that calculated? Based on nonequilibrium, or equilibrium?

MR. HEAD: The quality is calculated as equilibrium quality in a transient.

DR. BANERJEE: So this is based on equilibrium quality?

MR. HEAD: That is correct.

DR. BANERJEE: Okay, so we'll come back to this.

So do you apply this correlation to things like Atlas and so on as well?

MR. HEAD: Yes, we do.

DR. BANERJEE: Okay, so return to this.

MR. HEAD: All right, as I said before, the review of this with the staff was to ensure that the uncertainty treatment we had there already was sufficient to bound it, including the conservative assumptions that were already there, and defining the fuel-specific limits for the fuel types we got.

Next slide.

LHGR limit is a burn-up dependent limit, fuel performance is a burn dependent phenomenon.

And so because there are questions about power distribution and our ability to predict what kind of fuel burn-up and exposure you may have, we had to go – we went and looked at that process as well.

Fuel designs that we currently have out there right now are licensed to a peak pellet exposure of 70 gigawatt days per metric ton. The LHGR limits are defined, as I said, as a function of exposure, and include Pen power peaking, void reactivity coefficient, bundle power allocation factors, all of these – beginning to sound like buzz words – but these were the things that were at issue in the discussions we had with the staff.

The standard method that is used for VY and indeed for all the GE product line that was reviewed, and it was determined that the current uncertainty treatment that we have in the methodology right now for factors affecting this parameter was sufficient to retain adequate margin, and no other changes need to be made here.

Next slide is MAPLHGR. This again is a

limit related to local power. It looks at the power in a bundle on a more global basis, at least at an axial node. And it is what feeds into the LOCA analysis for the most part.

And in the LOCA analysis we're looking at peak clad temperature, local oxidation, number of parameters there as far as acceptance criteria.

The review of this limit also had to go look at the treatment of uncertainties. But what we found within LOCA space was that the Safer Jester (phonetic) methodology, which is what is licensed to do the LOCA analysis with the GE fuel types, has built into it inherent conservative assumptions on the front end in order to drive maximum peak clad temperature calculations.

And we went through all of those conservative assumptions, and the uncertainties that fed into this process and determined that there is adequate margin there without taking any additional penalty in this area.

Next slide. Shutdown margin. This is more of a global parameter for the core. It's also one that's very important as well. And we recognize the power uncertainties, and the ability to calculate the depletion of the fuel can have an impact here.

So this is obviously one of the things that we looked at from a standpoint of it being a concern.

CHAIRMAN DENNING: Can you go back to the maximum average planar?

MR. HEAD: Sure.

MR. BOLGER: One of the things we recognize is that you're not really – if you look at the peak bundle, you're not really doing anything to the peak bundle that is any different from what the peak bundle was previously; correct me if I'm wrong.

But what is really happening is that you're radially flattening the core.

MR. HEAD: That is correct.

CHAIRMAN DENNING: And so somehow, if there is a loss of margin, it's somehow related to, across the core, everything is more event.

MR. HEAD: A larger population of bundles that are close to that limit; yes, that is correct.

CHAIRMAN DENNING: And so the thing that appears to be limiting, or the thing that concerned you as being limiting, would be its behavior in a LOCA. And that's what this relates to, is in a LOCA the fact that you have flattened everything out, and so you have lots of rods, lots of bundles that are coming to similar conditions at the same time, does that have an impact on the safety of the ability to address LOCA?

MR. HEAD: That is correct. But I think it's in the methodology, and Fran would be the best guy to answer that.

MR. BOLGER: The LOCA methodology, the SAFER model assumes a core of average bundles. And then a single hot bundle.

As we transition to an EPU type core, actually the core starts looking more like the SAFER analysis type core, where you have more bundles at about the same power level, and perhaps a single bundle at the MAPLHGR limit.

CHAIRMAN DENNING: Okay.

MR. HEAD: All right, shutdown margin. As I said, this is a global parameter, and the concern here is that our ability to predict fuel depletion might impact our ability to predict shutdown margin.

In this particular case, from a core design standpoint, shutdown margin is relatively easy to meet. The way we accomplish that is by the addition of burnable poisons in the fuel.

In my world, gaddalinia (phonetic) that we use for burnable poison is cheap compared to the possibility of not meeting a shutdown margin requirement. Because if you don't meet a shutdown margin requirement in your tech specs, you've got to unload a core, start over. It's a huge consequence form a standpoint there.

