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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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509th FULL COMMITTEE MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY, FEBRUARY 5, 2004

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The Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Mario V. Bonaca, Chairman, presiding.

COMMITTEE MEMBERS PRESENT:

MARIO V. BONACA Chairman
GRAHAM B. WALLIS Vice-Chairman
STEPHEN L. ROSEN Member
GEORGE E. APOSTOLAKIS Member
F. PETER FORD Member
THOMAS S. KRESS Member
GRAHAM M. LEITCH Member
DANA A. POWERS Member
VICTOR H. RANSOM Member
WILLIAM J. SHACK Member
JOHN D. SIEBER Member

ACRS STAFF PRESENT:

SHER BAHADUR
MAITRI BANERJAN
BILL BATEMAN
CHRISTOPHER BOYD
AMY CUBBAGE
JIM DAVIS
BOB DOWNIG
SAM DURAISWAMY
DON FLETCHER
JIM HAN
MICHELLE HART
KEN KARWONSKI
ALLEN HISER
WILLIAM KROTIUK
DAVID KUPPERMAN
RALPH LANDRY
HOWARD J. LARSON
STEVE LONG
SHANLAI LU
LOUISE LUND
STEPHEN RAUL MONARQUE
MARCOS ORTIZ
JOEL PAGE
DAN PRELEWICZ

ACRS STAFF PRESENT:

MUHAMMAD RAZZAQUE

UPENDRA "KUMAR" ROHATGI

WILLIAM SHACK

JOE STAUDENMAIER

ED THROM

ROY WOODS

I N D E X

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

8:31 a.m.

CHAIRMAN BONACA: Good morning. The meeting will now come to order. This is the first day of the 509th meeting of the Advisory Committee on Reactor Safeguards.

During today's meeting, the Committee will consider the following: ESBWR Design - Thermal-Hydraulic Issues; South Texas Project Cause Investigation of the Reactor Vessel Bottom Mounted Leakage; Resolution of Certain Items Identified by the ACRS in NUREG-1740 Related to the Differing Professional Opinion on Steam Generator Tube Integrity; Approach for Evaluating the Effectiveness (Quality) of the NRC Safety Research Programs; and Preparation of ACRS Reports.

A portion of this meeting may be closed to discuss general proprietary information applicable to the ESBWR design.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Dr. Joe Larkins is the Designated Federal Official for the initial portion of the meeting.

We have received no written comments or

request for time to make oral statements from members of the public regarding today's sessions. A transcript of portions of the meeting is being kept and it is requested that the speakers use one of the microphones, identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

I would like to note that in our published agenda for today, the meeting is supposed to adjourn at -- recess at 7 p.m. In reality, we will recess at 6 p.m. We have an activity we have planned before and that will give us the time and probably a few minutes before 6 p.m. we will recess.

We will begin with some items of current interest. First of all, I would like to refer you to items of interest in front of you, a couple of speeches by Chairman Diaz. There is interesting congressional correspondence; information on operating plant issues and on the second page you'll find the announcement for the regulatory information conference that will be held in Washington from March 10 to 12, 2004 for those who plan to attend, this is important information.

I have an announcement to make. While Jenny Gallow is on rotation to NRR, Sharon Steele --

okay, she's not here. All right, I'll make the announcement tomorrow when she's hear so we can recognize her.

All right. So that will be put off.

With that we will then move on to the first item of the agenda and that is the ESBWR design, thermal-hydraulic issues. I will turn this presentation over to the subcommittee chairman, Dr. Wallis.

VICE-CHAIRMAN WALLIS: Thank you very much, Mr. Chairman. This Committee, I think at least on two occasions before this, had a presentation from GE or GENE or whatever it's called now on the ESBWR. And these have been very interesting and informative meetings. This time we're asked to decide on a decision to be made by the staff which is whether or not to accept the TRAC-G code for the analysis of this system and for use in its design certifications.

So this time we are asked to make a decision.

The subcommittee met with the staff and GENE -- what should I call you, folks? GE, okay. GE. And we spent two days. It was very informative. The staff presented their SER and the main interest of the subcommittee was not that the staff was making decisions, but why they made these decisions and this became revealed in the second day, mostly, when we saw a lot of evidence. It was this evidence, including, I will add a lot of work done by the staff itself, which was very impressive for the committee and really helped us to reach a decision, at least the subcommittee, I think, made.

So that's about all I wanted to say. You have received through the e-mail a draft letter on this subject from me. Those of you who didn't receive it can get a copy from Ralph Caruso.

Now I think we're going to hear from GE first, is that correct, so they can set the stage and so I'd invite GE to give us a presentation, please.

MEMBER FORD: Graham, could I just make a statement? I have a conflict of interest in this subject, since I'm a GE retiree.

VICE-CHAIRMAN WALLIS: Thank you very much. It's been noted.

I'm not sure what parts of this, if any, are going to be proprietary. I looked at the staff's slides. It wasn't clear to me if any of them were proprietary or not.

MS. CUBBAGE: We're planning to have an open session.

VICE-CHAIRMAN WALLIS: You've arranged

with GE that some of this information which was proprietary before is now going to be open?

MS. CUBBAGE: Correct. In some cases, we removed the numbers from the scales.

VICE-CHAIRMAN WALLIS: I think that's a great advance.

Thank you.

MR. RAO: Thank you. I'm Atam Rao from GE Nuclear Energy. We are still GE and we are part of GE Energy now. We are no longer GE Power Systems.

The next four slides that I have of the presentation are more as reference and an overview of the design of the ESBWR. What you see in the top lefthand corner is an isometric of the ESBWR. There's the reactor vessel. This is the state of the plant during normal operation and what we have in this plant is three pools of water, about a thousand cubic meters located above the core and the standard suppression pool, about 3,000 cubic meters. Also, the top of the suppression pool, the elevation of that is above the top of the core.

Following the last coolant accident or any other event where core cooling might be threatened, the plant depressurizes through diverse depressurization systems. You can see the safety relief valves out here and shown in blue are the diverse depressurization valves up at the top.

So we have two means to depressurize the plant. Once you depressurize the plant, this is the final state that the plant ends up in where the core remains covered during the transient and at the end state. It's a fairly elementary analysis.

The reason why we have so much margin in the design is basically for a couple of reasons. One, the reactor vessel is about six meters taller than the ABWR and we have about two and a half times as much water in the reactor vessel. So that is the first part of the safety system is the large amount of water in the reactor vessel.

And when you get a blow down, there is about three meters of water covering the top of the core for all the pipe breaks. So it ranges between -- you'll see the exact numbers in one of the later presentations.

And the water make up required is extremely slow and you can rely on gravity to keep the core covered.

On the right hand side you see the safety systems. I won't be going into these. I presented them before. This is not to scale. This is the isometric here which is to scale. This shows all the pools of water and the decay heat removal, heat exchanges which are mounted above the drywall floor here. They're shown out here. This is the isolation condenser and this is the passive containment cooling system.

This shows an outline of the total plant and you can see that the number of mechanical and fluid systems is substantially reduced in the plant and again, these charts here are for reference. I know they are extremely small versions of it, but I can address any questions you might have as they relate to the issues at hand.

In addition to the design being simple, the analysis is fairly simple. Also, we've done extensive testing of different components that are new to the ESBWR. This shows the depressurization valve, a full scale test was done.

VICE-CHAIRMAN WALLIS: This is a magician in front there or is that a lion tamer to deal with the panthers and the pandas?

MR. RAO: This is a Ph.D. from Dartmouth College, thermal hydraulics expert.

(Laughter.)

He has been working on it for 20 years and he wants to retire. And that's why he's so happy he can see golf every day down the road.

This is the vacuum breaker, full-size vacuum breaker test. These are the passive containment heat exchangers and these are the full height test facilities that you'll see referred in some of the presentations. This is what's called GIST and this is the plant test facility in Switzerland.

What is shown on the next shot, again, is more for reference. It shows some of the key parameters of the ESBWR shown on the right hand column here. It compares the parameters to operating BWRs, BWR-4, BWR-6, the ABWR. And what you see basically in the top part of the chart is the operating parameters. They are within the experience base. We have not gone out of what is the experience base: power densities, the size of the equipment. There are a few extrapolations, but they're within the range of 10 or 15 percent.

What you see in the bottom two rows is a measure of the overall safety of the plant. You see reduced core damage frequency. As you go from left to right you see that there's been a steady improvement in the core damage frequencies for BWRs. And what you see in the right hand columns is the ABWR and ESBWR.

These are approximate numbers, not the exact detail numbers. What it shows is the order of magnitude of the core damage frequency for the ABWR and ESBWR, similar.

But the key thing to notice is in the last row out here is as we evolve the BWR designs, the core damage frequencies improved because we added more divisions of equipment, more diversity and more equipment basically is the way we improved the overall core damage frequency.

VICE-CHAIRMAN WALLIS: Also more water, I must say.

MR. RAO: Well, there is more water -- there are a few other things that are different in the ABWR relative to the earlier designs, but it reduced the number of large pipe breaks, for example. You don't have any large pipe below the core elevation, for example, in the ABWR or the ESBWR.

But the key thing is that we were able to keep the core damage frequency the same between the ABWR and ESBWR, but with a lot less equipment which is shown in this measure out here, which is the size of the safety building volume.

So what it does is it reduces the complexity of the design, it makes the analysis a lot easier and makes life a lot easier for the operator.

And of course, ultimately, in addition to improving the safety and the security, this simplification results in a significant improvement in the overall economics of the plant design.

What is shown in the top right hand column, right hand part of the picture --

VICE-CHAIRMAN WALLIS: I don't think we're talking here about improvements in security?

MR. RAO: We're not revealing that there, but --

VICE-CHAIRMAN WALLIS: It may become an issue, but I don't think we're making any recommendations or decisions about security.

MR. RAO: No.

VICE-CHAIRMAN WALLIS: Thank you.

MR. RAO: But just as background, all the safety systems are inside the containment which is in order and so from that perspective there's a significant improvement there.

When you look at the plant building, this is an actual section of the building, what you see is the major piece of equipment is the reactor vessel and what we've basically done, compared to the BWRs that you might be familiar with is that we've eliminated almost six floors of safety-grade equipment that used to be attached on the outside of the reactor building. This is the containment boundary, basically. All of that safety-grade equipment is now no longer there.

What we have also done is we've -- like the BWR six Mach 3s, we have a separate fuel building.

Last chart and the next step, we are following what we call a stepwise approach for getting this plant through the design certification process. The reason we adopted this approach is we believe it gets the long lead items reviewed earlier. Just to put it in perspective, the submittals that went into what we're discussing today were in the range of 5,000 pages of submittals.

So what we are looking for is approval of the TRAC-G code for both the ECCS and containment analysis.

VICE-CHAIRMAN WALLIS: That's just a restricted set. I think I originally opened this meeting saying there was approval of TRAC-G for design certification. It doesn't get that far. It's just for LOCA analysis.

MR. RAO: Yes, thank you. There are more specific words that the staff has used and I've just skipped it.

VICE-CHAIRMAN WALLIS: We'd like to see what those words actually are when we get there.

MR. RAO: Yes. The staff's words are more complete.

We will also ask for approval of the TRAC-G for undisputed operational occurrences in the middle of the year. And then approval of TRAC-G for stability and ATWS by the end of this year.

VICE-CHAIRMAN WALLIS: So you will be coming back to us several times this year?

MR. RAO: Yes. And then once we've got all of these analysis methods out of the way, we will come in with a design and what's called the DCD by the middle of next year. Since most of the hard stuff would have been gotten out of the way, our expectation is that the FSER would be done within about a year. I just want to clarify these dates are still under discussion with the NRC staff and it's -- this is what our goal is and our expectation is.

And the next presentation is by Dr. Shiralkar. If there are any questions on the design, I will try to take them right now.

MEMBER ROSEN: I'm just curious about your statement that you think most of the hard stuff has been done with the TRAC approvals. Certainly has been difficult in the new feature of the design, but when we look at a new design, we look at the new features and there are some new features.

MR. RAO: Yes.

MEMBER ROSEN: For instance, these new vacuum breakers. So there are some challenges ahead relative to review the design. Don't you agree?

MR. RAO: Yes. The information is there and we believe it will be a lot easier. That's our hope. I'm still following Dana's advice. Dana stepped out. He told us that it will be approved in two weeks. So we're still looking to that.

MEMBER ROSEN: Well, Dana has a way of perhaps exaggerating a little bit.

MR. RAO: No, there are hard -- what I was trying to say is that this part will focus on the hardware, okay. What we will have done out here will be the -- all the analysis tools that are needed to evaluate the performance would be out of the way, the testing would be out of the way. And the focus in the DCD would be on the systems. We'd have to look at the redundancies and the reliabilities of the systems. We've presented that information as part of this submittal already, so the information is there and that's why we feel that the review will be easier because the information is already there on the table.

MEMBER ROSEN: We have hardware to look at. We have operations, maintenance, testing, all of the standard things that need to be looked at. Some of them may be complicated by the passive design. I just don't know. So I wouldn't understate the need for deliberate care as we go forward.

MR. RAO: No. We expect this to be as thorough a review as the ones that we've gone through right now.

VICE-CHAIRMAN WALLIS: This make sense to me. If we approve, the staff approves the design tools, then it's conceivable that you might do some optimization, a little tweaking of the sort of things, details before the DCD using these design tools. It might turn out that improvements could be made by making some slight change in a valve or something, conceivably.

MR. RAO: Yes. It's shown out here on this table out here the items with the asterisk are items that we are looking to optimize and what we did give the staff was a reference design which is what's shown out here. When we come in in the middle of 2005 now that we have the analysis tools approved, we will be doing some optimization of the design. But we don't expect any of these parameters to be changing by anything like 50 percent. We're talking about 10 or 15 percent at best.

VICE-CHAIRMAN WALLIS: Another question. The role of PRA in all of this. This not, presumably, or is it, a risk-informed application? And the move, even if it's not a risk-informed application, presumably you're going to submit risk information because that would be useful. Is the PRA part of the submittal you're going to make in 2005?

MR. RAO: Yes. We will make the submittal for the PSA in the -- what we're calling the DCD and the safety analysis report in the middle of 2005.

The PSA was used extensively in the design of some of the features in this plant. And there's not enough time to cover that out here, but we can --

VICE-CHAIRMAN WALLIS: That's very desirable, it seems to me. Rather than designing something, thinking about risk afterwards. One should put risk measures right into the design at the beginning and aim for a certain level of risk or safety, let's call it. You call it PSA, so let's say a certain level of safety. Designing a certain level of safety into the plant from the beginning.

MR. RAO: I don't know whether it shows up out here, one of the things that we included in the design as a result of this safety consideration was separating out in one of the earlier stages of the design the PCCs and the ICs were one component. That heat exchanger -- look at the heat exchangers. They look alike, except this one is a higher pressure heat exchanger and this is a lower pressure heat exchanger. So very early on in the design, we decided we wanted to separate out the isolation condenser and the PCC because that is a prevention system and this is a mitigation system. So we separated out the prevention and mitigation. So that was one of the bigger changes that we adopted.

Another change that we adopted may not show up in this one is we actually have a nonsafety low pressure injection system which relies on the pumps from the fuel pool cooling system because we've got the pumps and the power sources for that. We saw by adding an extra line in a few wells we could reduce the core damage frequency by about a factor of two. So that was put into the design as a result of the PSA.

So the PSA was used extensively in the optimization of the design and the optimization that we'll be doing in the coming months is primarily related to the vessel in the core. We're going to keep the vessel dimensions the same because of construction considerations. We want to stay with the current infrastructure, so it's going to remain at 7.1 meters.

VICE-CHAIRMAN WALLIS: Can we move on to Bharat's presentation?

MR. RAO: Yes.

VICE-CHAIRMAN WALLIS: Do Committee Members have other questions for Atam Rao?

MEMBER LEITCH: Just one real quick question. Is there still some further testing on-going to confirm the applicability of TRAC-G for the AAO and the stability in ATWS situations or is the physical testing actually complete?

MR. RAO: The testing that is needed for these submittals is complete.

MEMBER LEITCH: Okay.

MR. RAO: I have you a lawyer's answer. The testing needed for these submittals is complete, but we always keep going testing and we have additional testing that's on-going, but those are confirmatory tests.

MEMBER LEITCH: Okay. Thank you.

VICE-CHAIRMAN WALLIS: Are we ready to

move on?

MEMBER KRESS: One of the things that normally concerns us about BWRs is the stability issue at low power.

MR. RAO: Yes.

MEMBER KRESS: Have you addressed that for the ESBWR and will we hear about it?

MR. RAO: You'll be hearing about it. We're going to make a submittal in the middle of the year on stability and we'll give you more detailed presentation at that time. But the short answer, Bharat can address any questions that you have on the stability during his presentation.

VICE-CHAIRMAN WALLIS: Okay, we'll move on to the next presentation. Thank you very much.

MR. SHIRALKAR: Good morning. I'm Bharat Shiralkar from GE. The thrust so far of the ESBWR submittals to date has been to obtain confirmation that the technology program is efficient and that TRAC-G is applicable for safety analysis. And in my presentation today I'll just touch upon a few highlights to support that conclusion that, in fact, TRAC-G --

VICE-CHAIRMAN WALLIS: May I ask, none of this is proprietary? Is that true?

MR. SHIRALKAR: That is correct.

VICE-CHAIRMAN WALLIS: Thank you. Or if it was proprietary before, it no longer is. I think some --

MR. SHIRALKAR: I think some of the scales have been removed, yes.

VICE-CHAIRMAN WALLIS: Okay, but some of these figures which I think we see here in your presentation have been presented in the past as if they were proprietary. You've done things to make them nonproprietary?

MR. SHIRALKAR: Yes.

VICE-CHAIRMAN WALLIS: Thank you.

MR. SHIRALKAR: We followed a systematic approach in the ESBWR technology program. We pretty much followed the steps of the so-called CSA process. We defined scenarios, defined important phenomenon, determined code applicability, established the assessment matrices, done the tests and defined the experimental accuracy and the code accuracy and defined the margins.

What I'd like to do in this presentation is just to give you a few examples of test coverage, key phenomena, model accuracy and the overall design margins.

Turning to test coverage first, what this figure is shows the response of containment and reactor pressure vessel in terms of pressure versus time for a typical pipe break. You can conveniently divide the transient into three segments. The first is a blowdown period which lasts about the first 10 minutes or so when the reactor depressurizes and the containment comes up to pressure.

Following that, the gravity driven cooling system initiates and we have what is called a GDCS period where the GDCS pools are draining into the reactor vessel and refilling it. That lasts for maybe about an hour.

Following that then we have the long-term period which is basically a containment response issue where the decay heat is being removed by the passive containment cooling condensers.

VICE-CHAIRMAN WALLIS: It would be nice to see those curves actually begin to come down after three days. They reach a maximum --

MR. SHIRALKAR: They are pretty -- yes, I think what happens is that you come into a quasi-equilibrium.

VICE-CHAIRMAN WALLIS: Yes, but they don't go up any further.

MR. SHIRALKAR: They don't go up any further. They stabilize. You do have, of course, active system that's available to bring the pressures down, but the passive will just maintain the pressure at about that level.

VICE-CHAIRMAN WALLIS: It might go up, for instance, if you ran out of water in the passive system. You have -- eventually, you have to refill.

MR. SHIRALKAR: You have to refill it, yes. So the bottom part of this figure shows the testing that has been performed. These are all integral systems tests. The TLTA and FIST and the test and containment blowdown tests cover the early part of the transient. The GIST tests were done to look at the performance of the GDCS system. They initiated about 10 bar pressure and covered the late blowdown in GDCS phase as do the GIRAFFE system and integral tests.

The long-term period is covered by GIRAFFE and the PANDA test facilities. It's different scale facilities. GIRAFFE is a small facility. PANDA is fairly large, about 150 scale. And some of the PANDA tests were started earlier in the GDCS phase to provide other labs with the other tests.

So you can see that we have overlap in

coverage with these tests of the entire LOCA transient.

Finally, as far as the component tests are concerned, the PANTHERS PCC which is pretty much a full-scale PCCS condenser, passive containment cooling condenser has been tested over a range of conditions of steam flow and uncondensable flows covering the entire range of the LOCA transient.

So among these tests now we have overlap in coverage at different scales for the entire LOCA transient.

Just to show you that tests of different scales produce similar results, here are a couple of examples. The figure on the right here and the bottom figure are for heat removal by the passive containment cooling condensers. This one shows the heat removal as a function of the normalized pressure and plotted are data from the PANDA IC/PCC which is a section of the PANTHERS PCC, the PANTHERS PCC being almost full-scale. And you can see the data from these different sized facilities comes together very nice.

VICE-CHAIRMAN WALLIS: What we're really doing here is evaluating TRAC-G. So it would be nice to have a TRAC-G prediction on these curves.

MR. SHIRALKAR: We do have that, of

course, later.

VICE-CHAIRMAN WALLIS: That's what the subject of this meeting is.

MR. SHIRALKAR: Yes. This is part of establishing that there are no scaling effects from the data, that the test data come together and similarly, this one shows the degradation of heat transfer, given uncondensables. This is the heat removed by the condenser plotted versus the concentration of uncondensables from different facilities at different scales and again they line up very nicely.