The standard GE design practice, and indeed, it's a practice across the industry, is to design to something greater than what the tech spec limit is. We designed it greater than one percent delta K over K. And at times, different utilities will impose even an additional conservatism on that, based on what they may have going on within their plant at the time.

Like I said, it's relatively easy to design a core that meets all the shutdown margin requirements.

And the reason that you do that is not so much that, like I say, you're afraid of busting the 38 percent limit in your tech specs, but things happen where for instance a – you know, we design these cores sometimes a year in advance. We have a transformer problem, or something, where we have to shut down a unit early. And that core that we just shut down is carrying over additional reactivity, and I've got to be able to absorb that in the design.

And so that is part of what feeds into this conservative approach to always bound ourselves on shutdown margin.

And our experience with this VY has been very good. We've got real reproducible results. Our code packages are doing real well, both GE's and what we do independently as Entergy. So this was very easy to show that we've got adequate margins.

Next slide. Okay, next issue that we looked at was stability. The stability analysis for VY is performed to ensure that the 1-D detect and suppress methodology is sufficient to preserve safety limit MCPR in the event we have TH instability event.

The prevention portion of that solution

includes a separate administratively controlled exclusion and buffer region that is evaluated every cycle. Those boundaries on our power to flow map actually change depending on the cycle design.

The second part of the detect and suppress portion is a solution is a flow biased eight purim (phonetic) flux grand grip that prevents oscillations of a sufficient magnitude. That scram setpoint feeds into the analysis to determine whether or not the stability solution for the plant for that cycle is going to be valid. And it's looked at every cycle.

We don't change the setpoint necessarily, but we do change the boundaries in the power to flow map.

DR. BANERJEE: Is it adjusted during the cycle? Or does it need adjustment?

MR. HEAD: We typically bound the entire cycle. But it's a training problem. It's an issue with operations.

So we typically just bound it once, and cover it for the entire cycle.

DR. BANERJEE: Why do you take just the 1-D solution?

MR. HEAD: VY is one of – it's a small core, and the oscillations in a small core are typically core-wide.

MR. BOLGER: The term 1-D is not indicating that it's a one-dimensional model. It's open 1-D. There were a number of different options.

DR. BANERJEE: Ah, I was wondering. So what is this option, can you explain to me? What is the option – well, 1-D then has administrative control of this PF region and so on, right?

MR. HEAD: Here's a power to flow map that shows the exclusion regions. The red line here shows the exclusion region. We also have under there the buffer region. And when we operate the plant, we never go here intentionally.

You could have a run back where you are up here operating, and you have a pump trip that will take you back down in here. The immediate corrective action by operators is to drive rods and get down out of that region. Because you have a susceptibility while you're down here to initiate a thermohydraulic instability event.

So that is part of the solution.

DR. BANERJEE: That's operator action.

MR. HEAD: That's right. You don't go here. If you do have an oscillation when you're down here, you've got an trip setpoint up there that will trip the plant if the operators don't take action already.

DR. BANERJEE: This is option 1-D?

MR. HEAD: That's option 1-D

Option 3 is – you'll have to explain there. There are a couple of different ones in existence out there. Some of the larger cores that can have localized stability issues are option 3, right?

But what we've got for VY is 1-D, which is detect and suppress.

DR. BANERJEE: So the analysis that this is based on is not 1-D?

MR. HEAD: That's correct, it's not. It's just the terminology.

DR. BANERJEE: So what is the analysis it's based on? How many Ds?

MR. HEAD: Want to get Doug to cover that? Doug is an expert in stability from GE.

MR. NEWKIRK: Doug Newkirk with GE.

The analysis to calculate the exclusion region is ODSY-based, which is a 1-D kinetics thermohydraulic code.

DR. BANERJEE: Plus the radial, it takes radial variations into account?

MR. NEWKIRK: That is correct. The bundles are grouped into bundle groups, so the radial difference in power is accounted for.

DR. BANERJEE: And so it couples to a thermohydraulic model which is channel by channel in this radial group? Or each radial group is characterized by sort of an average channel or something?

MR. NEWKIRK: That's right. All of the channels in the core are grouped into channel groups that are at a certain power level. And so you start with, you'll model some individual hottest channels. But then the other ones are grouped together by power, and so you have a descending power for each channel group.