The top figure here is one on containment performance. This is the containment peak pressure plotted as a function of noncondensable concentration in the wetwell. And this data covers different gases like helium and nitrogen in air. It also covers different scales which is a PANDA test facility and a GIRAFFE test facility which is a small test facility. And it makes the point that the primary cause of the pressure increase is simply the transport of noncondensables to the wetwell. It's a nice correlation between that concentration and the pressure reached in the wetwell.

VICE-CHAIRMAN WALLIS: This is simply a

partial pressure thing which is almost a homework problem, isn't it?

MR. SHIRALKAR: Yes.

VICE-CHAIRMAN WALLIS: Put more gas in, the pressure goes up.

MR. SHIRALKAR: Exactly. The difference being, the difference from the 45 degree line being some increase due to the vapor pressure in the wetwell.

VICE-CHAIRMAN WALLIS: The other question is how well can you predict this transfer of noncondensable.

MR. SHIRALKAR: We'll show you that as we go along.

So this is with respect to the test coverage. The next item I was going to talk about was --

MEMBER RANSOM: On the normalized values, where is the design nominal value on those --

MR. SHIRALKAR: On the pressure it will be at about 3 bar.

MEMBER RANSOM: No, you have it normalized from I think 1/10th --

MR. SHIRALKAR: Are we talking about this figure here?

MEMBER RANSOM: Right.

MR. SHIRALKAR: This figure is normalized to a pressure of 3 bars.

MEMBER RANSOM: So that is the normal operating condition --

MR. SHIRALKAR: For the PCC. This also covers the IC data which goes to much higher pressure.

MEMBER RANSOM: Okay.

MR. SHIRALKAR: Turning to the LOCA transient, as Atam said earlier, the ESBWR LOCA transient response to pipe breaks is extremely mild and the reason for that is simply the amount of water that you have in the reactor vessel. You have more than twice the amount of water that you used to have in the previous designs and what happens is that when you scram the reactor falling and it breaks, the vise inside the core region here collapses and the water that was sitting in the downcomer and around the separators basically rushes in and establishes an inventory inside the chimney. So this water now has now come down here and settled inside the chimney and beyond that point it's just a matter of how much water you lose due to the blowdown process and how much water do you maintain.

The right hand plot shows that if you look at the water level above the top of the core versus time in the ESBWR, the minimum water reached, level reached is about more than two meters above the top of the chimney, the minimum water level being at this point --

VICE-CHAIRMAN WALLIS: The top of the core?

MR. SHIRALKAR: Yes, above the top of the core within the chimney.

So the initial inventory dominates the LOCA transient just be of the sheer volume of water inside the vessel and we maintain a margin of .12 meters to cover it.

So given that, I wanted to give you a flavor of what some of the important factors are in this transient and to show you that we do have the code qualified and assessed against those phenomena.

We're looking ultimately at a prediction of the chimney level for the reactor vessel and this is determined primarily by the void fractions in the different regions. The void fraction in the different regions are calculated in TRAC-G by what is called interfacial sheer model. It's the sheer between the two phases.

And so we're looking at the models in TRAC which are the interfacial sheer in the core and the interfacial sheer in the chimney, interfacial sheer in the lower plenum downcover and also critical flow determines how much inventory you lose due to the blowdown process.

For all of these, this column shows that we have realistic models in the TRAC code and that they have been assessed against relevant data. And finally, the chimney level is the output calculation of using all of these models, the integral calculation and for that also you have assessment against integral tests.

VICE-CHAIRMAN WALLIS: Most of these interfacial sheer effects have to do with whether or not the steam which is leaving carries water with it, is that what the --

MR. SHIRALKAR: Yes, and how much water remains inside the regions, how much water is left, yes.

VICE-CHAIRMAN WALLIS: Steam has to come out.

MR. SHIRALKAR: Yes.

VICE-CHAIRMAN WALLIS: And the question is does it carry a lot of water with it by sheer or does the water stay behind?

MR. SHIRALKAR: Exactly. This shows typical comparisons of TRAC-G for one of the important parameters and that is the chimney void fraction of the interfacial sheer in the chimney and here we're looking at data from various facilities which have large hydraulic diameters, diameters that are comparable to chimney diamaters. A chimney partition cell is a square region with the dimensions of .6 meters.

VICE-CHAIRMAN WALLIS: There is something in the transcript, I read the transcript at our subcommittee meeting which I think needs to be corrected. The transcript reads 26 meters and I think it should be saying .6 meters.

MR. SHIRALKAR: Zero point 6 meters.

VICE-CHAIRMAN WALLIS: Because it's very strange to have a transcript that says the size is 26 meters. That's way out of line. We don't have a chance to change these transcripts, but for the record, if anyone is looking at the transcript of a subcommittee meeting that 0.6 somehow got transcribed as 26. And that is not correct.

MEMBER POWERS: Were that the only flaw that ever showed up in the transcript it would probably be devastating.

VICE-CHAIRMAN WALLIS: There are lots of other flaws in the transcript --

MEMBER POWERS: Are you really proposing that you want to spend the time plowing through and correcting transcripts?

VICE-CHAIRMAN WALLIS: No, but somebody else who is really interested in this might.

MR. SHIRALKAR: It must be due to the lack of clarity in my accent.

MEMBER POWERS: No, don't blame yourself. Dr. Kress is famous for the line "defense-in-death" --

(Laughter.)

MR. SHIRALKAR: Fortunately, they probably misspelled your name too.

(Laughter.)

MEMBER POWERS: So you don't get blamed.

MR. SHIRALKAR: At this point, 0.6 meters and these facilities provide data in vessels that have sizes of the order from 50 centimeters to 1.2 meters.

This is a simple test where steam will bubble up through stagnant liquid. Comparisons of TRAC-G versus the data --

VICE-CHAIRMAN WALLIS: I think you need to say the TRAC-G wasn't fudged to fit this data. I understand the model in TRAC-G that's used throughout the whole rest of the system is the same model that fits these data. It's not as if you fudge it, is that true?

MR. SHIRALKAR: There's only one model that's used, but there is a correction for large diameters.

VICE-CHAIRMAN WALLIS: Oh, there is, okay, so there is some correction.

MR. SHIRALKAR: There is a correction and the correction, in fact, uses some of this data --

VICE-CHAIRMAN WALLIS: The surprising thing is it doesn't make much difference because the steam seems to be broken up into small bubbles, so that's why you don't have to correct very much of the data for small pipes.

MR. SHIRALKAR: Yes, we entered the interfacial sheer correlations through an equivalence with the vapor flux correlations and we have found that we needed to make some changes to the VGJ term, for example, for large diameters which affects the size of the bubbles.

This one is data from the ESBWR which is an experimental volume water reactor that was run in the late 1950s, early 1960s I think in Oregon. This has a core of about one meter, 1.2 meters and a height of the chimney is about 1.5 meters. And there was some probes in there to measure the pressure drops and obtain void fractions in the peripheral region and the central region.

And we predicted those quite well, slightly over-predicted the peripheral void fraction which is not surprising because there is a power gradient in the reactor and you have lower power regions near the periphery and we were using just one pipe for that condition.

And this is the Ontario hydro data which was obtained in 50 millimeter, 50 centimeter pipe, 10 meters high, vertical pipe in which the void fraction was varied by draining the loop at pressure. And the prediction of the void fraction were quite accurate. In fact --

VICE-CHAIRMAN WALLIS: It shows up better in our transparency, I think.

MR. SHIRALKAR: I'm sorry?

VICE-CHAIRMAN WALLIS: I think the comparison shows up better in the handout than on the screen unless I'm -- I guess it is there, but it's a little ghostly.

MR. SHIRALKAR: It's kind of hard to see, but I think we have shown this before in larger plots and we can provide you the larger plots.

VICE-CHAIRMAN WALLIS: That's okay.

MR. SHIRALKAR: These are just to show you some examples at this point.

The conclusion was that interfacial sheer model predicts large diameter data with errors that are comparable to data uncertainties that means on the order of 2 to 3 percent which is about as good as you can do, obviously. So we're happy with that.

Another important parameter is critical flow and we've got a couple of comparisons here. One is through the Marviken test in the top lefthand side. And a pressure suppression --

VICE-CHAIRMAN WALLIS: You have no scale there, but the Marviken test is available to anybody who wants to to look it up.

MR. SHIRALKAR: Yes. True.

VICE-CHAIRMAN WALLIS: There's nothing secret about Marviken.

MR. SHIRALKAR: But you don't know which test it is.

(Laughter.)

VICE-CHAIRMAN WALLIS: It's not because you don't know the flow rate --

MR. SHIRALKAR: It's concealed because you know what the test number is. But anyway, you can probably find out.

VICE-CHAIRMAN WALLIS: That's all right. That's okay.

MR. SHIRALKAR: And the pressure suppression test facility, the GE test facility with is blown down from -- looks like a blowdown from a vertical vessel and again, the critical flow is predicted accurately. I can tell you that we looked at a number of critical flow measurements and the errors typically are -- the standard deviation is less than 10 percent.

VICE-CHAIRMAN WALLIS: I think what the subcommittee asked you to do was to show us some pictures and not a whole torrent of words.

MR. SHIRALKAR: Yes, thank you. We were trying to comply.

Here integral predictions of the DGCS line break case in the GIRAFFE test facility shows that the reactor pressure vessel on the lefthand side and response and the chimney level on the right hand side. And you can see again the predictions are fairly good. The minimum level in the chimney was predicted narrowed with .1 meter which is quite a bit less than the margin that we have of 2 meters. So we think it's good enough.

MR. SHACK: What's the diameter of that line?

MR. SHIRALKAR: Diameter of?

MR. SHACK: The GDCS line. Is that a 6-inch line?

MR. RAO: The line itself is 6 inches, but the nozzles are 3 inches connecting to the vessel.

VICE-CHAIRMAN WALLIS: So the nozzles limit the flow.

MR. SHIRALKAR: Yes.

MEMBER RANSOM: Have you done any work to justify the use of standard deviation for characterizing the uncertainty in these comparison?

MR. SHIRALKAR: We have used it, yes. We try -- when we do that, you mean for the --

MEMBER RANSOM: What I'm asking really is this implies a statistical distribution of the errors and I'm wondering if that's a correct characterization or should there simply be a range of deviation?

MR. SHIRALKAR: I think it's different for different things. Like for void fraction data, for example, where we have a lot of data, I think you can characterize it quite accurately in terms of statistical distribution.

MEMBER RANSOM: The implication is that this is some kind of normal distribution.

MR. SHIRALKAR: It's not necessarily normal.

MEMBER RANSOM: It implies it.

MR. SHIRALKAR: If you have enough data, you can test it for normality in terms of the distribution of errors which we have done, for example, void fraction errors.

MEMBER RANSOM: Well, the danger would be that if somebody takes the sigma that you give them and then assume that that represents a normal distribution of the errors, then they're going to get an incorrect result.

MR. SHIRALKAR: True. when we do statistical analysis, we are careful to try to characterize them as a uniform distribution if you don't have enough data or the normal distribution if we have that data or different distribution if we can't characterize it.

MEMBER RANSOM: I think this is important if you move, as you move towards the realistic methodology as opposed to say a conservative --

MR. SHIRALKAR: That's true. In fact, for the AOOs, the operation of transients, we do apply all of them in a statistical manner and we take, we go to a lot of trouble to try to characterize these distributions as the best we can.

MEMBER LEITCH: I assume that in the actual plant, the operator has no knowledge, no direct knowledge of chimney level. It's like present BWRs, he's really looking at the level and --

MR. SHIRALKAR: That's right. You only have the downcomer level.

MEMBER LEITCH: That's the only information he has?

MR. SHIRALKAR: Yes.

MEMBER LEITCH: Okay, thanks.

MR. SHIRALKAR: Turning to containment pressure response, if you look at the containment pressure response to a break, there's a short term response where you have the blowdown flow into the drywell. You have the vent clearing process and then the wetwell starts to pressurize. But in the ESBWR, the long term pressure is the limiting pressure. The short term peak is much smaller, usually, and so the long term pressure can be calculated very simply. You can calculate it and what I've shown here on this read line is almost the back of the envelope calculation in which what you do is you push all the noncondensable initially in the drywell or to the wetwell and you make an estimate of what the suppression pool temperature would be to get a vapor pressure and you add it to get the total pressure.

And you can see that you can almost make a hand calculation or a rough calculation that will tell you where you're going to end up.

VICE-CHAIRMAN WALLIS: The other thing to do would be to put all the noncondensables in there and then vary the temperature in the space and saturation pressure and find out how hot it would have to be in order for that line to move up to this design pressure.

MR. SHIRALKAR: Yes. We know, in fact, that if the suppression pool gets hotter than let's say 190 degrees Fahrenheit or so then the wave of pressure increase is fairly rapid.

VICE-CHAIRMAN WALLIS: That's right. And that little red line would move up closer to the big red line.

MR. SHIRALKAR: Exactly.

VICE-CHAIRMAN WALLIS: So you have to calculate that temperature pretty well.

MR. SHIRALKAR: Yes, yes. You can estimate it by assuming that a part of the pool above the vent level is the active absorber of energy and so on.

VICE-CHAIRMAN WALLIS: That was, I think, your approach that you took before the subcommittee was to bound these things.

MR. SHIRALKAR: Yes, and I pointed to make also that we have a margin of about a bar on the pressure, to the design pressure.

So again the phenomena we're trying to calculate here is that containment pressure and the parameter of interest, the important parameter, the PCC heat transfer, how much energy will remove the PCC, non-condensable transport to the wetwell and suppression pool certification. These are the parameters that control the ultimate pressure response.

We have a realistic TRAC-G model for the PCC heat transfer. The non-condensable transport and suppression pool certification we're treating in a conservative way, but we do have some data that allows us to assess how good those approximations are. And we also have data for the integral response of the containment pressure from the PANTHERS test.

To show you a couple of examples, the PANTHERS PCC performance PANTHERS is a full-scale heat exchanger for the containment, passive containment cooling for the ESBWR scale which is about 75 percent of the side that will be in the ESBWR. So it's a very large scale heat exchanger.

The figures, this figure here shows the energy removal by the PCC, the function of the inlet pressure. The inlet pressure is the test we run so the inlet pressure with a floating variable. The inlet pressure floated to the level that was needed to remove all of the energy because as the pressure increases the delta T crosses from the primary to the secondary increase.

And you can see the track here is calculating at slightly higher pressure to condense the steam which is slightly conservative.

These figures here are for steam air conditions for a given steam flow rate and a given air non-condensable flow rate to show the efficiency of condensation which is defined as the fraction of steam that's condensed, a fraction of the inlet steam, a function of the inlet pressure. And this one shows the pressure drop in the condenser, as again, a function of the inlet pressure.

TRAC-G calculations predict these data very well. One thing to note is the pressure drop within the condenser itself is very small. It's on the order of 5 to 6 kPa which is less than a psi and so these differences which are still large are still at the order of say 1 kPa or thereabouts.

VICE-CHAIRMAN WALLIS: Essentially means that the wetwell and the drywell have about the same pressure, doesn't it?

MR. SHIRALKAR: No. The wetwell drywell pressure is usually set by the submergence of the --

VICE-CHAIRMAN WALLIS: It's a hydrostatic term. This would be in the steam space.

MR. SHIRALKAR: That's right. The PCC performances are predicted and the errors are small compared to the design margins. That's the point I wanted to make on this figure.

And finally, this is a prediction of the pressure, containment pressure reached in integral systems tests. PANDA is a large-scale test with a drywell wetwell and reactor pressure vessel simulation that is a steam source.

VICE-CHAIRMAN WALLIS: This is a real eye test. You're going to have to tell us what's going on.

It's a real eye test to look at this. You're going to have to describe what you mean by the various curves.

MR. SHIRALKAR: Okay. These are three different tests with the -- this one is the nominal test with the small initial volume of non-condensables that get moved over to the wetwell. And following that, the PCC is able to remove the energy and so the pressures level out, fairly mild transient.

VICE-CHAIRMAN WALLIS: This is pressure versus time?

MR. SHIRALKAR: Yes, pressure versus time. This is pressure versus time for three different tests in the PANDA test series.

VICE-CHAIRMAN WALLIS: And one of these traces is the prediction?

MR. SHIRALKAR: This one, the top trace is the driver pressure. The bottom trace is the wetwell pressure.

VICE-CHAIRMAN WALLIS: Those are measured or predicted?

MR. SHIRALKAR: The two lines there which I can barely read, but I think the dashed line --

VICE-CHAIRMAN WALLIS: It's a solid line and a dashed line that are --

MR. SHIRALKAR: The dashed line is the TRAC-G prediction. The solid line is the data.

VICE-CHAIRMAN WALLIS: And the message is that --

MR. SHIRALKAR: The message is that the predictions are good for all these three cases. This one is slightly conservative.

VICE-CHAIRMAN WALLIS: And those deviations that we see at the right hand end of that curve that you were just on, are not significant compared with some criteria?

MR. SHIRALKAR: No. And the reason the track is calculating a higher pressure and the reason for that is this test was a very extreme case where we had 100 percent non-condensable initially in the drywell. So all of those have to be moved over to the wetwell and some of them remain behind in the test and TRAC-G calculated -- all of them moved over and calculated a higher pressure at the end.

But even that --

VICE-CHAIRMAN WALLIS: So you argue that's conservative, I suppose?

MR. SHIRALKAR: It's conservative and even that pressure difference is not significant compared to the one bar margin that we have.

VICE-CHAIRMAN WALLIS: Okay, that's good. Thank you.

MR. SHIRALKAR: I'd like to make a point on this chart that the margins for LOCA that we've been talking about are large. What I'm showing are results for three breaks, three limiting breaks that we consider, the main steam line break, the GDCS line break and a bottom drain line break. We considered different failures. One, a failure of a DPV, the failure of an SRV, safety relief valve, a depressurization valve which depressurizes into the drywell. The SRV depressurizes into the wetwell, into the suppression pool

VICE-CHAIRMAN WALLIS: You call these limiting LOCAs. The implication is that all other LOCAs are somehow milder than these ones?

MR. SHIRALKAR: Yes.

VICE-CHAIRMAN WALLIS: Is that the case?

MR. SHIRALKAR: Yes.

MEMBER ROSEN: What is this bottom drain line? What's the purpose of that?

MR. SHIRALKAR: The bottom drain line is for -- it's used for shutdown cooling. It's also used for clean up system.

MEMBER ROSEN: For what?

MR. SHIRALKAR: Reactor cleanup.

MEMBER ROSEN: So it's more than a drain.

It's not like -- it implies that it's a maintenance drain, the wording.

MR. SHIRALKAR: No, no. I think that's the terminology that we use.

VICE-CHAIRMAN WALLIS: It's a pipe coming out of the bottom.

MEMBER ROSEN: It has functions, significant functions?

MR. SHIRALKAR: Yes. Okay, the message is the margins are large --

MEMBER ROSEN: Now large is it, the bottom drain line?

MR. SHIRALKAR: I'm sorry?

MEMBER ROSEN: How large is the bottom drain line?

MR. SHIRALKAR: Atam, can you respond to that?

MR. RAO: It's a 2-inch nozzle. There are four of them, four 2-inch nozzles at the bottom.

MR. SHIRALKAR: Okay, the limiting LOCA, there are more than two meters of margin, core uncovery and the containment has close to one bar margin to the design pressure.

VICE-CHAIRMAN WALLIS: It's one bar in how many bars?

MR. SHIRALKAR: Four.

VICE-CHAIRMAN WALLIS: One bar in four bars?

MR. SHIRALKAR: Right. In conclusion, we feel that we ran a comprehensive test program that provides data for all the phenomena of interest. We have large margins in the ESBWR and that the TRAC-G calculation report the phenomena accurately. The mix in phenomena are an exception. They're treated conservatively.

So in conclusion the TRAC-G is applicable for ESBWR LOCA analysis and should be approved for design certification analysis in conjunction with a defined application methodology which the staff will talk about in a little more detail. The application methodology prescribes how margins are to be included in the calculations.

That's all.

VICE-CHAIRMAN WALLIS: Thank you very much. There were very few questions during your presentation. I'd say that's either because you did a very good job of explaining or you did such a poor job that nobody understood anything.

(Laughter.)

I think that the alternative is the first one. Thank you.

MR. SHIRALKAR: Thank you.

VICE-CHAIRMAN WALLIS: That was very helpful. Thank you.

Now is the staff ready? The staff will take us through the third and fourth quarter here.

This other handout that we have is just informative about this design of the chimney. I don't think we need a presentation on that.

You folks have more slides than GE?

MS. CUBBAGE: A few more.

VICE-CHAIRMAN WALLIS: Please go ahead.

MS. CUBBAGE: My name is Amy Cubbage. I'm the project manager for the ESBWR pre-application review. GE has requested approval of the TRAC-G code for ESBWR LOCA analyses. The scope of the staff's review included application of TRAC-G for ESBWR LOCA, qualification of TRAC-G for ESBWR and also the PIRT testing and scaling in support of qualification.

VICE-CHAIRMAN WALLIS: What do you mean by -- the second one seems to be a more general one? That's the question I had earlier on with Atam's presentation.

Are you approving TRAC-G only for LOCAs or for ESBWR without qualification which seems -- without some -- qualification is used as the term here, but that second bullet which seemed to be a blanket approval and the first one is only for LOCAs.

MS. CUBBAGE: That's right. That should have also been for LOCA. I just --

VICE-CHAIRMAN WALLIS: Oh, okay. Thank you. So it is only for LOCA we're talking about.

MEMBER KRESS: The third bullet, you just reviewed the PIRT that was done by GE?

MS. CUBBAGE: That's right.

MEMBER KRESS: You didn't do a PIRT yourself?

MS. CUBBAGE: That's right. This is a list of the specific submittals that GE made and were reviewed by the staff. Copies of these reports were provided to the committee last year.

VICE-CHAIRMAN WALLIS: We take that as read, I think.

MS. CUBBAGE: Pardon me, sir?

VICE-CHAIRMAN WALLIS: We'll take that as read and move on or do you want to take details?

MS. CUBBAGE: No, the only thing I wanted to point out is that we issued a large number of requests for additional information and GE was responsive to all of those requests.

VICE-CHAIRMAN WALLIS: Thank you.

MS. CUBBAGE: This is the schedule for the current review activities. I just want to point out that we planned to issue the final SER next month on TRAC-G for LOCA and containment.

This slide shows the submittal schedule for additional ESBWR submittals from GE and the dates here look different from what GE presented because these are the submittal dates and not completion dates and we have not developed a schedule for completing these activities.

Our conclusion is that TRAC-G including the application methodology is an acceptable evaluation model for ESBWR LOCA analyses and TRAC-G is acceptable for reference --

VICE-CHAIRMAN WALLIS: Let me go back to that last slide so we can get something clear here.

MS. CUBBAGE: Okay.

VICE-CHAIRMAN WALLIS: I expect that the reasons these are somewhat vague is that the staff intends to do what it takes to do a thorough review of these various submittals. It's not going to be driven by some deadline.

MS. CUBBAGE: That's right.

VICE-CHAIRMAN WALLIS: You've got to do it by a certain date. That's the reason that these are vague?

MS. CUBBAGE: Well, these are vague -- these are submittal dates.

VICE-CHAIRMAN WALLIS: No, but it seems to me that's appropriate. I mean if you had some deadline where you have to do the review by a certain date, that would seem to be inappropriate. You do whatever it takes to get it done.

MS. CUBBAGE: That's right.

VICE-CHAIRMAN WALLIS: Okay, thank you.

MS. CUBBAGE: That's right. So continuing with the conclusion, we've concluded that TRAC-G is acceptable for reference during the design certification review of the ESBWR and that approval would be subject to conditions that will be specified in the safety evaluation.

Ralph Landry is going to walk through the basis for the staff's conclusion.

VICE-CHAIRMAN WALLIS: You may have to run with the number of slides he's got.

MR. LANDRY: My name is Ralph Landry from the NRR staff and I am going to try to get through a lot of this fast.

MS. CUBBAGE: Is it on?

MR. LANDRY: Okay. I'm going to try to get through some of these pretty quickly. I have a lot of word slides that I want to just touch on and then get to the slides that show additional results.

Bharat showed some results and I'd like to touch on some other results so that when you see the picture of what he showed and what we showed, you get a little bit bigger picture of what we did in the review.

Okay, how do we find the code is acceptable? Well, there's a lot of parts that go into determining the acceptability of a code. We have to start with understanding what the bases are for the review and for the acceptance of the code. We have to look at in this case a realistic code so that we have to understand how the phenomena have been identified and ranked properly. We have to look at the test program which I'll get back to you in a minute because of regulatory bases that direct us to a testing. We have to look at the scaling, has the facility and the test program been scaled properly. We want to look at the TRAC-G code and the documentation. This is the specific models within the code and are those models sufficiently accurate or is the uncertainty in the models sufficiently understood that the uncertainty can be generated and carried through into the final analysis?

And in the case that we're going to talk about today, the staff has done considerable number of confirmatory calculations. We license on the basis of the material that is submitted to us. However, big caveat. When we review codes today, we want the code and we look at the code, run the code and run our own codes. This gives us a basis and a warmer feeling for the capability of a code, but we can look at the code capability. We can take the code apart ourselves and then we compare the code to our own code calculation or capabilities.

MEMBER KRESS: Ralph, let me ask you a question. You outlined what I would call criteria acceptance code. Are those written down anywhere in guidelines or in a review plan or something? Do they now exist in your head?

MR. LANDRY: Well, a lot of it's in the head. But I'm going to get through some of those.

When I go into the regulatory bases, those will define very high level what goes into a review and acceptability, but then there are other materials that are not regulatory, but are the basis on which we do our reviews that are defined and are in greater detail. So I'm going to try to get through a little bit of that this morning.

VICE-CHAIRMAN WALLIS: And let me say that there is somewhere in the works and it's been in the works for six years. I'm not sure if it's ever emerged, regulatory guide on what codes have to do and so on?

MR. LANDRY: There's a draft regulatory guide --

VICE-CHAIRMAN WALLIS: There's been draft for so long, it may just blow away.

MR. LANDRY: Reg. Guide 1120, I believe the number is, is about what is an acceptable valuation --

VICE-CHAIRMAN WALLIS: It addresses some these questions that this Committee has been asking for some time. If it isn't out there in the world, it's a real crying shame that it hasn't been issued properly.

MR. LANDRY: It's still in the works.

VICE-CHAIRMAN WALLIS: That doesn't make any sense. It's not something you did, but I just think this Agency is delinquent in addressing a very important issue about what's the quality of these codes, reducing regulatory guide which never emerges from behind a veil.

It has nothing to do with you, but that's --

MR. LANDRY: I agree with your frustration with that that it would be nice to have those documents out sooner.

VICE-CHAIRMAN WALLIS: It's not my frustration. It's not my frustration. I think it's just my judgment on the state of affairs.

MR. LANDRY: Thank you, Graham.

MR. SHACK: When you say you get a hold of the code, do you actually get the source code so that you can see that the model that's implemented in the code actually is the model that's described in the documentation?

MR. LANDRY: Exactly, so they, the manner in which we review a code is -- we insist that the code must be submitted. That means the source code must be submitted and executable so that we have it, the executable that the applicant is using. We have the source code because we've gone into the source code in a number of cases and made changes. When we wanted to study a sensitivity, we've gone into the source code, made a change, rebuilt the code, recompiled and then rerun ourselves.

But of course, that is a code that we have altered, so we can't hold the vendor, the applicant to this is what their code does because it's not a code that is in configuration control any longer, but yes, we do get the source code because we do want to have the ability to make changes beyond the changes that you can make through input data.

VICE-CHAIRMAN WALLIS: I point out that you don't always get the source code from the applicant.

MR. LANDRY: We are now.

VICE-CHAIRMAN WALLIS: You are now?

MR. LANDRY: Or the vendor-owned codes.

VICE-CHAIRMAN WALLIS: It makes it very much easier for the ACRS to approve something if we know that you have seen the source code and have been able to check it.

MR. LANDRY: We have.

VICE-CHAIRMAN WALLIS: Thank you.

MR. LANDRY: That I have to be very careful about, Professor Graham. When I say the vendor's code. Vendors also use commercial codes for certain things such as physics and those codes we don't get the source code on because that's a commercially owned product. So I'm just talking about the thermal hydraulic codes right now.

Okay, how do we approach the review and where's the material written down? Well, this code because we submitted it as a realistic model was based on the CSAU outline. The CSAU outline is a 14-step process which defines what goes into an acceptable evaluation model. The review which we performed was conducted by NRR, RES and contractors under both offices.

NRR reviewed the code models for the LOCA and containment. We performed independent calculations using the TRAC-G code itself and we did independent calculations using the trace CONTAIN linked code.

We reviewed the uncertainty methodology. The Office of Research reviewed the test program, the scaling and performed independent containment calculations using the contained code. Overall, management of the review and the SER was handled by NRR.

Some of the regulatory bases and I just want to hit these real fast so I can get into the figures. If you look at 10 CFR 50.46, the regulation dealing with LOCA evaluation models, it specifies that sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during loss-of-coolant accident analysis must be provided and that there is a high level and this is where we've had the discussion with the thermal hydraulic subcommittee, what constitutes a high level probability that the criteria would not be exceeded. That is not defined. This is a high level statement, but we have to then assume or look at an individual application and determine is the level of probability that is submitted acceptable.

For the containment, the regulatory bases are the general design criteria 16, 38 and 50 and the Standard Review Plan section 6.2.1 and in particular, SRP Section 6.2.1.1.C, I think I have enough ones in there which defines the requirements for pressure suppression containment systems.

In addition, because this is a standard design we also have to look at the requirements of 10 CFR 52 and in particular .47. Certification of a standard design which utilizes simplified inherent passive features can be granted only if and then there's a whole list of requirements. In particular, you have to demonstrate the performance through either analysis, appropriate test programs, experiment or combination. The interdependent effects have to be demonstrated through acceptable analysis, appropriate test programs, etcetera. And sufficient data must be shown to exist to assess the analytical tools that are used.

This is what forms the basis for now going back and looking at the test program that has been submitted by General Electric in support of the ESBWR. Is the test program sufficient to provide the data necessary to assess the analytical tools which are going to be used in support of the design?

Okay, because it's a realistic analysis method, I'm not going to go through all 14 steps of the CSAU methodology. I just want to hit a couple of the important ones.

One important step is that the phenomena must be identified and ranked. And this is done through a two-step process. A top-down process by which you start with the scenario to be analyzed and from that point move to the phenomena which are important and a second process called bottom-up where you look at the features of the hardware design and from those features move through to what processes are in important.

This two-step process was performed by

General Electric for the ESBWR design and resulted in two PIRTs, one dealing with the reactor coolant system and associated hardware itself, and the other dealing with the containment system.

The PIRTs that were reviewed have been found to be comprehensive and include all high ranked phenomena expected in a LOCA in the ESBWR.

VICE-CHAIRMAN WALLIS: That means you guys couldn't think of any other high-ranked phenomena that could be included? Is that what that means?

MR. LANDRY: We looked through the PIRTs and we did not come up with any phenomena that struck us that were not already accounted for by General Electric and their panel. This is not done by one person. There's a panel that reviews the PIRT for the applicant and then what we're looking at is the end product of the entire process of development.

The PIRT does not extend to long-range cooling for LOCA/ECCS and containment and must do at the design certification stage. This is one of those caveats that we put into the SER that must be met by the applicant when they come with a design certification. The PIRT is fine as far as it goes, but it does not cover long-term coolant.

The testing program was reviewed and here

I've listed only those tests that are integral tests. There are a number of other -- Dr. Rao showed you at the first, in his first presentation which include separate effects and component tests. We're only concerned right now to focus on the integral system test. You can see that through the GIST, GIRAFFE, PANDA and PANTHER tests that we have a range of integral systems.

Dr. Shiralkar showed you his figure number 3 which gave the phases of the LOCA transient for ESBWR and the test programs and how those test programs cover. If you look back at that figure you'll see that for every phase of the LOCA in the ESBWR, there are at least three facilities providing data and in some cases such as in the GDCS phase, there are as many as five facilities at each point providing data which can be used to assess the capabilities of the code or analysis of the event.

This kind of coverage of the test program at various scales indicates to us that they have provided for all the parameters expected in the SBWR and the ESBWR, that the test program is applicable to the ESBWR and that no further testing is indicated for TRAC-G qualification or LOCA in the ESBWR.

VICE-CHAIRMAN WALLIS: Hold on a minute

now.

MR. LANDRY: We did want to point out that there was a program called PANDA-P which was performed after the closure of the ESBWR in 1996. This is a program that was a mock-up done by the European Community at the Paul Scherrer Institute in Switzerland, mock-up of the ESBWR. So it's an ESBWR-specific program.

But because that program was not done under the auspices of General Electric, it does not necessarily meet the QA requirements and therefore we're saying that if they can show that the code is qualified without the PANDA-P program, then it can be used for confirmative purposes. But we are now allowing it to be used for assessment purposes.

And after review of the test program, the Office of Research, and we agree, that yes, the test program that has been proposed without PANDA-P is sufficient for demonstration of qualification of TRAC-G. So that PANDA-P can now be used for confirmatory purposes.

MEMBER ROSEN: Ralph, my question has to do with this last bullet on the slide that no further testing is needed. And if you go back one slide, would you go back just one slide? Look at the last bullet on this slide. It says that the PIRT does not extend to long-term cooling.

Now isn't it possible that when the PIRT is extended for long-term cooling that new testing will be provided?

I mean how did these two bullets line up? They seem contradictory.

MR. LANDRY: There is the possibility. However, when we look at long-term cooling, because of the phenomena that normally occurred during the long-term cooling phase, we do not expect to see phenomena that have not already been assessed within the code. This is primarily a single phase process when you get into long-term cooling. You're not governed by boiling. You're not governed by two-phase flow or the very severe heat transfer processes. So we do not anticipate at this point that there would be phenomena identified for the long-term cooling phase which have not already been assessed in the prior phases of the analysis.

MEMBER ROSEN: But go with me on this one. What if there were? Then that statement on your next chart would not be correct, right?

MR. LANDRY: Well, at this point, this is one of those lawyer-type words, no further testing is indicated. That doesn't mean absolutely, categorically no further testing would ever be required. But at this point we see no indication of a need for further testing. If that indication was shown to be necessary, then of course, at the design certification stage we could say it would need more testing.

MEMBER ROSEN: Why wasn't the PIRT completed? Why was this piece left over?

MR. LANDRY: General Electric would have to address why they cut the PIRT off when they did, but from our examination of the PIRT and our examination of the event, we do not foresee any phenomena that would be new --

MEMBER ROSEN: You're telling me the answer to the PIRT, what the PIRT --

MR. LANDRY: Let me ask Dr. Shiralkar to respond.

MR. SHIRALKAR: This is Bharat Shiralkar. The long-term cooling phenomena was considered, but not a detailed PIRT was developed for it. It's simply a matter of an inventory balanced in long term to make sure that the volume is such that the liquid is up to the right levels.

So it's backed by a few and it will

probably depend on the final design, but it's not something that involves new phenomena.

MEMBER ROSEN: You're also telling me the answer to the PIRT, the long-term cooling. I think I share your view that I can't think of any phenomena that might be -- that will need to be tested for long-term cooling, but that's the function of the panel, isn't it, to decide that?

So there's a presumption ahead of the fact that it may be okay because that may, in fact, turn out to be the way it is.

MR. LANDRY: But we have left that door open that they must complete the PIRT with the long-term cooling phase at design certification and it will be reviewed.

Looking a little bit at the testing program, Bharat has already shown a lot of the results of the testing program. I'd just like to look at one and I realize this is fuzzy. This is from a cut and paste through several processes to remove the material that's proprietary.

If we look at the performance of the PCCS as data were obtained through the PANTHERS/PCC test, we overplotted, would be the error in steam flow expected for a GDCS line break and the air and steam flow through PCCS for main steam line break. And we can see all the data -- all the test points, there are test programs or test groupings. We can see that the test groupings at the PANTHERS/PCC facility has obtained data that really encompasses all the anticipated phases of the LOCA at the ESBWR.

And as Bharat has pointed out, the PCC test were at a facility that is nearly full scale, so these are very large scale tests that pipes are the same size diameter. The headers are the same size. The lengths are the same size. It's just the number of tubes that are not the same as for the ESBWR.

VICE-CHAIRMAN WALLIS: Could you go over what the vertical axis is here?

MR. LANDRY: This is Air Mass Flow Rate.

VICE-CHAIRMAN WALLIS: Oh, I thought you said something about error.

MR. LANDRY: No, air.

VICE-CHAIRMAN WALLIS: Air mass.

MR. LANDRY: That's one of those things that will appear in the transcript as error mass flow rate.

VICE-CHAIRMAN WALLIS: Air. It's air.

MR. LANDRY: Air, A-I-R.

MEMBER ROSEN: Now I would have concluded that these tests don't cover all the data. Look at all of the points that are not in the shaded volume. What does that mean?

MR. LANDRY: These are tests --

VICE-CHAIRMAN WALLIS: The points are the tests.

MR. LANDRY: These are test groupings. These are groups of tests.

MEMBER ROSEN: Right.

MR. LANDRY: And groups of tests that up here in the unexpected region, so that there's a large volume of data maybe not hitting every single point on each line, but there are a lot of test data in the regions where we expect the PCC to be operated.

MEMBER ROSEN: So you're saying that the data that's significant is in the shaded area.

MR. LANDRY: Right.

MEMBER ROSEN: All the other data, although there were tests done, it doesn't yield data that's significant to the important region.

MR. LANDRY: That's correct, but it does give you data that you can test and see how your code does in those regions also.

VICE-CHAIRMAN WALLIS: You're saying the data has to be -- cover a bigger power than that than the region.

MR. LANDRY: That's correct.

VICE-CHAIRMAN WALLIS: If you're interested in it, because if the data covered the smaller part of the map in the region you're interested in, then you'd have some concern.

MR. LANDRY: You don't know where your boundaries are. And you don't know how your capability is to predict those boundaries.

The scaling analysis gave us a great deal of difficulty. On this, I would like to point out that this review was done over a fairly short period of time and the only reason we got through this review in that kind of time frame was because of the level of cooperation which we received from General Electric. We had for long periods, we had weekly phone calls. We had a great deal of interaction, a lot of questions back and forth and we received extremely good cooperation from General Electric through this whole process.

And the scaling in particular, received a very high level of scrutiny. The original scaling report the staff found to be very deficient. General Electric went back and redid the scaling, using a much more rigorous scaling analysis based on a method that was developed by Marino diMarzo from the University of Maryland and research staff. Developed a procedure for doing a scaling analysis. That procedure was applied by General Electric in the GDCS initiation phase. This is the most critical phase of the LOCA for the ESBWR.

They considered multiple volumes in that analysis. The system meaning equations with interactions. They looked at comparison of results with data and calculations in non-dimensional space. And this should be Pi, not Ps, where the resulting Pi are different in form and value from the original submittal and the trends in the magnitudes suggest though that the data is relevant and sufficient.

VICE-CHAIRMAN WALLIS: There's still the issue of not matching all the Pis. You never can match all the Pis.

MR. LANDRY: No.

VICE-CHAIRMAN WALLIS: And if a Pi should be 1 and it turns out to be .6, there's always a question about well is that good enough. So some sort of judgment has to be exercised and the use of this scaling type analysis.

MR. LANDRY: That's correct.

VICE-CHAIRMAN WALLIS: And some sort of

assessment of how wrong you might be if the Pi is not quite what you want it to be.

MR. LANDRY: We wanted to point out -- let me ask Dr. diMarzo to make a comment.

MR. diMARZO: Marino diMarzo. I can clarify exactly what Graham, you are saying here is exactly the efficiency that was revealed there. There were, so to speak, distortion, if you wish in the Pis and we couldn't figure out what would have been the effect of such distortion among the different facilities and therefore we tried to tell them that their link is distortion to the figure of merit being the minimum vessel inventory before GDCS injection. That was vigorously done and basically we demonstrated essentially that these distortions were irrelevant in the range that they were having to the figure of merit.

VICE-CHAIRMAN WALLIS: Okay, that's something that I don't know that we've seen in detail.

MR. diMARZO: Right, because originally they started saying one third three type of thing for all this stuff?

VICE-CHAIRMAN WALLIS: Yes.

MR. diMARZO: We said that's too --

VICE-CHAIRMAN WALLIS: Too gross a

criteria.

MR. diMARZO: No, but besides, you can have a distortion that's off by 10 percent and causes a disaster. You can have a distortion that's off 200 percent and causes nothing.

VICE-CHAIRMAN WALLIS: Right.

MR. diMARZO: So we had to do that and they did that.

MR. LANDRY: So the end result was that from the new scaling analysis which was performed, that the trends and magnitude suggests that the data are relevant and sufficient, the database is sufficient and relevant for code assessment and that the scaling analysis is rigorous, however, it's limited in scope at this point because it's limited to just the GDCS initiation phase.

Code documentation. This has been a sore point for at least 20 years now and continues to be a sore point. General Electric has provided a very, very large quantity of documentation for this review, but that documentation comes from the ESBWR design review that was terminated in 1996 as well as the ESBWR specific documentation provided for this part of the review.

The review of the code documentation

disclosed numerous errors, omissions which General Electric has committed to address in a revised TRAC-G model description topical report. And that revised documentation must be submitted within 90 days of issuance of the TRAC-G SER.

I'd like to address just one aspect of the ECCS models at this point.

MEMBER ROSEN: You're requiring the revised documentation after you get the SER?

MR. LANDRY: That's correct.

MEMBER ROSEN: A priori, I would have said before.

MR. LANDRY: No because --

MEMBER ROSEN: Normally --

MR. LANDRY: There are things in the SER that they have to see.

MEMBER ROSEN: Pardon me?

MR. LANDRY: There are things in the SER that they have to see, also in the process of revising their documentation. And they can't see the SER until we're ready to release it.

MS. CUBBAGE: We reviewed the information they submitted in response to REIs and they have to incorporate that information in the approved version of the topical reports which is typically done after we approve the SE.