DR. BANERJEE: So the analysis is in real time? Or is it in modes?

MR. NEWKIRK: No, Odyssey is a frequency-based code, so it calculates the gear ratios. So the exclusion region is based on a .8 core to K ratio criteria with a .15 adder onto the Odyssey calculated K ratio.

DR. BANERJEE: So you can get radial modes, but you can't get azimuthal codes in this code; is that correct?

MR. NEWKIRK: In -- ?

DR. BANERJEE: In your calculations.

MR. NEWKIRK: The kinetics model that's being applied is a one dimensionally axially, so the radial component is averaged. Now thermohydraulically the bundles are grouped into a number of different radial groups.

DR. BANERJEE: Right. But the kinetics are – I just don't understand.

CHAIRMAN DENNING: Are the oscillations top bottom then? They're not radially around?

DR. BANERJEE: They're not azimuthal.

CHAIRMAN DENNING: They're not azimuthal.

DR. BANERJEE: But they are radial.

CHAIRMAN DENNING: I don't know.

MR. NEWKIRK: The kinetics model will predict variations in the axial direction. It's a one-dimensional axial kinetics model.

CHAIRMAN DENNING: Track G is not used then for stability?

MR. NEWKIRK: Well, it' not used in this exclusion region methodology.

DR. BANERJEE: But it could be, right? Or not?

MR. NEWKIRK: Well, Track G is a time-dependent code. So that could tell you where oscillations could begin on the power flow map. But the approved methodology is to use a frequency based code and calculate the K ratios.

CHAIRMAN DENNING: And when you go to power uprate, how does the exclusion region – what happens to the exclusion regions? Does it get bigger?

MR. NEWKIRK: In this particular case, the exclusion region did get a little bit bigger, but that is as much as function of the actual core design as it is anything else.

You see those lines move from cycle to cycle sort of independent of – even when we had constant power for past cycles, they moved periodically.

CHAIRMAN DENNING: What is recent BWR operating experience? Do BWRs in the last 10 years get into regions in which --

MR. HEAD: Absolutely. Nine Mile was the

most recent I think in the U.S., right?

MR. NEWKIRK: There was actually – Nine Mile Point Two had an instability event three years ago. And Perry had an instability event last December.

CHAIRMAN DENNING: And how were they recognized?

MR. NEWKIRK: You saw oscillations on the APRMS. But then those plants are larger plants that have the Option solution, and they have an automatic suppression function. It's called the OPRM. It's a brand new plant.

DR. BANERJEE: But radially flattening the core does increase its propensity to instability, doesn't it? Or does it?

MR. NEWKIRK: Well, actually, the lower radial peaking factor does help stability. Typically when you have higher peaking, that will exacerbate instability.

DR. BANERJEE: Is this because of leakage? Or why is that?

MR. NEWKIRK: It's just the power shapes, power distribution.

DR. BANERJEE: Okay. But this core, how is it sort of – it is validated for a core of this size and shape?

MR. NEWKIRK: Is the code validated?

DR. BANERJEE: Yes.

MR. NEWKIRK: Yes, it is.

DR. BANERJEE: For something of this nature? So how was it validated?

MR. NEWKIRK: There were instability tests at Vermont Yankee as a matter of fact back in the '80s that were, they were decay ratio tests. And the Audit C code was that qualified versus that test data. And then it's been validated against other plants as well, other larger --

MEMBER LEITCH: That curve that shows the APRM flow bias scram (phonetic), the AL after that, does that mean that's the alarm when the scram is on?

MR. NEWKIRK: That's the analytical limit.

MEMBER LEITCH: Analytical limit?

MR. NEWKIRK: And so what you see established in the field is backed off from that, down to a lower power level.

MEMBER LEITCH: Okay. I was thinking that looks like a pretty high --

MR. NEWKIRK: It is, it is very high.

MEMBER LEITCH: So now take me through this again. You lose a reserve pump for example, and you move down toward that instability region.

The operator then drives rods.

MR. HEAD: Right. He would drive rods and come down.

MEMBER LEITCH: And tries to get down out of that region.

MR. HEAD: That's correct.

MEMBER LEITCH: And if that is not successful --

MR. HEAD: If he sees oscillations he will punch it out. He would scram the reactor.