MR. LANDRY: Dr. Shiralkar addressed a couple of the particular models such as critical flow. I'd like to look at now the level tracking model. When we looked at the models in the code, a number of those models we found code comparisons with data that we said okay, that looks good enough and the question always come up how good is good enough?

When we looked at things like CCFL, we said that the average deviation was less than the measurement error. The same for the two phase level swell. The data were within and were consistent with the errors in measurements and you can't expect a code to be any better than your error in measurement. Some others, the critical flow model bounded the measured -- predicted -- bounded the measured data. We looked at the error rate in interfacial sheer and wall friction and found that those error rates were all at an acceptable level, acceptably low.

We looked at another axes-stripped plot to be nonproprietary. This is from one of the PSTF tests. We looked at the level versus time and you can see that the TRAC-G plot with the data. Again, the TRAC-G prediction is pretty well picking up what the data showed to be happening in this test.

Another --

MEMBER POWERS: I understand there are two ways to look at that plot. One is hey, it's pretty good. And one is, hey, it's horrible. The peak is wrong, the slope is wrong, the breadth of the peak is wrong.

MR. LANDRY: The peak, when it's going up is going up and when it's coming, it's coming down. It's not terribly far off and when we look at -- that was only one test. When we looked at some of the other tests.

MEMBER POWERS: What I'm trying to ask is how do I know that's pretty good?

MR. LANDRY: You can't do it just on one test. You have to look at a number of tests. If you look at a number of tests, then you say is overall the code doing a good job. Here, the code is coming up to the -- pretty close to the same level swell value as a peak. When it drops down it's coming down pretty close to the same lower level.

MEMBER POWERS: It's similar to the magnitudes.

MR. LANDRY: The magnitudes are similar.

MEMBER POWERS: The fact that that observed peak is broad is not nearly so important as you've got the height correct.

MR. LANDRY: Got the height correct and you're coming up when you're coming up, here you're leveled off, but when you're going down, when you're going down, you're not going up when the data are going down and vice versa.

VICE-CHAIRMAN WALLIS: I think what you really want to say eventually in this kind of a comparison is that the uncertainties which are displayed here, the difference between the data and the predictions of uncertainty and how well you can predict are properly -- feed into some analysis of uncertainty and that they are within the range which is acceptable for some ultimate uncertainty and figure of merit such as a level in the chimney or something. That's what we'd like to see, I think, is some sort of quantitative measure of uncertainty that's compared with this uncertainty we see here and it feeds right through the whole analysis to the end and then you know how uncertain you are in some figure of merit.

I think that's what we'd like to see, not just a qualitative description that it looks okay.

MR. LANDRY: And the greater uncertainty you have here, the greater that uncertainty --

VICE-CHAIRMAN WALLIS: There might be the uncertainty and level of that amount is really critical in whether or not the core is cool.

MR. LANDRY: That's correct.

MEMBER KRESS: Well, you know, what I would like to see when I see a curve like that is an explanation of why they differ. I'm sure this has to do with the level swell model, probably. I'm not sure, but I would guess that and I would like to see some twitching of the code a little bit to see certain parts of it to see if I can reproduce this curve so I could have some assurance of why that I know why they differ.

MR. SHACK: Well, how about error bars in the data?

MEMBER KRESS: Well, that would be useful, but you know, this data I probably -- pressure gauges and so --

MR. SHACK: It's very good.

MEMBER KRESS: Yes, that could have some pretty good error bars though.

MEMBER ROSEN: Ralph, I think you need to be a little more careful about what you say is that the data is going up when it should be -- when the TRAC-G says it's going up and going down -- that's not true across the whole spectrum here.

I can show you where the slope is positive on the slope for data and negative on the TRAC-G at the same instant.

MR. LANDRY: I'm just making a general statement right now. We have to look at more tests than just this one though. This was a different test. You can see the data and the code are even lower over much more of the range.

MEMBER KRESS: That's a small break?

MR. LANDRY: I don't know which test this is. I just randomly pulled several tests just to not try to bias what I was showing.

Another PSTF test that was performed. But in addition to looking at the tests, sensitivity studies were performed on the level swell model. This is a sensitivity that was performed for one of the tests, 580115, whichever test that was, looking at different nodalization. And you can see that except for the one case where the four node case, 81529 node cases, almost like right on top of each other --

VICE-CHAIRMAN WALLIS: Where are the data here?

MR. LANDRY: This is just looking at the sensitivity to normalization without comparing --

VICE-CHAIRMAN WALLIS: We can't make this a judgment of that going up and coming down at the same time. There's no data here.

MR. LANDRY: Right. This doesn't have the data. This was a plot to look at the effect of nodalization.

VICE-CHAIRMAN WALLIS: It would be interesting to see if by improving the nodalization you can come closer to the data or something. That might be a useful message.

MR. LANDRY: We just wanted to show on this that when the sensitivity is done to nodalization that we see that nodalization is very insensitive.

VICE-CHAIRMAN WALLIS: Is the trend monotonic? As you have more nodes you get closer to the data or do you get further away from it?

MR. LANDRY: I don't know where the data lie initially.

VICE-CHAIRMAN WALLIS: That would be something to know, too.

MR. LANDRY: We don't have a plot where we're plotting the data.

An additional sensitivity was done looking at time step size and here this is part of that same test, varying the time step over a range of five shows that almost insensitive to time steps.

VICE-CHAIRMAN WALLIS: We don't know the time on the X axis, so it's a little hard to compare this, but if things are only happening over a period of a minute, then .05 seconds is not going to --

MEMBER KRESS: This is probably about a 10 minute range, you would say?

MR. LANDRY: I don't know if I can say.

MEMBER KRESS: The blow down phase is like 10 minutes.

MR. LANDRY: I'd have to ask General Electric what I can say.

VICE-CHAIRMAN WALLIS: The message here is the staff has itself been running these runs, right?

MR. LANDRY: These runs were run by General Electric.

VICE-CHAIRMAN WALLIS: Oh, they were run by General Electric. They weren't run by you. Do you run tests like this yourself?

MR. LANDRY: We did runs looking at the LOCAs themselves and --

VICE-CHAIRMAN WALLIS: But you did this on a sensitivity test yourself, with that code on certain things that mattered?

MR. LANDRY: These, we did not do. We did tests looking at the effect on thermal margin and effects on --

VICE-CHAIRMAN WALLIS: That would be more important evidence than this.

MR. LANDRY: Containment models --

VICE-CHAIRMAN WALLIS: Is it possible for you to show that evidence at some time?

MR. LANDRY: We don't have that.

VICE-CHAIRMAN WALLIS: You don't have that?

MR. LANDRY: We've done sensitivities, but not on specific models such as level swell.

VICE-CHAIRMAN WALLIS: But you said, no, you said you did sensitivity studies on the more important question of what's the effect on some safety parameters, didn't you?

MR. LANDRY: On thermal margin.

VICE-CHAIRMAN WALLIS: Right.

MR. LANDRY: We did studies on thermal margin. We did studies on --

VICE-CHAIRMAN WALLIS: That seems to me is the more important message. There's a more important message there than what we just saw. I just wondered if you wanted to show that after lunch or something. At some date, give it to us or something. That's a more important -- just maybe we don't need it now, but that would be a more important piece of evidence for the Committee, I think. Maybe at the design certification stage, we'll look for that kind of thing.

MR. LANDRY: That's workable. PCCS performance. I don't want to say too much on this because Bharat already went into a great deal on the PCCS performance and comparisons.

Just we'd like to point out that the tests that were performed indicate that there's full condensation of a steam.

VICE-CHAIRMAN WALLIS: Full condensation? What's that mean?

MR. LANDRY: It's super heated steam. There's no --

VICE-CHAIRMAN WALLIS: You never condense all of the steam if you've got non-condensables.

MR. LANDRY: But you can have a humid non-condensable coming out.

VICE-CHAIRMAN WALLIS: Yes.

MR. LANDRY: But you don't have super heated steam in it.

VICE-CHAIRMAN WALLIS: Yes, but full condensation.

MR. LANDRY: By full condensation, we mean super heated steam.

VICE-CHAIRMAN WALLIS: It's like the issue we had in the subcommittee about 100 percent condensation. It's not a meaningful expression. We've berated you for that or GE for that and now you're saying full condensation. That's the same thing.

MR. LANDRY: But we're trying to put a caveat on it and say that we're talking about super heated steam. You no longer have super heated steam coming out.

VICE-CHAIRMAN WALLIS: It's quite a different statement.

MR. STAUDENMAIER: This is Joe Staudenmaier, Office of Research. There isn't full condensation of the steam. They do have measurements of how much steam goes through and goes into the suppression pool at the conditions.

VICE-CHAIRMAN WALLIS: So avoid these sort of statements. Or maybe you put that in just to get us irritated.

MR. LANDRY: I wanted to see if you were reading it.

(Laughter.)

I wanted to see if you catch that subtle change in words.

We looked at TRAC-G versus PANTHERS test results and I think this is a different test than Bharat showed. This was from test 15, looking at the efficiency. You can see that the efficiency of TRAC-G prediction versus PANTHERS was very good.

VICE-CHAIRMAN WALLIS: Now we can assume, I think, that the efficiency scale is not from 0 to .1, so that the efficiency of these things is terrible?

Whatever the scale may be, it's showing up good efficiency?

MR. LANDRY: Yes.

VICE-CHAIRMAN WALLIS: It's something like 90 percent or something here?

MR. LANDRY: It's very good efficiency. We looked at the delta P comparison, TRAC-G and the test data were very close.

VICE-CHAIRMAN WALLIS: This is where I go to my colleague, Dr. Powers' question. Yes, it looks fairly good, but is this difference in delta P you're showing here important? If there's more pressure drop in PANTHERS in TRAC-G, does that have some adverse effect on the ability of the system to survive?

I think Bharat would say well, it's such a small difference compared with the overall pressure we're interested in or something, but it doesn't matter. You've got to make that comparison.

Just looking at the figure doesn't tell you whether being off by a factor of almost 2 at delta P halfway along there matters or not.

Do you have some assurance that this deviation doesn't matter?

MR. LANDRY: We looked at the overall containment performance, overall calculations are very conservative, so our conclusion is that this does not matter.

Bharat, would you like to add something?

MR. SHIRALKAR: Yes. This is Bharat Shiralkar. The only important criteria here is the difference in submergence between the main vent and the PCC vent. That pressure difference is of the order of about 8 kPa or so. So as long as a very small fraction of that, it really doesn't matter. You're not in any danger of uncovering the main vent.

That's the criteria that we used.

VICE-CHAIRMAN WALLIS: So you're saying this small difference is small compared with some driving pressure or something?

MR. SHIRALKAR: That's right. The

pressure that would cause the main vent to uncover.

MR. LANDRY: The uncertainty determination valve, we presented this to the Thermal Hydraulic Subcommittee. We'd like to point it out again here that previous submittals of TRAC-G which we've reviewed for application of the operating fleet AOOs included an uncertainty analysis that was very rigorous and very sound. This is an analysis that was termed a normal distribution one-sided upper tolerance limit statistical method. It's an extension of order statistics. It's extending the order statistics assumptions to the point of saying that the output variable or metric has to be shown to be normal.

We found that that methodology was very good. When we reviewed the LOCA submittal for ESBWR, however, what we saw was a statistical methodology that wasn't a statistical methodology. What General Electric has done is taken all of the parameters that are being calculated, borrow the LOCA, place them at their two sigma, should be limits, to define the limiting case, rather than running a set of cases as you would do with order statistics or the normal distribution approach. They were only running one case because they're setting all of the parameters at their two sigma limits. And by doing so, they're not using a variation of parameters. So it's not a rigorous statistical methodology. It does, however, come down to the end of saying that the success of the calculation with the parameters set at their two sigma limit is determined by the minimum static head in the chimney.

When we looked at the analyses that were done and we'll have a plot later that shows the peak cladding temperature, if we get to it, predicted by the codes, we can see that the peak cladding temperature that is predicted is the operating temperature of the fuel. The core never uncovers. The core stays covered by a considerable amount. The level in chimney indicates a considerable coverage so there's never any core heat up, so the criterion that are listed in 5046, as you have to have a PCT under a certain amount and limits on clad oxidation, etcetera, really are I hate to say meaningless, but they really don't have much use in this design because you don't' ever heat up the core beyond the normal operating temperature.

VICE-CHAIRMAN WALLIS: Let me just ask you about this limiting case. I think what you mean is that you take all these parameters to the two sigma value. It's not really a limit because there is something beyond that and you use these two sigma limits to find out what's the worse thing or what's the extreme you could get if you went to all of these two sigma values.

MR. LANDRY: That's correct.

VICE-CHAIRMAN WALLIS: That's not really a limiting case in the sense that it couldn't be worse than that, because there's always a bit beyond the two sigma which would let you go further.

So it's not limiting in the sense --

MR. LANDRY: This was not taken to the point of what do we have -- what conditions do we have to have to --

VICE-CHAIRMAN WALLIS: But you see what I mean. To use the word limiting is a little misleading here.

MEMBER KRESS: I would have thought you would have shifted your criteria from the 9595 on peak clad temperature and called it 9595 on uncovering the core. You know you're there if you do that and you have to have some sort of relationship between the two sigma

--

VICE-CHAIRMAN WALLIS: And 95 --

MEMBER KRESS: 9595. I don't know how you get that without a proper uncertainty analysis. I don't see any rigorous way to take two sigma parameters and assure myself I've got a certain level of confidence.

MEMBER POWERS: It seems to me that you have no idea where you are. You're in outer space someplace.

MEMBER KRESS: That's exactly right.

MEMBER POWERS: I mean if I have a simple process with two uncertain parameters once of which exacerbates the situation and one of which ameliorates the situation and take it to two sigma, I'd probably end up about average.

It seems to me you want to do a Monte Carlo or something on this and look at what your 95 percentile really looks like rather than arbitrarily taking things out to two sigma. I have no idea what you're getting at.

MEMBER KRESS: That would be my -- I don't know what it means. I don't know what the margins are.

MEMBER POWERS: It certainly doesn't provide you any comfort.

MEMBER KRESS: Right.

MR. LANDRY: This very well may be a

question that can be asked at the design certification stage, but --

MEMBER POWERS: It will be.

MR. LANDRY: This is a question for the design certification stage, demonstrate the limit on the chimney level because at this point we have to come back to the focus of the review. The focus of the review is the capability of a computer code to analyze the LOCA.

Now --

MEMBER POWERS: But see, our difficulty is --

MR. LANDRY: You get to the point of what is the actual limit of the level in the chimney. That's really not a code issue at this point. That's an issue once you have the actual hardware design.

MEMBER POWERS: But Ralph, you see the difficulty I'm having here is you take everything up to this two sigma, because you have ameliorating things and exasperating things, you may not have exercised the code in any extreme. You may be sitting just where you were if you took them all to mean value.

VICE-CHAIRMAN WALLIS: It's how they combine. But I think what I understand they did is they took the value, estimate value of these various parameters and they took plus two sigma and the minus two sigma. So they've got three things and then they take the whole spectrum of answers they get from all these three different inputs, whereas in the parameter, nonparameter statistics, you take a distribution, use Monte Carlo sample. Here, they're sort of sampling between these three things and not the whole continue of the distribution.

MR. LANDRY: That's correct.

VICE-CHAIRMAN WALLIS: And again, there's a question of how does the plus sigma and one thing combine with minus sigma and the other to make it better or worse. I think that's a key question that they really didn't answer very well in the supplement.

MR. LANDRY: That's correct. And that's the kind of question that we will probably be asking when we get to the design certification stage to go back and do a parametric study.

VICE-CHAIRMAN WALLIS: And I would guess that the staff would also do this sort of statistical or sensitivity study.

MR. LANDRY: We'll look at more studies --

VICE-CHAIRMAN WALLIS: But not quite in such a rigorous complete way, but just to make sure that things were being reasonable.

MR. LANDRY: I think an important part of that is that by specifying a sigma and a mean, you really can't do the nonparametric analyses because you don't know what the distribution is.

VICE-CHAIRMAN WALLIS: It's an approximation. If it were normal, you might have a better understanding of what you were doing.

MR. LANDRY: Right. It doesn't have to be normal. All you have to understand to do a parametric or a nonparametric statistical analysis is the probability distribution function of each of your parameters.

VICE-CHAIRMAN WALLIS: I think the problem is that if you have say an estimate that something is a hundred and your two sigma gives you 80 to 120, it might be that 110 is the worse case. There are all kinds of things you can argue about.

MR. LANDRY: That's why you do a parametric study.

VICE-CHAIRMAN WALLIS: Or you do the random thing over the whole distribution.

MR. LANDRY: Continuing with the uncertainty analysis, the containment response was evaluated as a bounding condition. The staff has raised questions about the realistic plant evaluation that is performed in this manner and we will probably have more questions when we do the design certification about performing parametric studies to properly evaluate the operation of the plant itself.

The staff finds the General Electric method acceptable due to the predicted lack of core uncovery. However, should at the design certification stage it be found that the ESBWR core does uncover or heat up, then a proper statistical analysis will definitely be required.

Some of the independent calculations, I'm trying to race now to get into the --

VICE-CHAIRMAN WALLIS: You've got 10 minutes to finish up here. I think you can do it.

MR. LANDRY: We've looked at a lot of cases, a total of 28 cases broken down into 10 areas. I'd like to focus today on just the main steam line break and GDCS line break cases that we ran because we ran these cases ourselves with TRAC-G and with the trace contained link code.

VICE-CHAIRMAN WALLIS: The message here is that when you are doing the top things and only TRAC-G, you're comparing it with data and when you don't have data you're comparing TRAC-G with trace or contain or whatever.

MR. LANDRY: Such as the gravity preservation. When we did that, we were comparing TRAC-G with the hand calculations.

VICE-CHAIRMAN WALLIS: Okay.

MR. LANDRY: With the hand calculations. We distributed to the Committee what we performed in that calculation.

If we look at the GDCS LOCA, the break mass flow rate looking at trace and contain, or trace, contain and TRAC-G, one of the questions that we brought -- that came up during the discussion with the applicant and with the Thermal Hydraulic Subcommittee was the TRAC-G blip in break flow.

General Electric has gone back and examined that further and they found that the problem there was the way they were nodalizing the GDCS line coming off. They were using one node. They went back and increased that to four nodes and this just blipped one away and they're now getting the same response that TRAC-G is getting or trace -- TRAC-G is getting the same response as trace.

VICE-CHAIRMAN WALLIS: Now the beginning of this trial, the comparison isn't very good. I guess you'd argue that that it's sort of an integrated flow that you care about. You're depressurizing the system and so it's good enough. But in terms of saying that both codes sort of agree, that's not a very good agreement in the first --

MR. LANDRY: They don't overlay, but we do see that both are ramping up similarly and dropping, but the timing is off. This is another of those points that we're going to have to look at further.

VICE-CHAIRMAN WALLIS: And the flow rate differs at the beginning significantly, so there's something different about a critical flow model or something?

We can go on forever here, but I guess it goes back to all of these questions we had earlier. When is the deviation significant and when isn't it?

MR. LU: This is Shanlai Lu from Reactor Systems. And the calculation performed by trace and contain for the initial probably 200 seconds, and it's very significantly determined by the initial steady state and right now, we are in the process to rerun the initial steady state, trying to identify what you're going to need, issues related to that. Because we do have a much quicker DPV opening, early opening.

VICE-CHAIRMAN WALLIS: This is an on-going process?

MR. LU: Yes.

MR. LANDRY: If we look at the downcomer collapsed level, this is the top of the active core. If you look at the downcomer level predicted by both trace and TRAC-G, you see very similar results.

Looking at the chimney collapsed water level --

VICE-CHAIRMAN WALLIS: This is the important measure, probably of safety, isn't it?

MR. LANDRY: For the LOCA at this point, the chimney level is the measure of safety. We see both codes predicting the chimney levels so you come down to the minimum pretty close to the same point at the same time.

VICE-CHAIRMAN WALLIS: It looks as if they get some event wrong at about -- as they're coming down, but otherwise it looks reasonably good. There's cliffs, it goes through two cliffs there. It looks as if some event occurs --

MR. LANDRY: They both do, but at different times. There must again, going back to my colleague, Dr. Kress' point, you understand what's going on and why there's a cliff.

MR. LU: It drops simply because of the DPV open --

VICE-CHAIRMAN WALLIS: It's the event that occurs?

MR. LU: Yes, that's the event that occurs.

VICE-CHAIRMAN WALLIS: If there were nothing to cause that, you'd be suspicious. With just a code doing it erratically that would not be a good signal at all.

MR. LU: You're right.

MR. LANDRY: Looking at the mass flow rate through the break, this is for the main steam line break. We again see TRACE, a high flow, higher flow than TRAC-G, but the two come down and stay together for almost the whole time.

Looking at the GDCS injection mass flow rate for the main steam line break, then the two codes are fairly close, come up at the same time. TRAC-G showing just a little bit more flow as the peak.

The peak cladding temperature is a problem. This is the trace prediction of PCT.

VICE-CHAIRMAN WALLIS: It never goes up.

MR. LANDRY: You see the PCT? Well, right at the break time jumps just a little bit and then immediately comes right back down, levels off very quickly. So there's no excursion --

VICE-CHAIRMAN WALLIS: Goes up in the beginning because you've still got the heat supply and you've done something that tweaks the heat close.

MR. LANDRY: You have that slight delay with the reactor scram hitting it.

This is a comparison of two trace runs, the trace run for the main steam line break and for the GDCS line break to show that yes, indeed, the GDCS line break does come up with a minimum water level in the chimney, but keep in mind that what would normally be zero is two meters.

VICE-CHAIRMAN WALLIS: Something very weird that happens with that jiggle at 600 seconds. The water leaps up and leaps down. That's not going to happen, is it?

MR. LANDRY: Shanlai is looking at that.

MR. LU: Yes, we are looking at that right now.

VICE-CHAIRMAN WALLIS: I should hope so. You've suddenly created a measure of water from no where.

MR. LANDRY: It's an instantaneous blip.

VICE-CHAIRMAN WALLIS: Yes.

MR. LANDRY: So out of the staff's independent calculations we've run 28 cases looking at the LOCAs, main steam line break, GDCS line break plus those initial cases that we had listed.

The analysis results indicate that TRAC-G is capable of analyzing the limiting LOCA response of the reactor coolant system and the containment peak pressure and temperature.

VICE-CHAIRMAN WALLIS: And that's the -- this decision is made based on your judgment, looking at all these curves and all this evidence, there was a judgment made that TRAC-G is capable.

MR. LANDRY: This judgment is made on the basis of slide 2, the agenda.

VICE-CHAIRMAN WALLIS: All the slides.

MR. LANDRY: All those items --

VICE-CHAIRMAN WALLIS: You asked these questions. You looked at the evidence and you say in my judgment this evidence satisfies that need.

MR. LANDRY: That's correct. When we put all these pieces together, the testing program, the scaling, the calculations which have been supplied, the calculations which we've done, we've come to the conclusion --

VICE-CHAIRMAN WALLIS: Well, you're a wise and experienced regulator and I think that the Committee may well believe you, your judgment of these events, these things is right. I think one concern among many we might have if you retire, someone else is going to look at these curves and wiggles and may not have the understanding of how to interpret them and may not make a wise decision which is I think why we're trying to drive the staff in the direction of being more specific about the criteria area and how they're evaluated.

MEMBER POWERS: I thought we were going to require that he just not retire.

VICE-CHAIRMAN WALLIS: We can also require that he not retire, but also if he doesn't retire, it will be like ACRS members and his judgment may steadily deteriorate as he gets older.

(Laughter.)

MEMBER KRESS: Or he may die.

MEMBER POWERS: It's not allowed, Tom.

MR. LANDRY: Is this getting into the story of Henry VIII and talking about the cow?

VICE-CHAIRMAN WALLIS: No, his wives are the ones --

MR. LANDRY: Have you heard the story about Henry VIII --

VICE-CHAIRMAN WALLIS: Be careful, be careful.

MR. LANDRY: Supposedly a person came in and said Henry VIII was going to hang the guy the next day and the guy said well, look, if you don't hang me I can make this cow learn to talk. And another person said to this knave how in the world can you do something as rash as that? You can't make the cow learn to talk? He said no, but I've got a year to do it. In a year's time, I could die. In a year's time, the king could die. In a year's time, the cow could learn to talk.

(Laughter.)

You never know.

VICE-CHAIRMAN WALLIS: Well, is this your evaluation of a code ever taking that form when you go back to the vendor and say code X within a year might be able to predict something useful?

(Laughter.)

MR. LANDRY: No, we're saying at this point that the TRAC-G code including the application methodology is an acceptable evaluation model for the ESBWR loss of cooling accident analyses as presented in the TRAC-G application for ESBWR.

MEMBER KRESS: Does that bless the two sigma --

MEMBER SIEBER: Yes, it does.

MR. LANDRY: The staff therefore concludes that TRAC-G is acceptable for referencing during the design certification, review of the ESBWR provided the conditions specified in a safety evaluation are met. That is contained in that statement.

VICE-CHAIRMAN WALLIS: I wouldn't think it is blessing the two sigma. It's a tool which is used and you're not accepting the method of calculating uncertainties. You're accepting the fact that you can put in numbers into this code and you can get numbers out of it.

MR. LANDRY: When we get to the design certification stage we may very well say now we want to see --

VICE-CHAIRMAN WALLIS: Acceptable tool. You're saying this hammer is useful for construction purposes. You're not saying that all the details of how you hit the nails and all that sort is acceptable. Is that right?

MR. LANDRY: Correct.

VICE-CHAIRMAN WALLIS: Good, that's what I thought you were --

MR. LANDRY: Basically, the application methodology is acceptable. But when we look at the design certification, when we look at uncertainty analysis that has been provided, we may want further support for that uncertainty analysis.

This concludes the staff's presentation.

VICE-CHAIRMAN WALLIS: You've done very well. We're on the course. We agreed ahead of time that everything would happen exactly as the schedule -- you've done very well.

MR. STAUDENMAIER: This is Joe Staudenmaier, Officer of Research. There was discussion about lack of a reg guide for this type of application. There already is a reg guide for realistic LOCA submittals. I think it's 1.157. I don't remember the number exactly, but that's been around for quite a while, like 15 years or so.

VICE-CHAIRMAN WALLIS: And to think that you rewrote or you and some other folks worked on an improved reg guide.

MR. STAUDENMAIER: It wasn't meant to supersede 1.157. It was to apply to calculations other than LOCA calculations.

VICE-CHAIRMAN WALLIS: I see. Other than LOCA, it didn't include LOCA?

MR. STAUDENMAIER: It could be easily applied to LOCA --

VICE-CHAIRMAN WALLIS: It also included

LOCA.

MR. STAUDENMAIER: But there already was a --

VICE-CHAIRMAN WALLIS: Okay. That one has not come out yet, the one that I was complaining about?

MR. STAUDENMAIER: It's still in draft form.

VICE-CHAIRMAN WALLIS: I really cannot understand that.

MR. STAUDENMAIER: Neither can I.

VICE-CHAIRMAN WALLIS: Thank you very much. Does the Committee have more questions for Dr. Landry?

MEMBER LEITCH: I have, perhaps, a broader question that relates to the certification of these designs. I haven't been through this certification process before, but I guess what concerns me about this design is that in a current fleet of BWRs, the adequate -- I'm talking about normal operation now, not accident conditions. You have adequate flow and you pull the rods and they're critical and start to steam and so forth.

Do we have a code that takes a look at

this design where all the flow is natural and you begin to pull the rods, how do we know that there's no stratification of flow, that there's no localized hot spots in the fuel? Is there a code that addresses that? Is that something that is considered in a later phase of the design or is that something that we basically don't consider to be a safety issue and therefore we don't get into that?

MR. LANDRY: That will come up during the design certification phase. General Electric will have to at that point present their hardware design, the hard design of a facility, their operating procedures and so forth and all the support for and modes of operation.

At this point, this review was very focused on just the TRAC-G code, only for LOCA.

MEMBER LEITCH: I understand.

MR. LANDRY: So we did not get into that, but those are the kind of questions that would normally come up during the design certification phase.

MEMBER LEITCH: See, my concern is that with the current fleet, you've got adequate flow, plenty of flow, but I just wonder how we are going to gain the assurance that we're not going to have, as I say, some stratification or some localized heating of the fuel or some other strange phenomena going on there until the natural circulation is established.

Once we get over that hump and have good, natural circulation, it's easy from there, but how do we get started, I guess is the question I have.

MR. LANDRY: In this part of the phase, we start much later than that.

MEMBER LEITCH: Right.

MR. LANDRY: You're operating at full power.

MEMBER LEITCH: Right.

MR. LANDRY: And now what happens when everything goes wrong.

MEMBER LEITCH: Yes. So the answer to my question is good question, but too soon.

(Laughter.)

MR. LANDRY: It's a design certification issue.

MEMBER LEITCH: Yes, okay.

MEMBER SIEBER: Yes, it's 2007.

MEMBER KRESS: Keep that question in mind. We'll ask it again.

MEMBER LEITCH: I will.

MEMBER RANSOM: Ralph, given this memo

relative to the question I asked about, whether or not the hydrostatic pressures were calculated correctly, depending on where the connection was made on the 3D vessel, and I guess in my mind it's still an open issue because it came with a yes, TRAC-G does account to a certain extent for the changing elevation but it showed errors from minus 3.7 percent to 5 percent depending on where it was connected.

Experience in the past had shown that even those errors can result in significant recirculations under natural circulation conditions. And so I don't feel like that has been completely resolved. Your hand calculations show nowhere nor are the actual conditions under which these calculations were made, whether they're single phase or two phased, which might have some bearing on the significance of that error.

MR. LANDRY: We're going to continue that discussion with General Electric in trying to resolve what TRAC-G is going. This is something that we have to have on-going with them.

We were trying to determine in doing that hand calculation whether or not the gross error that TRAC-B had was present in TRAC-G or not.

MEMBER RANSOM: Sure.

MR. LANDRY: And in so doing, we've determined that no, that gross error is not there, that they are accounting for elevation relative -- elevation differences relative to the centroid of the donor cell. But whether there is still an error in that, yes, there is still an error from our hand calculation, but we want to continue that discussion with them.

So we were satisfied that yes, they are, they have gotten rid of the gross error. Now we're in the fine tuning stage.

MEMBER LEITCH: Ralph, at the conclusion of the subcommittee meeting, there were a number of open items presented. Unfortunately, I don't have that handout material with me.

MR. LANDRY: That's in your briefing book, by the way.

MEMBER LEITCH: Okay. Have those issues now been closed or is that subsumed in the statement that says provided the conditions specified in the safety evaluation --

MR. LANDRY: That's correct. Provided that all the confirmatory items and conditions in the SER are satisfied.

MEMBER LEITCH: So those six or eight

things that were mentioned there are subsumed in that statement?

MR. LANDRY: There are a number of items that must be taken care of at the design certification stage. They're really design certification issues and that's why we've tried to say the code is acceptable for reference in the design certification stage provided you do these.

And again, General Electric has not seen the SER at this point.

VICE-CHAIRMAN WALLIS: Well, I have one comment. One comment in my draft letter point out that your decision seemed to be based on the whole other proprietary information which was not available to the public so there was nothing in the record that showed you had actually compared some evidence with some predictions and so on.

And it seems -- and I suggested that it would really help in a public presentation like this that you and GE would agree to show some evidence that was acceptable in terms of proprietary matters and so on. And you seem to have anticipated that by doing it. There's at least to some degree, GE's been willing to show what previously was proprietary in some form and you've been willing to show by their agreement some evidence which previously was provided. That's a really good thing.

MR. LANDRY: Thank you.

MEMBER POWERS: That means he's learned to anticipate you. You're getting predictable in your old age.

MR. LANDRY: We understood your criticism or your comment at the subcommittee meeting and we've worked with the applicant to try to find a way in which they can present and we can present together material that would normally be proprietary in a way that it could be in the public record.

VICE-CHAIRMAN WALLIS: Thank you. Are we finished with this? Do I hand it back to you?

CHAIRMAN BONACA: Okay, thank you. Let's take a break now until 10:55.

(Whereupon, the proceedings went off the record from 10:41 a.m. to 10:55 a.m.)

CHAIRMAN BONACA: Let's get back into the meeting. The next item of the agenda is presentation of the South Texas Project cause investigation of reactor vessel bottom mounted penetration of leakage. And I believe that Jack is going to take us through that.

MEMBER SIEBER: Okay. Thank you Mr.

Chairman.

Before we begin with the presentation, I would like to give a minute to Steve Rosen, who has a conflict of interest statement to make.

MEMBER ROSEN: I think that's the statement, that I have a conflict with respect to the South Texas Project.

MEMBER SIEBER: Okay. So we will duly note that.

I will point out that the issue of bottom mounted reactor vessel penetrations has been with us for some time. The examination in South Texas, which is one of the early ones, occurred by licensee initiative, which was found, a very minor amount of that.

Those of you who watch and read the NRC Web site, you will notice that there is an updated LER on the Web site, which gives a lot of detailed information about conclusions from the examination and repair of these two penetrations. In addition, there was a special inspection team report and review of the staff evaluation of that. There is information, though, which I don't have, which I understand is also on the Web site that is in its infancy at this point in time.

So what I would like to do is to introduce our presenters from NRR. The actual presentation will be made by Matt Mitchell. And to introduce him, I will introduce Bill Bateman.

MR. BATEMAN: Thank you.

It is a pleasure to be here this morning. Again, my name is Bill Bateman. I am Chief of the Materials and Chemical Engineering Branch. With me is Matt Mitchell, a senior technical staff member of the branch. And also Matt was a member of the special inspection team that did investigate and review the South Texas event.

We have been before you, folks, I think two other times along the way. And the licensee has been here as well. I think most of you have a pretty good idea about a lot of particulars. What we are here for today I think is to close the loop on the root cause. Matt will do that.

The one thing that I did want to mention is, as you all know, we did issue a bulletin on this matter and requested that licensees inspect the bottom head penetration. So we have had at least one outage season since then, and there have been no other licensees that have found any similar-type indications at the bottom of their vessels. So, at least to this point in time, South Texas is unique.

So, with that, I will turn it over to Mr. Mitchell.

MR. MITCHELL: Okay. Thank you, Bill. I'll move to the first. You have two packages of slides: one word slides and one set of pictures. So I am going to sort of intersperse those throughout the presentation, and we will see how this works.

The last time that the staff was here to give the ACRS a presentation of this nature was July 11th, 2003. At that point in time, the South Texas licensee was sort of in the middle of their investigation and repair of the STP unit I vessel. They had completed their NDE campaign and had confirmed the presence of axially oriented flaws in two of the STP unit I BMI nozzles, numbers 1 and B-6. They had also repaired the two nozzles using a half-nozzle repair technique, essentially implementing an Alloy 690 half-nozzle from the exterior of the vessel. That was sort of the state of knowledge at the time we were last here.

I am going to skip over to the pictures just so that we can reorient ourselves one more time with what we are talking about in terms of a BMI nozzle.

This first picture sort of gives you the global cross-section of essentially a side hill nozzle in the bottom vessel head. You see the Inconel Alloy 600 nozzle, the Inconel welds, and its connection to the low-alloy steel RPP bottom head. This is again a slide you have seen before when we did the July presentation.

MEMBER FORD: And, just to make sure, the Inconel weld is 182. That is correct?

MR. MITCHELL: Eighty-two, 182, yes.

MEMBER FORD: One eighty-two root, then 182?

MR. MITCHELL: I believe so, yes. The next couple of slides, again, just to refresh our memories, I am going to show what the outcome of the licensee's ultrasonic inspections seem to indicate in the way of the flaw shapes in the two penetrations. The first one I will refer to as penetration 46, shows 2 fairly substantial axially oriented flaws running in the tube wall, one of them connecting between above and below the J-groove welds, which would presumably be the leakage path for the reactor coolant to get to the exterior of the vessel and leave the boron deposits, which were observed.

MEMBER FORD: Where is it shooting for the

UT from?

MR. MITCHELL: They are shooting from the inside. Yes. What they had done was they had developed tooling after off-loading the core. Getting the simple tubes out of the way, they would then come off the refueling bridge with a tool which would come down, lock onto the top of the BMI tube, and then send a UT probe down the inside of the tube.

CHAIRMAN BONACA: Now, the weld material you show as being intact?

MR. MITCHELL: Yes. And it is shown that way principally because UT results were unable to really interrogate the weld material. It was appropriate to claim that they had fully inspected the tube but the weld was somewhat impervious to penetration by the UT probe.

CHAIRMAN BONACA: So we don't know still to today?

MR. MITCHELL: Actually, I can speak to that in just a few minutes because we do have some additional information on that point.

MEMBER SHACK: We actually have a pretty high degree of confidence there was a cracked shape within the tube. They got a nice clean shot at this.

MR. MITCHELL: Yes, yes, absolutely. I am going to show penetration 1 in a second in this set of slides because it essentially has the same kind of information that the other slide had on it. It shows again a rather large axially oriented flaw.

But I wanted to draw in this sort of small red semicircle that you see on the overhead projection. That is my representation of what the boat sample or the material sample that the licensee took to do further tests and evaluation. I have a better picture of that. Your next slide shows a much better drawing of it.

Just so you can kind of get a better orientation of where that fits, that is the sort of shape of the boat sample that was obtained by the licensee.

Now I am going to go back to slide 3 in the word slide package. So at the time we were here last, the licensee was in the process of obtaining these boat samples or material samples from the penetrations. They were unable to get a sample from penetration 46. They did obtain a sample from BMI's penetration 1, in which they captured both the material of the tube and the material from the weld.

And the intent of where this sample was taken from was twofold: certainly to capture a section of the axially oriented crack to try to confirm the cracking mechanism responsible for the eventual reactor coolant pressure boundary leakage and to also attempt to capture what had shown up as discontinuities or anomalies in the UT probe inspection. These were anomalies at the interface between the weld and the tube and were believed to be lack of fusion zones that had occurred during fabrication.

Your next picture slide, which I think I am going to leave up there for the rest of the presentation, shows another good view of the boat sample that was taken, this gray sort of shaded area. It shows up better if you actually have the color printout, but the black and white isn't quite as good, and where that was taken from relative to the axial flaw and then some of the other features, which I am going to get to in just a moment.

The licensee obtained this sample and, of course, took it in or sent it to Framatone for destructive testing so that they could actually examine the cracked surfaces and other features within the sample. What they were able to confirm was that the axially oriented crack was completely inter-granular in nature within the part of the boat sample where they could obtain the flaw surfaces to look at, which would be consistent with primary water stress corrosion cracking being the mechanism of crack initiation and propagation.

They noted that the axially oriented PWSCC flaw in the tube was located at and connected to one of these discontinuities or anomalies which was observed in the UT scans. Those were, in fact, shown to be weld lack of fusion zones. That was confirmed as part of their analysis.

In this drawing, what I have outlined here in green shows up a little better as the extent of that axially oriented PWSCC crack. What I have tried to circle in blue is the lack of fusion zone.

Further, when they opened up this specimen, they found something which they had no indication was there. They found a small flaw, which is circled in red on the overhead projection, which connected the weld lack of fusion zone to the interior surface or the crown of that partial penetration weld. And it basically spanned a ligament of about 80 mls, or .08 inches, through the J-groove weld material.

This apparently permitted reactor coolant to transport itself from the interior of the vessel through this flaw and into the weld lack of fusion zone. The flaw in the weld was, in fact, exactly the same extent as the lack of fusion zone. So there is a reasonable understanding that the occurrence of those two features was connected, that they were interconnected in their appearance within the tube and within the sample.

I am now going to go on to slide 5 in the word package. The licensee attempted to determine the cause of this flaw into the J-groove weld material. But because the surface was heavily oxidized, they were unable to conclusively find out or make a case for how that flaw came into existence. They hypothesized that it might be due to hot cracking and/or fatigue mechanisms working to get that flaw to appear at that location.

They also determined that there was no significant inter-granular cracking of the J-groove weld material. They had obviously a rather extensive sample of the J-groove weld material as part of the boat sample. At most, they saw cracking of about one to two grains in depth around the border of where the weld lack of fusion zone was.

So there was nothing of any great extent to indicate that the weld material was, in fact, acceptable or had shown signs of initiation of primary water stress corrosion cracking. And it gets back to the point of the representations shown here of the flaw being entirely within the tube seems to be consistent, therefore, with the observations from the boat sample.

CHAIRMAN BONACA: Now, this boat sample section, you know, you introduced this now. Is it typical of the weld on all of the tubes that go in?

MR. MITCHELL: I'm sorry?

CHAIRMAN BONACA: You are showing here a boat sample section.

MR. MITCHELL: Yes.

CHAIRMAN BONACA: What is it?

MR. MITCHELL: That is the material sample. When I said they went and took an electric discharge machining tool in, in order to get this sample for further investigation, that is the sample I was referring to.

CHAIRMAN BONACA: Yes.

MR. MITCHELL: So they have essentially made cuts of that nature.

CHAIRMAN BONACA: I understand now. Right. I understand now. But that flaring of the weld material is typical of older welds for older penetration.

MR. MITCHELL: That would be typical, yes. So if I move to slide 6, based upon, then, the information that the licensee had at their disposal from the UT inspections of both penetrations 1 and 46 and the information obtained from the investigation of this material sample, the licensee proposed what they considered to be the most likely scenario for how the cracking at South Tex. occurred. And it goes that during initial fabrication, weld lack of fusion zones were created within the weld material or the weld-tube interface.

A flaw in the J-groove weld then occurs and connects this weld lack of fusion zone to the primary coolant sometime early in the plant's operating history and taking "early" as a very relative term because, really, based upon the information, you can't say exactly when that might have occurred.

Reactor coolant then floods the weld lack of fusion zone and creates all of the necessary conditions for primary water stress corrosion cracking. You have known susceptible material. You have a very highly stressed location due to the weld residual stresses. And you have the primary coolant in that location.

VICE-CHAIRMAN WALLIS: Is there some mechanism for concentrating boron? In other words, the concentration of boron in the crack is different from the primary water concentration. It could be temperature gradients or something which is causing diffusion or some sort of separation so that you get a more aggressive material in the crack than you get in the primary water.