MEMBER RANSOM: I've got a question. It doesn't have to do with stability. But when you flatten the power out over the bundles, it seems to me that I recall that under some LOCA conditions you depend on breakdown of CCFL and the upper plenum and the sprays then allow downflow through some of the outer bundles and research in the higher power bundles, as a means of coolant, which you presumably would lose if you just flatten it completely.

MR. HEAD: You say CCFL, you're talking about LOCA? What are you referring to there?

MEMBER RANSOM: Countercurrent flow of the CC and LOCA analysis, right, so you get a multidimensional effect. You get downflow through some of the bundles, and other flows to the higher power bundles.

MR. HEAD: That is correct. You would probably see an impact of that.

MR. BOLGER: I think this has come up before, and maybe Dan can answer it.

MR. PAPONE: Dan Papone, GE. We have discussed this in previous power uprate and EPU reviews here. And effectively it's in a way a self-limiting phenomena. Yes, you will, with more bundles in that average power range, you will hold up more water in CCFL at the top of those bundles, but that water that is being held up is being held up in the region of the coarse spray. That tends to subcool the peripheral region. We'll get the breakdown in the peripheral channels in bringing that pool of water to the peripheral channels.

So as we flatten the power, hold up more water, and tend to hold up that water, that feedback. In fact that self-limiting effect, where the subcool in the peripheral region.

So from that standpoint --

MEMBER RANSOM: What verification do you have of that? I mean originally you did all of these tests --

MR. PAPONE: Right, and that's where we developed the experimental basis for that hold up, and what happens with the breakdown specifically in the peripheral bundles, and also at the same time the venting center --

MEMBER RANSOM: So your comments then are based on core calculations?

MR. PAPONE: Primarily on the 30 degree sector test.

MEMBER RANSOM: You've done sector tests under the average conditions?

MR. PAPONE: No, this is in the – whatever their test bases were. I haven't been able to cover those to see how they applied, to what extent they have. But basic phenomena is that --

MR. PAPONE: Okay, continue.

MR. HEAD: Okay, one other things with respect to the stability, since we are trying to preserve safety limit MCPR without penalty, the .02 adder that we've put on there carries forward in this analysis as well.

And so given that, the VY power uprate was founded by the existing methodology with that term applied.

I mentioned earlier when we were discussing shutdown margin the Entergy actually maintains, develops and maintains core physics models using independent methods from GE. We use that to verify and challenge the vendor of core designs. We look at critical safety analysis inputs.

We use these models to follow our cores. We see things probably – I know more frequently for instance than GE does. We work closely with our site reactor engineers to watch these cores as they're burning to try to identify any trend that may be showing up.

We also use those same tools to evaluate operational experience that is coming out of the industry out there, and we factor that into our processes going forward.

CHAIRMAN DENNING: If you're in mid cycle, and you have to shut down for a period of time, and then you have to decide things like how long am I going to operate? What am I going to do in my next fill analysis, do you do that analysis, or does GE do that analysis?

MR. HEAD: We both do it, provide verification for one another there. So the answer is, we both do it.

With respect to the VY models, when Entergy bought Vermont, they were operating in cycle 22. We went back to cycle 20, did benchmarking against 20 through 24. The data – we're operating in 25 right now. We just started up a few weeks ago, and those models are holding – they're matching the plant quite well, all the benchmark data we have on them looks good.

MEMBER LEITCH: You're on 24-month cycles?

MR. HEAD: No, we're on 18-month cycles.

MEMBER LEITCH: And do you have all of the same type of fuel, all the 10X10s?

MR. HEAD: That's correct.

MEMBER SIEBER: You may want to take advantage of your modeling capabilities to satisfy some of your quality assurance requirements with regard to your fuel vendors?

MR. HEAD: We do that. When we go down to what is called the mini-review in the reload process, we often have – we compare notes. We're looking at differences there. We see differences in the methods. There are differences between the two.

But we typically understand those, and when we see something we don't understand, we typically get the guys together and figure out what's going on there.

MEMBER SIEBER: Well, that's a good practice. I encourage that.

MR. HEAD: And go to the next slide, if you would.

We actually used those independent methods as part of this effort here. If there were questions down on the lattice level as far as calculational methodologies. We did a number of detailed comparisons between CASMO-4, which is the tool that we used, and TGBLA06. A number of different cases, different voids, different exposure steps, different lattices even.