MR. BATEMAN: Matt, the best way to answer that question might be when they took the boat sample out, if they found any additional boron in that crack zone. I don't know if we have that information or not. That would be the only way to really answer your question.

MR. MITCHELL: Yes. I think one could say that certainly you can get concentration gradients at locations like this. Whether that, in fact, occurred in this location, I can't say.

VICE-CHAIRMAN WALLIS: His argument was not "Did it happen?" but "Was there no mechanism by which it could happen that we might investigate, such as a temperature gradient or something that would create a more aggressive material."

MEMBER POWERS: It raises a really interesting phenomenological question. Has someone looked at the diffusion of ionic species, more ionic species and the combination of a concentration gradient and at the low gradient?

VICE-CHAIRMAN WALLIS: Yes.

MEMBER FORD: As a general question, yes.

VICE-CHAIRMAN WALLIS: Yes. You would expect there are different driving forces for diffusion. They are well-known.

MEMBER FORD: Tension-driven diffusion, convection.

MEMBER POWERS: He is asking about the normal diffusion of an ionic species. I mean, the answer is in general, yes, people have looked at thermal diffusion in ionic species, but have they looked at these ionic species in this gradient?

MEMBER SHACK: I think the answer is probably no. In the BWR, the diffusion is generally driven by the electrochemical potential, which gives you a fairly big drive.

MEMBER POWERS: Like half a volt.

MEMBER SHACK: You don't have that. In steamerators, we have the concentration, the boiling mechanism, which you have, those kinds of secondary crevices. You wouldn't have that kind of a crevice here. You would have a small thermal gradient here.

You would probably have virtually no electrochemical potential gradient.

So there would be a small thermal gradient. It is hard to imagine that much of a concentration.

MEMBER POWERS: I don't know the quantitative aspects of this.

MEMBER SHACK: One generally also sees the boron concentration has a fairly limited effect on the cracking of the Alloy 600. We get boron on the brain, and that is sort of important for carbon steel. But for these highly alloy steels, it is not major. But plain old primary water does a wonderful job with Alloy 600.

VICE-CHAIRMAN WALLIS: A "wonderful job," do you mean it damages it or it doesn't damage it?

MEMBER SHACK: Correct. You don't have to postulate too much in the way of an aggressive chemical environment. You are beyond the high stress. And primary water would do the job.

MEMBER POWERS: Where could I look at the thermal diffusion of these ionic species? It is hard on the ions for sure, but that is fairly geriatric.

MEMBER FORD: I agree with Bill. I find it hard in that particular scenario when you don't have any big potential drop, you are in a PWR environment, you are not exposed to the air on the outside, which is an initial issue on the DHB, you could concentrate the boron. I don't see how you get much of a concentration of boric acid in that crevice.

MEMBER SHACK: And even if you did, what difference does it make?

MEMBER POWERS: Well, I guess what I am struggling to understand is you obviously have some intuition on this. How did you get that intuition? And how do I go about getting that that intuition?

MEMBER FORD: Well, there are three mechanisms in a situation like that, if you get concentration of species, an ionic species, just by potential gradient, down the crack. We don't have that in this particular scenario.

Everything is done at a low potential. The crack tip and the bulk crack mouth, they are on the same low potential. You don't have a potential driving right here, like we would have in the boiling water reactor under the old operating conditions.

Conduction, I don't think that that is a big issue, particularly in diffusion. I don't think that is a big driver. So my first reaction is no, I don't see how you could get a boron concentration.

My other question arises, well, what else would give rise to that circumferential crack? If you did have an Alloy 82, the high chromium content in 82, as opposed to 182, you could conceivably have a hot crack in concentration.

So that is why I am saying you have got to be crazy to say, "hot cracking," a potential hypothetical argument for saying that that is the origin of that circumferential crack.

You asked what my thought process was. That was my thought.

MEMBER POWERS: The specific question was a thermal gradient. I think that was an example. It has been excused out of hand. I am trying to understand why it is excused out of hand.

MEMBER SIEBER: His original question here was, how does he get the information so that he can understand?

MEMBER FORD: Oh, I see. Any book on crevice chemistry would.

MEMBER SIEBER: Any book on crevice chemistry.

MEMBER FORD: I will give you the title of an accomplished proceeding on crevice chemistry. I will also send you a paper, another paper.

MR. MITCHELL: We are looking at the CRDMJ group weld from Davis Bessee. We are actually trying to make crack row specimens. We are having a hard time making crack row specimens because we get so many hot cracks. Every time we take a chunk of metal out to try to make a specimen, it comes from a hot crack. The fact that you have hot cracks here is not really terribly --

MEMBER FORD: This is why Bill and I keep on bringing up this question. As far as the chrome content, you go like Alloy 690 from 600 or 82 from 182. You are generally improving the storage room systems because of the increased chromium content and the effect that has on the chromium content in the green boundary. It also is adding a problem with relative weldability. You do not agree, Bill?

MR. BATEMAN: I agree. Industry has had problems making the 690 repairs.

MEMBER FORD: So you are trying to throw in there is the notion of one problem, stress corrosion cracking. You are putting it into another bin with the manufacturer.

VICE-CHAIRMAN WALLIS: Which was the material that this primary material does a wonderful job on? I didn't understand that what you meant by it.

MEMBER SHACK: It is susceptible to cracks.

VICE-CHAIRMAN WALLIS: Which material is that? Which is where in this picture?

MEMBER SHACK: The tube in the green.

VICE-CHAIRMAN WALLIS: So the tube is being made out of something which is very susceptible to cracking in primary water.

MEMBER SHACK: Well, it's not an issue. It wasn't thought to be an issue when they redesigned these things.

MEMBER FORD: Not initially

MEMBER SHACK: It wasn't the idea.

VICE-CHAIRMAN WALLIS: That doesn't sound good at all. So a "wonderful job" doesn't mean anything. I was thinking that it would fall apart in a week. It means you have to worry about it.

MEMBER SIEBER: Yes. It takes more than a week.

MEMBER FORD: I think you have got to look back to the era when these things were designed. Alloy 600 at that time period was state-of-the-art in terms of quantifying stress corrosion cracking assessment. It was not that great. It didn't have the experiments.

If you shove Alloy 600 into specialized water as it was experimental techniques existed in the '50s and the '60s, it wouldn't crack by a hell of a long time, but in our time frame, it was bad enough.

It wasn't until we got to the Curio in France and decided to do some experiments there. They initially said, "You have got to be kidding." But then you do more experiments. It is true. It will crack.

CHAIRMAN BONACA: The only question I have is lack of fusion is not an uncommon thing. It happens during welding.

MR. MITCHELL: Absolutely not.

CHAIRMAN BONACA: I guess I am testing the hypothesis that this is coming from lack of fusion. Very likely it seems like a reasonable scenario that is being developed. It tells me that you have susceptibility at the other plants.

MR. MITCHELL: In fact, as a result of the UT inspections that they did at STP unit I, they characterized lack of fusion in all 58 of the STP unit I BMI penetrations to some greater or lesser degree. In fact, the two that actually showed signs of cracking were not at the most extreme end in terms of having the greatest magnitude of apparent lack of fusion.

I think what this is trying to tell us is that the existence of this flaw, this flawed area through the J-groove weld that lets primary coolant get to that weld lack of fusion zone is, if you will, the critical controlling step in terms of getting at least this mechanism for PWSCC started. One could say that the other BMI penetrations at South Texas may, in fact, not have that feature, which would allow coolant to get into the weld lack of fusion zone.

MEMBER POWERS: Could I ask what quality assurance was applied to these welds when they were manufactured?

MR. MITCHELL: At this time when these types of welds are being manufactured, they were subject to dye penetrant examinations, root paths, dye penetrant, dye penetrant halfway up or half-inch up into the weld, and then on the crown once it was completed. That was the typical NDE that was applied to this type of a configuration.

MEMBER POWERS: And so we concluded that those methods are inadequate?

MR. MITCHELL: It apparently did not identify this configuration if this was, in fact, present since fabrication. If that was a hot crack or part of that flaw was initiated as a hot crack, apparently the dye penetrant exam was inadequate to find it during fabrication.

If it was, for example, subsurface, immediately after fabrication and popped through early in plant life, you might not have picked it up from the last dye penetrant exam that you did.

MEMBER SIEBER: Are there other UT examinations at other plants in these areas?

MR. MITCHELL: You mean in service, after they have been put into --

MEMBER SIEBER: In service, yes.

MR. MITCHELL: As far as I am aware, in the U.S., no. I am waiting to see if somebody else remembers more about this. I see Allen Hiser in the back of the room. He may have a better recollection.

I believe the French did do some UT on BMI nozzles, but I would have to go look that up again.

MR. BATEMAN: That's true. They did do some. They have done a substantial amount of UT on these nozzles, but they have found no indications.

MR. MITCHELL: It was 14, I think 14, plants out of their fleet that they thought were particularly susceptible.

MR. BATEMAN: I don't remember the exact numbers.

MR. MITCHELL: They called the manufacturing history. Al, maybe you know the exact numbers?

MR. HISER: I think it is something on that order that Matt mentioned, about 14 plants that had some fabrication or shipping-related issues that caused them to be thought of as more susceptible. We believe the number is about six that have done some ultrasonic exams.

I think it is a continuing management program that they have. So far they haven't identified any service-related cracking.

MR. MITCHELL: I think that our other understanding is that I believe they stress-relieve those. Did the French not stress-relieve those penetrations in their vessels? I think that was what we had heard.

MR. HISER: I think that was one of the factors that caused some of the nozzles and specific heads to be characterized as more susceptible.

MR. MITCHELL: Right.

MEMBER SIEBER: And so I guess the bottom line of my question is, we are relying on visual examination is when to assure the pressure boundary. So we would have no clue until one starts to leak that the conditions that would cause flaw grooves and stress corrosion cracking are occurring in any vessel at that location.

MR. MITCHELL: It would be correct to say that our expectation is that we managed these by looking for evidence of leakage and then take appropriate action in response to finding evidence of leakage.

CHAIRMAN BONACA: The question that seems to be actually here is that given that apparently this lack of fusion zone is common, is that surprising that we haven't seen any of this leaking until now?

MR. MITCHELL: You would have to have an idea of how prevalent. If you, in fact, considered this connection to be the rate-limiting step, you would have to have an idea of how prevalent such a feature is as part of fabrication. If it is very common, you might expect more.

You would say that perhaps 2 out of 58 at South Texas had the right set of conditions to have this occur. That gives you, what, about a four percent change roughly.

MR. BATEMAN: I'll just add a little bit

of information. Although South Texas is the only place we have found anything so far, industry is in the process and some, I think Westinghouse for sure, have developed equipment and techniques to go in and do inspections of these tubes if need be. So I think there is anticipation there that we will see more.

MR. MITCHELL: And I think much of the discussion we are having around the table at this point gets to points on my last slide that we have evaluated what the licensee has proposed as the most likely scenario.

Based upon the evidence available, I think the staff considers that to be a very reasonable --

VICE-CHAIRMAN WALLIS: Could I ask? Do you mean that this is a believable scenario or that of the many scenarios, this is the most consistent? They looked at many different scenarios, and this is the one which is most consistent with the evidence?

MR. MITCHELL: Yes.

VICE-CHAIRMAN WALLIS: That is what this would say?

MR. MITCHELL: Yes. The licensee considered such things as perhaps cracking could have initiated on the ID and propagated through.

VICE-CHAIRMAN WALLIS: This set of

scenarios that they postulated was complete, then, in your view? They didn't leave anything out?

MR. MITCHELL: Yes.

VICE-CHAIRMAN WALLIS: Okay.

CHAIRMAN BONACA: So you are saying that they postulated other mechanisms?

MR. MITCHELL: Going in, they thought about just fatigue. They thought about ID-initiated primary water stress corrosion cracking working its way out through the tube.

They had a fairly comprehensive or -- I'll just it plain -- a comprehensive list of scenarios to look into. And they settled to this as the most likely.

Then further, so based upon this postulated scenario, we can't at this point conclude that STP unit I is unique because of the way that the rest of the fleet of vessels was manufactured would tend to make one believe that such a set of conditions could exist elsewhere within the industry.

Therefore, the continuation of reliable inspections of the bottom vessel heads is appropriate to look for evidence of leakage and so that it could be repaired in a timely manner.

The staff has communicated with the

industry on this topic, both through information notice 2003-11, supplement 1, which contains this information from the licensee's final root cause analysis and LER that was issued in January of this year and through bulletin 2003-02 on our expectations for RPP lower head inspections.

CHAIRMAN BONACA: You would have to develop significant comfort that should a tube start to leak, you would have enough time. What I mean is that, from the cycle in which you are looking at it and there is no leakage to the next cycle, where you find the leakage, it is impossible to have catastrophic failure of the tube, right? I mean, you have to have that kind of confidence.

MR. MITCHELL: The experience with South Texas suggests that that would be the case, that this has manifested itself to date as axially oriented cracking, which is, of course, generally unlikely to lead to full-scale rupture and failure of a tube and that it would manifest itself by leakage, by boron deposits on the exterior head.

VICE-CHAIRMAN WALLIS: Can I go back to my previous question, then? You said the licensee had a lot of hypothesized scenarios and compared them with the evidence and concluded that a certain one was the most likely. This relies entirely on what the licensee chooses to investigate and tell you about.

Presumably someone independent, like Argonne National Lab, is also looking at possible scenarios. They might come up with other scenarios which actually are better than the licensee suggested.

MR. MITCHELL: We have not endeavored.

VICE-CHAIRMAN WALLIS: So you are relying entirely on something submitted by the licensee, rather than some independent experts, who might have a better explanation?

MR. BATEMAN: Well, in fairness to the licensee, the licensee --

VICE-CHAIRMAN WALLIS: I am not criticizing. I am just saying, you are relying only on the licensee?

MR. BATEMAN: Well, that is what I wanted to just expand upon a bit. The licensee did marshal all the forces available in industry to help them get through this. They didn't do this in a vacuum just with their own staff. They brought in people from many different places to help them work through this.

And so I would say that if you were to take it to a national lab or some other place, the chances are good we would come up with the same conclusion.

MR. MITCHELL: And, just to amplify on that, we certainly did not only look at the final list of hypotheses, if you will, that they came up with. We also examined their process, their root cause analysis thinking, which led them to that list of possibilities. I think that gives us an even greater degree of confidence that they have kind of covered the waterfront on this.

MEMBER SHACK: They have also presented their analysis at the CRDM workshop, which is sort of a public peer review, presented rather detailed evidence there. I mean, that hasn't shown nearly for all of the information they have put together.

VICE-CHAIRMAN WALLIS: That is really good.

MEMBER SHACK: Every industry analysis which was comprehensive --

VICE-CHAIRMAN WALLIS: It is in a public forum. So other experts have a chance to say, "How about this?" or "How about that?"

MEMBER POWERS: Well, it's a public forum of a very unusual type. It is only people who are intimately involved in the CRDM network.

MEMBER SHACK: No. There were intervenor

groups. The press was there.

MEMBER POWERS: As much as I admire the press, their credentials in metallurgy are often quite limited. What I am wondering about is the metallurgists of Bangladesh ordinarily work on bridges that say, "Oh, yes, I have seen this exact sort of thing in some other context" and "This is a special bridge."

What I am asking about is the broader, larger technical community, really, though. Is there a forum for doing that sort of thing within the corrosion community that says, "Oh, tell us all about your failures"?

MEMBER FORD: Yes, yes, not associated with corrosions, yes.

MEMBER POWERS: NASE?

MEMBER FORD: NASE, yes. NASE International has got a whole lot of subcommittees at their annual general meeting that meet at their annual general meetings so people from the petrochemical, from nuclear, from fossil power get together and chew over the fat over their various problems.

Now, I must admit that is not a really big medium. There are maybe 30 people in these meetings. In answer to your direct question, do they ever get together --

MEMBER SHACK: There are more than 30 people there.

MEMBER FORD: Within the subgroups, like PWR and BWR operators.

MEMBER POWERS: What I'm worried about is this. Professor Wallis asked, did the licensee consider everything? The answer was, "Oh, yes, he did." Well, that is quite untrue. I mean, I can assure you they left out something. Okay? It would be impossible to ever attest that they considered everything.

MEMBER FORD: Sure.

MEMBER POWERS: And I am wondering, some of these issues, especially when things are uncertain, if people in outside specific communities worrying about CRDM need to have an opportunity to examine and comment on the findings in some way.

This is the larger philosophical issue. It has nothing to do with this specific task. It is that the trouble is everybody worried about CRDM has a certain straitjacket in their thinking. And I am asking, is it appropriate to have that straitjacket or is that --

MEMBER FORD: Well, it is sort of people

in this room, I mean, go into these conferences. I know you have got a predilection against corrosion engineers talking with corrosion engineers.

MEMBER POWERS: No. It is not that that I want. It is corrosion engineers in one context talking to corrosion engineers --

MEMBER FORD: Well, within those two organizations, we should send you meeting minutes. There are people from the regulators, from universities, from national labs all over the world. And, believe me, all of those people in general are Type A type personalities. They will rip you apart if you have a loose idea. It is real.

So if you come up with a self-serving opinion, regardless of whether it is from one of these communities, it will be torn apart. And I can assure you of that. I have been torn apart. Bill has been turn apart.

VICE-CHAIRMAN WALLIS: So I guess, then, it is not really a question of tearing apart. It is a question of ideas of what might be a new hypothesis which is about to be torn and not torn about.

CHAIRMAN BONACA: But we are talking about the specifics of this deal. Could you put up slide number 1?

MR. MITCHELL: Slide number 1 of the pictures or the --

CHAIRMAN BONACA: Pictures.

MR. MITCHELL: The pictures.

MR. BATEMAN: While Matt is putting that up, there is another group. The ASME code is very much involved. They formed a specific working group that has expertise from all of industry to look into Alloy 600 issues, not just CRDM issues.

It is an Alloy 600 issue that we are dealing with here. It just so happens Alloy 600 is used in CRDMs, but we use Alloy 600 material to make the welds in the primary coolant system.

So it is a bigger, broader issue, and it encompasses all of the expertise there is out there at this point in time.

MEMBER POWERS: Certainly I realize that the Alloy 600 issue exists, but it is not the Alloy 600 people that I want to look at this. It is the people that don't work with Alloy 600 that I want to get their opinion on it because I think you got more than an adequate number of people who are knowledgeable on Alloy 600 looking at it. And I don't come away saying, "Ah. We have got our finger on the pulse here." I come away saying, "Well, we may understand this. Well, it could be something that surprises us."

MEMBER FORD: Well, we can talk about it offline, then.

MEMBER POWERS: Sure.

MEMBER FORD: I can assure you people from a wide variety of disciplines and interests are discussing it.

MEMBER POWERS: Okay.

CHAIRMAN BONACA: I had a question. That illustrates the thickness of the wall of the vessel. Okay?

MR. MITCHELL: Yes.

CHAIRMAN BONACA: I would like to know, do we understand now how far did the flaw in the tube expand towards the bottom of the wall of the vessel? How far did it go in physically? Do we understand it?

MR. MITCHELL: From the UT results, you could make a connection between the extent of the flaw and how far it would have propagated down the tube into the area where the ferritic material of the vessel is. If I have one of my drawing pens, I will try to do that justice if I can.

I think that might be pretty close to a fair representation. So you are not talking of any great extent in that direction, and to some degree you wouldn't expect it to go at great length because if it is driven by the weld residual stresses, once it penetrates a certain distance in either direction, you lose driving force.

CHAIRMAN BONACA: I'm trying to, I guess, pursue again the questions that I had before. How comfortable is one between the cycle, when it is not leaking, and the following cycle, where you find the leak that there is a zero chance that there is going to be a large failure of the tube during the cycle?

MR. BATEMAN: The key point, let me draw a parallel over the upper vessel head penetrations because we are all familiar with that as well. As long as there are axial cracks and only axial cracks, we had a certain comfort factor.

As soon as the cracks turned circumferential and, therefore, would be vulnerable to the kind of scenario that you are concerned about, we went to a much more aggressive inspection.

I think the same would hold true here. If in the future we found leaks were identified and they did inspections and found circumferential cracking, then the extent of our concern would certainly expand substantially.

CHAIRMAN BONACA: If I remember from the experience in CRDM, all you need is two axial adjacent or some distance from each other to expand into a circumferential one.

I mean, it seems to me that at some point you are going to find one if, in fact, this phenomenon is going to happen with some frequency.

I am not asking you to have an answer to that. I am only trying to have some comfort about the fact that with these kinds of penetrations, we are going to request just visuals. And probably it is the right thing to do. So there are reasons why for the CRDM visuals are not being considered adequate.

MR. MITCHELL: I think that the one other factor that should be considered when comparing these penetrations to the upper head vessel penetrations is, in fact, there is an intentional gap clearance between the tube and the vessel. So it is not an interference fit configuration.

I think that has led us to believe that there is a higher likelihood that leakage would make its way through this annulus and then be visible on the bottom head, as opposed to the upper heads, where you have an interference fit configuration.

CHAIRMAN BONACA: You haven't abandoned

totally the process of asking what if?