That, coupled with what the staff was doing helios we were able to get a real good handle on how well the methodologies were hanging together.

What we saw in all these results was what we would expect to see based on industry experience out there. The bad thing about having two different code sets is, you get slightly different answers sometimes. You have to reconcile that, and understand what is going on.

But if they're markedly different, it typically means you got an error someplace that you've got to go chase down.

All right. This section here, I was just going to briefly go through some of the safety analysis results. This will be discussed in further detail by the staff later today.

Part of the constant pressure power for a topical says that we will go look at specific safety analysis on a cycle specific basis. These are some of those results. The thermal hydraulic stability we talked about to some extent already. I'm sure there will be other discussions about this.

Overpressure protection, and the anticipated operational occurrences there. Again, the results were satisfactory, well below the ASME limit that we have.

ATWS, which is one of the events that is truly impacted by the power upgrade, again, the acceptance criteria for that is staying below the ASME limit. And come below that, the suppression pool temperatures that you see, due to that postulated event, are well below the criteria that we have for acceptance.

And we verified that the standby liquid

control system that you actually used to mitigate the Atlas event has adequate margin.

DR. BANERJEE: Are you going to talk more about Atlas?

MR. HEAD: This was it. I think the staff has additional discussions on that possibly.

We've got the experts here if you've got specific questions you want to talk about.

DR. BANERJEE: Well, the first line there, the heat pressure is 1490.

MR. HEAD: That's correct.

DR. BANERJEE: How much uncertainty in that? What have you established?

MR. BOLGER: The ATWS basis is a nominal basis and does not require any additional uncertainties. However, the methodology does include some conservatisms.

In particular, the set points in the safety relief valves that are used are set above nominal. Also, the capacity used for the safety release VARs are utilized are uncertified capacities, which is typically about 10 percent lower than what nominally would happen.

And lastly, in the analysis assumptions specified by Entergy, one of the safety valves was not credited, which adds some additional conservatism on the peak pressure.

DR. BANERJEE: Now in Atlas, have you talked about Atlas to this committee before? I don't recall, because I haven't attended all the meetings. If it's been discussed, it's been discussed. Who presented the results of Atlas, and what the transients looked like, and oscillations, and how you calculated these oscillations.

MEMBER KRESS: We did this in a generic fashion back in the early '90s.

DR. BANERJEE: Well, we went to GE, and we had a presentation there. And at that point I remember they were using TRACG, and they had lots of problems in doing the calculations.

So what has changed, and what has not?

CHAIRMAN DENNING: We're definitely interested. Let's pursue it a little bit.

MR. BOLGER: The TRACG is utilized in the Atlas instability portion of the methodology. Those were – those were submitted and approved a number of years ago.

Calculations were done based on initializing at the MELA (phonetic) condition with a pump trip. The case went into oscillation, and TRACG was utilized to predict fuel, whether there was fuel dryout and fuel failure type issues, and also, mitigating strategies.

More recently, we've been doing some additional TRACG type analysis for our operating domain expansion, and have also demonstrated the adequacy of fuel margins for instability events with fuel types through our 10X10 fuel type.

DR. BANERJEE: The TRACG calculations I remember from a few years ago, the oscillations were very large, very rapid, and it seemed very difficult to calculate. And in particular problems of dryout or not dryout, and things like this. Because both the size of the oscillations and the relatively high frequency.

It would be at least interesting in this case to see what analysis has been done in this – and how it's been done. I understand that you used ODYN (phonetic) rather than TRACG? Or I don't know exactly what was done.

MR. BOLGER: For the peak pressure analysis, and for the suppression pool temperature analysis was based on the ODYN methodology. ODYN is a one-dimensional model, and it is able to predict reactor vessel pressure due to an Atlas, and corresponding effects of what will happen once you get the resert pump trip, which will lower the power. And then further in time water level is reduced, and how does the event proceed from there?

And then at such time you have boron injection, and how does the event proceed from there?

And based on that, we can determine what the integral steam flow is into the suppression pool, and from there we can determine what the suppression pool temperature is.

DR. BANERJEE: Now, does ODYN follow these oscillations and things as well?

MR. BOLGER: No, ODYN does not predict oscillations. The scenario which is evaluated for the power uprate does not include an oscillation.