MR. MITCHELL: Absolutely not, absolutely not.

CHAIRMAN BONACA: Okay. I think I agree with your comment that given what we have seen to date, our response is volumetric exams as a baseline. If we had evidence of circumferential cracking, the response would be different.

VICE-CHAIRMAN WALLIS: Where does this tube go that is sticking up in the sky there?

MR. MITCHELL: It essentially acts as a guide tube for the thimble tube, which runs inside here.

VICE-CHAIRMAN WALLIS: So it runs up into the core, the plenum? It stops in the lower plenum or does it go in through further than that?

MR. MITCHELL: It stops in the lower plenum.

VICE-CHAIRMAN WALLIS: But it sticks out?

MR. MITCHELL: Yes.

VICE-CHAIRMAN WALLIS: I don't know how it is made or how it is put in or how other things are put in, but if something were put in later and bumped up against it, presumably this would have some effect.

MR. MITCHELL: It could.

VICE-CHAIRMAN WALLIS: I don't know what abuse it might be subject to while they are making something or adjusting something or changing something.

MR. BATEMAN: That's very possible. We had the same concern with the upper vessel head penetrations as well, that aligning, pulling these things to alignment, would induce additional stresses.

MEMBER SIEBER: The thimbles are actually extracted at every refueling. So there is a physical motion that goes on inside that tube. On the other hand, this tube is bigger and stronger than the thimble itself.

MR. MITCHELL: Absolutely.

MEMBER SIEBER: So if you are going to see wear or anything like that, you are going to see it in the thimble. And that has occurred. That has been noted in the past.

MEMBER LEITCH: Matt, I have some confidence that this is just a PWR problem.

MEMBER SIEBER: Yes.

MEMBER LEITCH: Could this also be a BWR problem but without the boron to indicate the potential leakage could be further down the line?

MR. BATEMAN: We do have some BWR leakage through the stub tubes. I am not exactly sure where in that, where the CRDM housing is welded to the stub tube. We are not sure exactly. The licensees haven't determined where the leakage is, but there has been some leakage at at least two facilities that I can think of.

And roll repairs to the housings have been the method of how those were repaired, actually put a rollover, some rolling device inside housing, and pressed it up against the vessel wall to stop the leakage.

MEMBER LEITCH: I am saying --

MR. BATEMAN: That is not an Alloy 600 problem. Well, there are some Alloy 600 welds, but I am not sure if they were at the two plants I am thinking of, if those particular welds were Alloy 600 or not. I don't know. Oyster Creek and Nine Mile, I don't know. They are two older plants. I don't know what weld material they use there right off the top of my head.

MEMBER LEITCH: See, in one sense, the boron is bad because we are concerned about corrosion. But in the other sense, the boron is a telltale that tells you you have got a little leak. You don't have that in a BWR.

MR. BATEMAN: Well, as you know, you worked at BWR in your past. One of the first things they do when you shut down is go in and do an inspection underneath the vessel to look for leaks. Of course, if they are very small, obviously, right, you won't see them. And boron would be a good indicator, you are right.

MEMBER LEITCH: And it is a difficult place to inspect. There is so much stuff under the belly of a BWR with the control drivers and all the instrumentation and the LBRMs. I mean, there is a whole forest of stuff under there.

MR. BATEMAN: It is a rat's nest under there.

MEMBER LEITCH: It is hard to see what is going on.

MEMBER SIEBER: Plus, the radiation is usually airborne.

MEMBER SHACK: Could you make good visual inspections on all the PWRs? I mean, I know South Texas is ideal, but how about the rest of them?

MR. MITCHELL: Other licensees have been performing inspections in that area. I should probably deflect that question over to our folks who have been dealing more globally with that issue, however, about the quality of those.

MR. SULLIVAN: We anticipated that might be a problem, PWRs. And so far somewhere on the order of 23 to 25 plants have done the inspection, depending on whether you want to count Davis Bessee and South Texas.

They all made the area accessible by either lowering the insulation or removing panels. They took stuff apart, and they were able to get complete access for visual examinations. A lot of them used cameras.

MEMBER SHACK: There is not some old plant with asbestos stuck to the bottom?

MR. SULLIVAN: We did not hear of any outliers with respect to being able to get access to get a good look at each penetration.

CHAIRMAN BONACA: How many of the PWRs have the bottom instrumentation?

MR. SULLIVAN: I think all of them do but the C plant.

CHAIRMAN BONACA: All but the C?

MR. SULLIVAN: The exception of Palo Verde.

CHAIRMAN BONACA: E&W plant they have that?

MR. SULLIVAN: Yes. It is somewhere in the high 50s.

MR. MONARQUE: The bulletin was sent out to 58 plants, all PWRs.

MEMBER LEITCH: Well, I'm still not sure I really got an answer to my question about the B's. I mean, are we doing anything? Is anything appropriate for BWRs?

MR. BATEMAN: Well, basically other than typical inspections underneath the vessel at the end of the operating cycle and the two plants that have identified leakage and addressed it, no, there isn't anything else that we are doing in that area.

MEMBER SIEBER: Well, are there any further questions?

MR. SHEA: Yes. My name is Jim Shea. I am down here sitting in for Bill Roland in region III.

One of the questions in our mind is working with Davis Bessee issues. I know they did an inspection, and I guess they are looking for this popcorn-type leakage. I was wondering, do we have any definitive way or thing to look for when we are looking for this type of leakage?

They did have some residue that they have addressed as wash-down and other things that they did not attribute to leakage from the nozzles. I was just wondering if we know definitively what you are going to see when you have leakage through this crack.

MR. BATEMAN: We can have Ted Sullivan answer that.

MR. SULLIVAN: We had discussions with a number of licensees and with the residents at a number of the plants to ask the question basically, "What are the licensees looking for, and how have they been trained?" The consistent answer that we got back was that they were looking for the kinds of deposits that they saw at South Texas.

I think that most of the inspectors at the plants would have seen those photos. They might have had some sort of formal training on it. They would have been familiar with the kinds of deposits that we are seeing on the upper head. And they were basically looking for those kinds of deposits that were somewhat puffy, like we have seen on the upper head and seen at South Texas.

They have tried to distinguish them from stains coming from wash-down from along the side of the vessel from reactor cavity seal leaks. A number of them did chemical analyses of these deposits by taking things like chemical swipes or by removing whitish material that they didn't think was a boric acid deposit but took the sample anyway.

I am not an expert in how they did the chemical analysis, but they used different types of analyses and concluded that the materials that they were removing were not from leakage from inside the reactor, as distinguished from refueling water or some other debris, like insulation.

MEMBER SIEBER: Okay. Any additional questions?

(No response.)

MEMBER SIEBER: If not, I would like to thank you for your presentation.

MR. BATEMAN: Thank you.

MR. MITCHELL: Thank you.

CHAIRMAN BONACA: Any other comments or questions?

(No response.)

CHAIRMAN BONACA: Thank you for your presentation.

We are going to recess until 5 minutes of 1:00.

(Whereupon, at 11:53 a.m., the foregoing matter was recessed for lunch, to reconvene at 12:55 p.m. the same day.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(12:56 p.m.)

CHAIRMAN BONACA: Let's go back into session. The next item on the agenda is the resolution of certain items identified by the ACRS in NUREG-1740 related to the differing professional opinion on steam generator tube integrity. Dr. Ford is going to lead us through the presentation.

MEMBER FORD: Thank you, Mr. Chairman.

The last two days, Tuesday and Wednesday, we had a two-day full meeting hearing the progress on the DPO issues which were raised in NUREG-1740.

Bill, do you want to add a conflict of interest?

MEMBER SHACK: I was going to let you finish your speech first, but yes, I have a conflict of interest in this since Argonne National Laboratory has been doing some of this work.

MEMBER FORD: As was discussed during the two-day meeting, the resolution of these issues in NUREG-1740 have been melded into a much larger steam generator action plan. This was described to us over the last two days.

In order to try and compress all of the information that we heard in these last two days into this current two-hour presentation, we advised the staff that: (a) there should be a brief mention of how the DPO issues were melded into the steam generator action plan, to confine themselves to summaries of the many tasks that are in this action plan, with the recognition that there might be some questions on errors, such as the iodine spiking factor and also the PRA.

For those members who were not present the last two days, you will see the full list of presentations just for your information.

At this point, I would like to pass it over to Joe Muscara to lead us through this overview.

DR. MUSCARA: Thank you, Peter.

I guess this morning we will provide a brief overview again and then go into the summary of the work we presented over the last two days.

First, as we indicated over the last two days, we have provided the ACRS subcommittees a detailed progress report on a multidisciplinary integrated research program to address the potential for steam generator containment bypass during severe accidents and also on other technical issues that were raised by the ACRS in NUREG-1740.

This integrated program that we have

developed in generators was quite similar in concept to the current activities on PTS. Now, the research work is also part of the steam generator action plan that was reviewed and endorsed by the ACRS in October 2001. The items 3.X in the action plan were resolved in the recommendations in 1740.

Considerable research has been completed since this time frame in the areas of in-service inspection, on the steam generator tube integrity under MSLB loading conditions, and primary system component response during severe accidents, and on thermal hydraulics, and also on the PRA.

Based on the completion of some of this research, some milestones have been completed. And some of those actions were closed. However, work in some of these same areas has continued based on the lessons learned in the research and underneath for refinements. Therefore, the steam generator action plan is updated periodically to reflect the ongoing activities.

I would also like to indicate that although some of these actions, some of these tasks and subtasks were closed, resolution of the major issues will be based on the staff's utilization of completed and ongoing research activities, which are scheduled in the action plan for 2005 and 2006. So we consider, really, our presentations over the last several days to be a progress report on research activities that are ongoing.

In addition, I wanted to let you know about an effort we conducted over this past year. There was an integration effort conducted by the research staff. Where the programs in the different divisions were reviewed and integrated into one program, I held six one-day meetings during this past summer where we discussed the overall main goal of the research. We also reviewed the ongoing research, identified new research that was needed, and also the interdependencies of tasks and the schedules.

So from this, we developed an integrated program for assessing the potential of severe accident-induced steam garniture containment bypass. Now, this work is planned to be completed by the end of fiscal '05.

What we were intending to do today, then, was provide brief summaries of the work that was presented in detail to the subcommittees and will provide summaries in the areas of materials and thermal hydraulics and PRA. We will also discuss the full pitch and the item spiking issues.

VICE-CHAIRMAN WALLIS: This integrated program, I was hoping to see a picture or something about how everything fits together. Was this simply a discussion amongst people doing lots of different bits of work?

I guess what we were asking, the subcommittee, was, how does this all fit together? How do you prevent sort of one group from doing an infinite amount of work on something?

They are going to have to stop. Have they done enough work to answer some questions? How does it fit into the big picture?

DR. MUSCARA: Yes. I apologize I did not make a viewgraph, but I did hand out yesterday the detailed integrated plan. Now, according to that plan, we clearly discussed the technical work and how the different tasks fit together, what are the predecessors and successors; that is, what input goes to each task and how the outputs of the task are used.

In order to make sure that the work proceeds as it should, we have planned to have periodic meetings of a technical team that has been assembled to integrate this work. The technical team members will meet every two months to review our progress, to define any additional needs, and to make sure that all of the interdisciplines are getting the information that they need.

In addition, the contractors are allowed to talk with each other so that they --

VICE-CHAIRMAN WALLIS: I guess we don't have time to do it now, but there has got to be someone in charge so you can really see how much detail you need in all of the pieces, how they fit together. Otherwise one non-contractor just can get carte blanche to investigate ad infinitum all kinds of stuff.

DR. MUSCARA: No. We define precisely what needs to be done. And my responsibility is to make sure that the work is integrated and that it is going on as planned. So I meet at least every two months with the group to make sure that we are doing work that is needed and not beyond.

In fact, I mentioned that we identified some new work that was needed. We also identified some work that was not needed. And we have reduced the emphasis on that work.

MEMBER FORD: I think the direct answer to your question who was in charge, it is Joe. Joe is in charge.

VICE-CHAIRMAN WALLIS: Then, of course, we have to satisfy ourselves that you know what you are doing while you are in charge.

DR. MUSCARA: Well, I have a team of technical leaders in the different disciplines.

VICE-CHAIRMAN WALLIS: Okay. That's fine.

DR. MUSCARA: We have defined the work that needs to be done, and we keep up with it on a frequent basis.

MR. WOODS: Joe, this is Roy Woods, research staff. Apparently Dr. Graham didn't get a copy of the project plan that you passed out yesterday. I can go get another one if that would be useful.

DR. MUSCARA: Sure.

VICE-CHAIRMAN WALLIS: Well, I guess it's more than just the plan. I don't want to belabor the point, but it is clear that there has to be judgment made on all kinds of points here about when you need more work here, when you need less work there, and so on. I am not sure that you guys are really on top of that yet.

MR. WOODS: We were taking the first cut at that in developing the plan.

VICE-CHAIRMAN WALLIS: When you really get on with this PRA and know what you need in the various components, how much more uncertainty will it tolerate in the various bits, you have a much better way of deciding if we need any more work or not.

DR. MUSCARA: Yes, precisely, but that we defined what we think we need at this point. We will keep up with it and keep updating it and also have the responsibility to keep management informed about our activities. So frequently when we have new needs or things are not progressing, we have a responsibility to make management aware of this and get problems resolved.

So we have a plan in place. I have confidence it will be conducted to completion in a good way.

MEMBER APOSTOLAKIS: In your second slide, you say that the integrated program is similar in concept to PTS. PTS had a very nice picture showing how the various disciplines came together. Do you have a similar thing like that?

DR. MUSCARA: Yes. In fact, we presented something like that yesterday.

MEMBER APOSTOLAKIS: But not today?

DR. MUSCARA: We have limited time today. And we felt that we only needed to go in a very broad overview.

MEMBER APOSTOLAKIS: So yesterday's is big thing?

DR. MUSCARA: If I may, then, I would like to go into the very brief summary of the materials-related work. The steam generator plan action item 3.6 relates to a trying to address the ACRS conclusion that improvements can be made over the current views of a constant probability of detection of .6.

To address that, we conducted an extensive eddy current round robin analysis of data obtained from a mock-up, where we developed from a bit of probability of detection curves as a function of the inspection method; of the flaw location in depth; as a function of flaw voltage; and all that up here, which is a structural parameter for the integrated tube. We did this for 76-inch Alloy 600 tubing.

Again, over the last couple of days, we have presented extensive information on this. Many curves were developed that describe the probability of detection over the entire range of flaw sizes in our parameters of interest. What we found is that probability of detection is fairly high, quite high, for flaws that can impact structural integrity.

VICE-CHAIRMAN WALLIS: See, that's the

kind of thing I was getting at. Were they high enough? And how high did they need to be?

DR. MUSCARA: Yes. And that clearly is part of one of the items that feeds into the PRA.

MEMBER POWERS: These data that you are collecting on the POD, will they eventually result in replacing the POD that is assumed in the alternate voltage repair criterion?

DR. MUSCARA: That's a possibility. It is not something that we have a plan for yet. The industry may provide an alternate criterion. In some cases, they are interested in having a depth base criterion. One such criterion has already been accepted, a depth base criterion for the degradation of the dented support.

MEMBER POWERS: The objection that was raised in the original POD report was using the constant .6 POD.

DR. MUSCARA: That is right.

MEMBER POWERS: We really think POD is a function of depth, and you really ought to develop one. Now, it looks like you are developing one here, but if you are not going to use it, you are wasting time.

DR. MUSCARA: Well, you are correct, but

at the time that we chose that .6, there really wasn't much data.

MEMBER POWERS: I understand that.

DR. MUSCARA: So the point here is that we developed the data. And the curves are now available. And if one chooses to go that direction, we have the technology and the data.

MEMBER POWERS: Okay. But you are not going to write a letter to NRR and say, "Here, guys, use this, and don't give us a hard time"?

DR. MUSCARA: We have transmitted the report with the major conclusions from the report. I don't think we said, "Here, use this instead of .6."

MEMBER POWERS: You can lead a mule to water. You are just not trying to make it drink.

DR. MUSCARA: There were some cracks, of course, that were missed. The POD wasn't perfect. And some of the reasons for missing some of these cracks were that the signals were really too complex. And sometimes they were misinterpreted.

Also, we find that some of these tight cracks, it was a low signal response. Therefore, the signal-to-noise ratio is low. And we did find some cases of human error.

MEMBER POWERS: Not at Argonne, of course.

DR. MUSCARA: Well, this was work done at Argonne, but, of course, the evaluations were done by a commercial team.

MEMBER POWERS: Not at Argonne.

DR. MUSCARA: Oh, no. They don't make errors at all.

MEMBER POWERS: I would expect human error there.

DR. MUSCARA: None. One thing I noticed -- I have been involved in this area for a long time and have evaluated the inserting generator, where we developed the POD code for the kind of flaws that were inserted -- was that there was a major improvement in the results from the current round robins.

I attribute that mostly to the current extensive training and qualification requirements for inspection techniques and personnel and also to improvements in the data analysis process. It is a much more complex process that goes on these days when the inspectors evaluate a given signal.

VICE-CHAIRMAN WALLIS: Wasn't it inspection reliability or was it consistency that was proved? It wasn't proved to me that you could detect small cracks any better, but all the teams did about the same job was the message I took home.

DR. MUSCARA: Yes, but reliability, I relate that directly to probability of detection. And with small cracks, there are limitations based on the physics. So that doesn't improve. But for the larger cracks, there was a big improvement.

VICE-CHAIRMAN WALLIS: They were all consistent. The teams performed consistently.

DR. MUSCARA: They were consistent. There was little spread between the teams. But also this result was a lot better than the work we did in the '80s, where the maximum PODs were about .8. Maximum PODs here were about .95.

Noise, of course, is a major parameter in either detecting or missing the flaws. And we have developed methods for adjusting the POD curves based on the level of noise. The idea here is that this data could now be used for this different noise situation. For example, plants may have more noise than our mock-up did. So this data can be adjusted to apply to any particular situation.

To move on to the structural integrity work for main steam line break loads, this address is the action item 3.1. We performed structural calculations based on pressure loads we obtained from NRC staff calculations with trays. And we used a factor of 1.5 on those inputs to bond any uncertainties on the calculated pressure loads.

We find that the most critical transient of the secondary site transient was the main steam line break from the hot standby. We also determined the dynamic loads have virtually no effect on failure due to the presence of axial cracks. In fact, axial cracks behave a bit better than they do if the crack wasn't there.

Now, finite element analysis modeling using one, two, four, and ten tubes that are locked at the support plate show that if only one or two tubes are assumed to be locked, the stresses on the locked tubes can exceed the ultimate tensile strength.

However, because the maximum displacement of an unlocked tube support plate is limited to about two inches, the unflawed tubes would not rupture. But there is, of course, a concern that circumferential cracks on some of these loads could propagate.

MEMBER POWERS: Joe, when you did these dynamic analyses, you are including the shock and vibration, the structure during the blow-down?

DR. MUSCARA: Yes.

MEMBER POWERS: My question is, how do you know what trace gives you is correct?

DR. MUSCARA: Well, we had extensive discussion on this over the last couple of days. The work was benchmarked against some existing data and also was compared to some hand calculations. Again, if you want to go into some detail --

MEMBER POWERS: Well, presumably I can ask some of the members of the subcommittee about the details of the viewgraph. The problem that I think we always had in looking at the dynamic analyses was squaring the calculated results to the eyewitness accounts of what went on at the Turkey Point blow-down. It just didn't seem to square in drama to one another. So I am struggling to know.

DR. MUSCARA: Well, actually, the calculations show deflections on top plates as large as three inches.

MEMBER POWERS: Well, the eyewitness has described as being flown off the walking deck and seeing waves coming down the structures at him. That is a good deal more deflection than three inches.

CHAIRMAN BONACA: I think that you can bend the plates that way. I wouldn't be surprised, in fact, if you would have booming and all of these noises and so on.

MEMBER POWERS: That is the difficulty we have always had, that we get these eyewitness accounts that are dramatic but suffer all of the same problems of an eyewitness account. You really don't have any measurements. You just have this guy's memory of a long time ago.

It is just difficult to understand without having experimental data that you can actually compare directly for a similar situation.

DR. MUSCARA: I think we also had the observation, again, at Turkey Point at the inside of the generator after the transient. There was no damage that was noticed. Also, of course, these loads have to be able to be coupled to the tubes. If you can't couple the load to the tube, then there is no --

MEMBER POWERS: It doesn't do anything. Yes.

DR. MUSCARA: So if you have a clean generator, where the tubes are free to slide, there is no load transmitted. If you have a degraded generator, where many tubes are locked, then the load is shared among the tubes. So, again, it is not a problem.

MEMBER POWERS: Halfway between is a problem.

DR. MUSCARA: Well, it is not quite

halfway in between, but we will see from some of these numbers.

So the finite element analysis showed high flaw tolerance under steam line break loads. Now, if the number of locked tubes in a given region -- we essentially looked at one-quarter of the generator in flow symmetry.

So if we have a number of locked tubes, more than 10, the true circumferential cracks, even as great as 180 degrees to wall, 100 degrees around the tube and all the way through the wall, are stable. They will not propagate. If the tubes are locked, then cracks as much as 300 degrees around the tube and all the way through the tube are stable and then propagate.