The basis for Atlas instability is retaining the original track analysis basis because the event -- the post-trip condition of the event, the power flow condition event, is unchanged from a power flow standpoint relative to what was submitted previously.

CHAIRMAN DENNING: Let me see, take me through that again.

You're saying that for the power uprate you did not have to do this Atlas instability analysis because you were saying that the basis was unchanged from previous; is that what you just said?

MR. BOLGER: That is correct. That the argument that was presented in the constant power pressure uprate submittal –

VOICE: This is proprietary. This is going into GE proprietary space. Can we hold this until we close the session a little bit later?

MR. BOLGER: Sure.

CHAIRMAN DENNING: Okay, well, questions about this slide. This is EPU numbers?

MR. BOLGER: That is correct.

CHAIRMAN DENNING: And when you say, pressure regulator failure, that is a complete failure? In other words, thermal trip without bypass?

MR. BOLGER: The way the pressure regulator fails open, the regulator fails open, that causes a reduction in pressure, and you get a low pressure isolation.

And then when you isolate the reactor, it turns into a pressurization event, and that is where the pre-pressure occurs, on the tail end of the closure of the MSIBs.

MEMBER LEITCH: And this assumes some operator action to start the standby liquid pumps? I mean this plant does have automatic standby injection; is that correct?

MR. BOLGER: That's correct.

MEMBER LEITCH: So what time is assumed for the operator to start the standby liquid control pumps?

MR. HEAD: I don't have that information right now. It is going to be on the present tomorrow, is it not?

MR. BOLGER: That's correct.

MEMBER LEITCH: Okay, I can wait until tomorrow.

I guess just the question is going to be, is that time appreciably different than it was before EPU conditions? But we can wait until tomorrow.

MR. ENNIS: We'll talk specifically to that tomorrow.

MEMBER LEITCH: Okay.

MR. HEAD: We lump all those operator actions the effects of timing, the EPU effect on timing, is all in one presentation I believe tomorrow.

MEMBER LEITCH: Okay, we can do that tomorrow, thank you.

MEMBER WALLIS: This peak pressure is only for a very short time?

MR. HEAD: Duration is – until slick starts driving it down?

MR. BOLGER: Do you have a slide on that?

MR. HEAD: I don't believe I do.

MEMBER WALLIS: Well, my question was, I think the slick system only pumps up to 1,400 PSI? That's what it says in its specification.

MR. BOLGER: The pressure peaks out, and then drops back down I think after about 30 seconds or so, the pressure gets back down.

MEMBER WALLIS: So for that period of time the slick system cannot pump against the pressure?

MR. BOLGER: That's correct.

MEMBER WALLIS: It doesn't make any difference?

CHAIRMAN DENNING: Now, as far as the suppression pool temperature is concerned here, this is an area, regime, where there is an MPSH problem; is that true?

MR. ENNIS: That's correct.

CHAIRMAN DENNING: But for a shorter period of time, a couple of hours, is that what the --

MR. ENNIS: That's correct. And that's in the presentation next week, right?

CHAIRMAN DENNING: Do we want to go into the closed session? Since we are not too far from when we get to the end of this we're going to break anyway.

MR. HEAD: We've gone one slide left.

CHAIRMAN DENNING: Yes. After that, then we're going to have to – we can't start up until 3:15 anyway, can we? So we might as well just go into the closed session right now?

DR. BANERJEE: Yeah.

CHAIRMAN DENNING: We'll go into the closed session right now. Because after that session, then we'll take a break.

(Off-mike conversation)

DR. BANERJEE: You have one more slide, right, before we go into the closed session?

MR. HEAD: Yes.

CHAIRMAN DENNING: You can go ahead and do the summary slide.

MR. HEAD: In summary, the EPU is done with – those methods were applied for all the analyses that were doing for VY. And again, because we had a couple of things going on in the industry, I believe it contributed to the staff's desire to do a little bit of additional review here.

And that review took us into looking at the uncertainties that we had built into the current methodologies.

What came out of that, again, was the decision on Entergy's part to conservatively bound any concerns the staff may have with those uncertainties, and impose that .02 safety limit adder.

(Off-mike conversation)

CHAIRMAN DENNING: Okay, we're in closed session.

(Whereupon, the proceedings went into closed session at 2:28 p.m.)