Again, we also have to keep in mind that these kinds of cracks would not be in the generator at the time of a steam line break because they would be leaking and they would be taken out of service. So, even though these large cracks are still stable, we don't expect to have these during the transient.

MEMBER POWERS: I guess I have trouble a little with that statement. You have always a probability that you have got a 300-degree through-wall crack in the steam generator.

DR. MUSCARA: That kind of crack would be leaking. And so it might not be detected by in-service inspection, but it should be detected by the leakage monitoring. Of course, if the leakage goes above 150 gpd, then there is an action, but it has to be taken care of.

MEMBER POWERS: If not that, then you have got a 300-degree crack in the steam generator.

DR. MUSCARA: Well, you could have a 300-degree crack that is part of the through wall in the steam generator. In order to show this, even with it being cool, it is still stable. My comment is if it weren't through wall, we would have detected it. So if it is not quite through wall, it is still a large flaw. And it is still thought of one.

MEMBER POWERS: You are saying there is no probability of ever having a 300-degree through-wall crack in a steam generator? It is absolutely zero?

DR. MUSCARA: No, no. I am saying there is some probability. I think it is fairly small.

MEMBER POWERS: There is always a probability?

DR. MUSCARA: Yes, yes. We had also looked at the potential for propagating these cracks by the cycles, by fatigue. The fatigue analysis indicated that you have one or two pressure pulses. And, of course, the second pulse is lower force.

We conducted some fatigue analysis to demonstrate that, even with 70 cycles, there is still a margin for cracks. If we are assuming only four tubes are locked, -- again, this is a very conservative assumption because if you have degradation, many more tubes would be rotten -- then through all cracks up to ten degrees still did not grow large enough to cause failure. And if ten tubes are locked, then the same is true for cracks up to 230 degrees, all the way through the wall. So, again, there is quite a bit of margin, even if we had fatigue crack load.

So the conservatives, see, again, we applied a 1.5 factor on the thermal hydraulic loads. And now we have many more cycles than what you expect from the transient.

Our conclusions were that loads associated with MSLB are unlikely to fail tubes in the greater generators with the current regulatory requirements, inspection, leakage requirements, and so on.

We have felt that no additional requirements in the analysis or experiments are needed. We have conducted some experiments and some analysis. We have seen so much margin that we believe where we are finding these, we would not come to a different conclusion.

I briefly wanted to move on to the last area I was going to address. This is the work that we have been conducting on the response of primary assistance components under severe accident conditions. Of course, we did work on steam generator tubes. And we have addressed that and discussed it with you in the past.

We have conducted detailed elastic-plastic-creep finite element analysis to determine the behavior of certain premises and components during a station blackout reaction sequence. We have looked at the hot leg and surge line, including O nozzles and outposts, the steam generator manway in the RTD, and instrument line welds.

One of the things that we have found was that most of these components failed at approximately the same time. The predicted sequence of these was the RTD weld was first followed by the instrument line socket weld but a surge line to hot leg nozzle, and the hot leg surge line bend and finding the steam generator manway.

I should briefly mentioned that these analyses were done with some early input on thermal hydraulics. Additional input, the latest input from the thermal hydraulics evaluations will be used in our near term to reevaluate these results. So we are working, iterating with the other disciplines, and updating our results as we need to.

In our work on these preexisting components relating to the high temperature properties, we find that in some cases, data is just not available. Many of these components were not meant for high temperature service. So we find a lack of data, for example, on carbon steel for the nozzle, on the manway cover bolts, and on type 308 stainless steel welds; in particular, for the heat-affected zone, where we expect that the material properties may be less than the rock material.

So the current analysis was based on estimate of properties, where the data was not available. On the other hand, this year, this fiscal year, we plan on conducting high temperature tests to obtain the data where the data is lagging.

In a brief overview, this was all I had planned on discussing today. If we may, we could move on to the summary on the thermal hydraulics. I would be willing to address any other questions if we can.

MR. BOYD: My name is Christopher Boyd from the Office of Research. And I have been asked to give a brief overview of the thermal hydraulic aspects of the steam generator action plan.

The work that was presented yesterday I summarize here. There were four aspects: the steam generator loads following a main steam line break or a feedwater line break, aerosol trapping in steam generators, the SCDAP/RELAP5 analysis of the severe accident conditions, and the computational fluid dynamics analysis of the steam generator in the plenum mixing during those severe accident conditions.

The first aspect, the steam generator loads following the main steam line break or the smaller feedwater line break, this is part of generic safety issue 188. This is a steam generator tube leakage concurrent with these large main steam line breaks covered in the steam generator action plan in the 3.1 area.

What was done, the test, was to perform thermal hydraulic analysis using TRACE to develop the loads on these plates following these two breaks. And then this information would be fed onto the stress analysis for displacement and crack growth assessments.

The tests that were done to make ourselves feel more comfortable with this analysis, the loads were compared to predictions from similar analysis, such as Westinghouse analysis using RELAP and a separate code that they develop for this.

Conservative load estimates were developed and calculations to compare with the TRACE results. And then the technique TRACE, NTRACE was used to predict some relevant tests of blow-down tests of various types. And then sensitivity studies were performed on the model parameters, the input parameters, and the numerics to gauge how the code was doing on this.

So the conclusions out of this were that TRACE is capable of calculating these thermal hydraulic conditions inside of PWR following these large breaks. The steam generator internal loading calculated for the Westinghouse model 51 was very comparative to the conservative bounding calculations and also compared well with some Westinghouse RELAP5 predictions. It did not agree with Westinghouse TRANFLO calculations, which were significantly lower.

The largest internal forces are developed by the acoustic transients occurring very early, first, second, following the break for the main steam line break at the main nozzle location. This was done at hot standby conditions.

Here is a little bit of data from that main steam line break with the 4.6 square foot of open area. You look at the DP across these tube support plates. The highest tube support plate is seven, getting the largest roughly eight and a half psi ⌂p across it.

VICE-CHAIRMAN WALLIS: I was thinking about this again. You have a break, and suddenly it depressurizes somewhere. Isn't there an acoustic way which is rather sharp that goes from there, propagates at the same speed as sound and steam? And in a quarter of a second, it goes about 100 meters.

So I don't quite understand. Maybe this is to be in a different, another forum. Maybe we need to look at it somewhere else, but it is a little odd that you don't get some initial impulse from the acoustic way, that you get this smooth behavior like this.

MR. BOYD: Bill, did you take a look at that? Is the TRACE code able to pick up that initial wave that moves out from the break? This is Bill Krotiuk, who actually did the work.

MR. KROTIUK: Let's see. Two things. As indicated in the comparisons with the test data, are we successful in predicting the travel of the acoustic wave from the tests for the semi-scale test that I had?

One thing you have to remember is that when you get that depressurization wave initially in a steam generator situation, it is a tortuous path from the location of the break to the first tube support plates.

So there are a fair number of transmissions and reflections before you reach that tube support plate. So I think that would be the reason why you wouldn't see --

VICE-CHAIRMAN WALLIS: The reason you have got this is that you have realistically modeled the internals. It is not as if it is just a vessel with a hole in the top.

MR. KROTIUK: That is right. The internals were.

VICE-CHAIRMAN WALLIS: That is helpful. Thank you.

MEMBER POWERS: Let me understand. You have got the shockwaves going through a complex structure. And they get reflected, bounced off, banging around each other so the points where they are reinforcing in their points are cancelling. Do I understand this correctly?

MR. KROTIUK: Basically, from the source of the initial depressurization, as you are traveling back, if you hit an area change, you will get a partial transmission and a partial reflection. So yes, there can be additions and subtractions to the pressure wave as it travels back.

When Chris was mentioning about the hand calculation, what I actually did is took the drawings and based on the immediate changes actually did calculate transmissions and reflections and compared that with the peak forces that are calculated by TRACE and got the same order of magnitude.

MR. BOYD: Okay. That's all we had in this area.

MEMBER POWERS: Chris, I am trying to understand the plot that you had there.

MR. BOYD: Okay.

MEMBER POWERS: The tube support plates, those are the pressure differentials across, then. What are the TSPs across the top? Is this a legend?

MR. BOYD: Legend.

MEMBER ROSEN: Let me ask a question about it. TSP 7 is the highest tube support going, so on down?

MR. BOYD: Yes.

MEMBER ROSEN: The largest pressure difference? Am I interpreting that right?

MR. BOYD: Yes. To get to TSP 1, you have to pass 7, 6, 5, 4.

MEMBER ROSEN: Right. So the first one it sees is 7, and that is the biggest difference.

MR. BOYD: It does seem to respond first also. I should turn this over to Dana on this slide. Another aspect in the thermal hydraulic work in the steam generator action plan is the aerosol trapping in the steam generator.

Our objective is to provide data in this area. We aren't too clear what these numbers will be. We can guess at the order of magnitude.

So there is a program at Paul Sherrer Institut in Switzerland. It is somewhat behind schedule, as I understand it. There will be five test phases that will address retention of aerosols, the deagglomeration deposition year, tube rupture, deposition along the tube array, going on to do retention in a full scale, steam separators and dryers, and the combined effects of the entire steam generator secondary side.

MEMBER KRESS: Is this saying that the iodine officially gets in or is it aimed at the severe accident condition products that come later?

MR. BOYD: I'm going to defer to Dana.

MEMBER POWERS: Tom, this program was conceived well before DPOs and things like this. This is the NUREG-1150 problem, where we discovered that in a bypass accident, we had not in our severe accident models the capability of calculating the decontamination on the secondary side of the steam generator.

MEMBER KRESS: It's the whole shebang.

MEMBER POWERS: Right. And we made a bunch of estimates for NUREG-1150 but came in with very large uncertainties. Unfortunately, that bypass accident is risk-dominant. So big uncertainties there translate into big uncertainties in the risk assessment. These tests are really designed to get an aerosol problem, which would be if all goes a mess here before you get that.

MEMBER KRESS: So this is steam and hydrogen-borne fission products in a dry system?

MEMBER POWERS: Yes, that's right. And they are really not looking at the iodine problem at all. It is a separate issue. Now, the European community looked a little at the iodine. It is not very pertinent to our accident scenarios. It is only pertinent if you have real big-time accident management strategies to worry about the iodine problem in this context.

MEMBER KRESS: It gets to the overall risk.

MEMBER POWERS: Yes. Just for your interest, the experiment involves a nearly full height steam generator model. I think it is actually two-thirds height, but that is essentially full height.

MEMBER KRESS: Holes in the tubes?

MEMBER POWERS: A hole placed everywhere, once in a while depending on the nature of the test. It involves full-scale actual separators and dryers. I mean, they got them from the plants.

MEMBER KRESS: What kind of aerosols?

MEMBER POWERS: Right now I think they are going to run titanium dioxide. They are basically looking for an iterate aerosol. This was not a chemical test. This was strictly a physical aerosol test.

What I can tell you is that in the test of just flow up the outside to the tubes, those estimates we did for 1150 are looking pretty good.

MEMBER KRESS: Do they try to simulate the thermal conditions in the --

MEMBER POWERS: Yes, not --

MEMBER KRESS: -- that are projected in the accident?

MEMBER POWERS: Not in this first round. It is an interesting test program. He has listed down the five major tests here. If they find anything they don't understand in any one of those, each one of those has a test matrix they can go explore. And each one of those initially had two tests. And then there is a whole matrix if anything interesting comes out of it.

MEMBER KRESS: The attention in steam separators and dryers, is that for BWRs?

MEMBER POWERS: No, no. These PWR steam generators have a dryer and a separator up at the top. They look a little different than the boilers devices do, but they --

MEMBER KRESS: They are there.

MEMBER POWERS: They are there. And they are not something you can actually calculate the deposition in. Really, you have just got to go measure the damn thing.

VICE-CHAIRMAN WALLIS: Now I'm a little puzzled here. You are not duplicating the heat transfer effects, but in this steam generator, you are heating the tubes. So you are setting up circulation patterns in there.

MEMBER POWERS: No. This is flow valve.

VICE-CHAIRMAN WALLIS: No, no, no. In the real thing.

MEMBER KRESS: This is going right there like that. This is driven by steam.

VICE-CHAIRMAN WALLIS: Straight out to where?

MEMBER POWERS: The only time you get in trouble is when you open up the safety release valve on the steam.

VICE-CHAIRMAN WALLIS: Straight out to where?

MEMBER POWERS: To the great out of doors.

VICE-CHAIRMAN WALLIS: It is coming out of a tube. It goes into a steam generator. And that steam generator has these big convection pallets swelling around. Those products go through all sorts of tubes before they go out.

MEMBER POWERS: No. It is one shot

straight up, out the safety relief valve.

MEMBER KRESS: You're thinking about the design basis accident. We are talking about severe accident.

MEMBER POWERS: This is severe accident time.

VICE-CHAIRMAN WALLIS: This is severe? Does this have to do with what we saw in the CFD pictures of the --

MR. BOYD: We were calculating the secondary circulations. And we talked a little bit about the secondary side but not under the conditions of a leak.

VICE-CHAIRMAN WALLIS: But is the leak big enough to overwhelm completely the circulation pallets? It is a big thing.

MR. BOYD: It pulls it straight out.

VICE-CHAIRMAN WALLIS: Well, you are saying that, but I don't see any numbers of the pallets. I don't see any analysis.

MEMBER POWERS: Unfortunately, my CBC machine is not right here at my hand to give you the plots, but I guarantee you when that is open, we are going to the straight out of doors.

VICE-CHAIRMAN WALLIS: Are you going to

show me this evidence sometime, are you?

MEMBER POWERS: You are too young to know about severe accidents. That is seriously ugly time.

VICE-CHAIRMAN WALLIS: I am being serious. My impression is that these big circulation patterns might have something to do with how things deposit in the steam generator.

MEMBER POWERS: If you want big circulation patterns, you need to move inside the vessel. That is where we get interesting circulation patterns.

VICE-CHAIRMAN WALLIS: Well, again, these are all assertions.

MEMBER KRESS: They are backed up by calculations. We don't have any --

VICE-CHAIRMAN WALLIS: It would be nice to see the calculations. Maybe I can sometime when I am old enough.

MEMBER KRESS: When you are old enough.

VICE-CHAIRMAN WALLIS: Thank you.

MEMBER RANSOM: What is the path that is from the core to the ruptured tubes? I guess they are already assumed to be ruptured and then out the steam line.

MEMBER POWERS: Yes. And it depends a

little bit on where you release your tube, where your tube is broken. Basically you either break at the support plate or up at the UBEND.

The reason you get into bypass accidents is usually that you have locked open the safety relief valve on the secondary side. Remember, everything is dried out on the secondary side.

MEMBER KRESS: Is it gas or aerosol?

MEMBER SHACK: It is gas, single phase flow.

MEMBER POWERS: No, it's two phases.

MR. BOYD: Which one of the members would like to take the next slide?

VICE-CHAIRMAN WALLIS: Are you going to tell us what the staff has done on this problem besides what Dr. Powers has done on it?

MEMBER POWERS: Dr. Powers is not doing this. He is paying attention to what is going on.

MR. BOYD: I should say that whenever the results come in from the artist program, we have plans to incorporate those into some MELCOR analysis.

VICE-CHAIRMAN WALLIS: You are monitoring the flow pattern inside the steam generator so we can see if Dr. Powers' assertions have held any water at all.

MEMBER POWERS: There is no water. It is all steam at this point.

VICE-CHAIRMAN WALLIS: We don't try to hold water.

MR. BOYD: So the next step, the next area of work in the thermal hydraulic tasks is the SCDAP/RELAP5 analysis. There are several tasks on the action plan.

Basically we are trying to calculate this TMLB' station blackout transient. Now, just to summarize it in a simple way, we have got this boil-off, a reduction in system inventory, core and covery leading to a period of rapid core oxidation. By this time, the steam generators are dried out.

One of the steam generators has a stuck open relief valve. It is at atmospheric conditions. So during this period of rapid oxidation, we see just extreme increases in the temperatures at the top of the core and out into the hot leg.

So all of the power from the core is distributed to the reactor coolant system structures, including the steam generators. And all of these structures are heating up at a very rapid rate. obviously the thinner structures heating up faster.

Some of the thinner structures, though,

like the tubes, are further from the vessel. So they see a smaller temperature, which helps. Anyway, something is going to break. And that is what we are trying to calculate, what ruptures first. We are approaching melting temperatures or heading that way quickly.

So the staff has reevaluated the work that has been done over the past decade, I would assume. And we have updated our assumptions and boundary conditions using all of the lessons learned to date. We have come up over the last year with an improved best estimate prediction and completed a series of sensitivity studies. That work was presented yesterday.

The modeling improvements that we recently made included nodalization studies, keeping things physical. There were some issues in the model, deep in the model, revised material properties to be consistent at the highest temperatures with the work that is being done on the structures.

Realistic heat loss to containment, the earlier calculations typically assumed no heat loss to containment. Reactor coolant pump seal leakage. We were assuming no seal leakage in earlier studies as a default where the reactor coolant pumps leak immediately just based on the way they are designed with no failures. And we put that in.

Thermal radiation modeling in the hot leg and some other components and then updated in-the-plenum mixing parameters based on a reevaluation of the 1/7 scale experiments and some CFD analysis.

The net effect of all of this, some of these changes would make things worse. Some would make things better. But the net effect was just a slight increase in the margin between the surge line and the tube failures.

At this point with this best estimate prediction, the surge line fails about three and a half minutes to the hottest tube in an unflawed condition. So we have gone a long way.

MEMBER POWERS: Let me ask you a question. There is an unflawed connotation strikes me as an idealization that doesn't exist.

MR. BOYD: And when I say, "three and a half minutes," let's step back a minute. We are talking about thermal hydraulic analysis. In the SCDAP/RELAP5 code, there is a Larson-Miller correlation. And we apply it with what I think of as stress concentration factors of one, one and a half, all the way up to seven and a half. So I am talking about the tube that has a stress concentration factor of one.

We only apply the temperatures right at the top of the tube sheet. And we were just doing a simple analysis to get some feedback so that when we make a change, we can get some feedback on what happens with the tube failure without having to go to the materials people.

The real tube failure analysis will be done using our conditions as boundary conditions.

MEMBER POWERS: What we have always wanted to know here is what was consequential flaw. This result, at least in qualitative land, has been around since 1980 that I know of. It said, "Well, if the tubes aren't flawed, well, they are really good."

And they said, "Yes, but the tubes are flawed, but what we don't know is, does that make any difference or not? What is a consequential flaw for this competition?"

MR. BOYD: We can answer that question in our crude analysis here with this what stress concentration factor on the Larson-Miller correlation. It might have to be two. I think the answer on the hottest tube is one and a half in this calculation.

It is between one and a half and two.

I don't focus on those from a thermal hydraulic point of view. They are giving us some feedback. I look at it as our crude scale. In the end, I want to pass this off to Joe and Argonne to do a detailed tube integrity study with our thermal challenge.

MEMBER POWERS: When they do that, they will go in and address the question of whether you can actually use Larson-Miller in this temperature range?

MR. BOYD: And none of that -- I will be honest with you -- concerns me in the thermal hydraulic land. I want to provide them with temperatures, pressures, and heat transfer coefficients. They have given us this. We use it for some feedback.

DR. MUSCARA: We've done a great deal of work to evaluate the behavior of tubes with flaws under these high temperature transient conditions. And we benchmark the models that we are using. We can predict the test results quite closely.

MEMBER POWERS: I guess I'm not sure what tests you're talking about.

DR. MUSCARA: We conducted a great number of tests where we have tubes with flaws pressurized and failing them by different --

MEMBER POWERS: Oh, I understand what you are talking about. You are not talking about tests that go into the severe accident machines.

DR. MUSCARA: Yes. These are tests where we do simulate the severe accident transfer.

MEMBER SHACK: It's ramping up in temperatures that we expect in the severe accident condition. And we have flawed tubes. So we have models to predict the failure of those tubes and have verified those models for ramp conditions akin to what the thermal hydraulics people calculate for the crucial part of the accident.

MEMBER KRESS: Well, how does Larson-Miller look?

MEMBER SHACK: It does very well.

DR. MUSCARA: In fact, it goes way beyond the transient. We have run tests under isothermal conditions and the constant pressure conditions and under many conditions that we knew that we were bonding the transient.

MEMBER SHACK: I think from a material side, the predictive capability is quite good.

MEMBER SHACK: For that part of the analysis.

MEMBER KRESS: In a stress concentration factor of one and a half, stress magnification, is it a pretty big crack, is it?

DR. MUSCARA: One and a half? Not too big.

MEMBER SHACK: Yes. You know, as we say, there is a certain probability that you will have flaws ranging from one to a larger number. We expect the probability that it is greater than, say, two to be quite small. Now, what quite small exactly means is another question.

VICE-CHAIRMAN WALLIS: Would you tie that in, this number, one and a half to two, to the size of the cracks you were talking about earlier? How big does a crack have to be before this goes down to one a half, goes to one and a half, say? Does it have to be 90 percent through-wall?

MEMBER SHACK: It's 90 percent through-wall on a certain length. It could be --

VICE-CHAIRMAN WALLIS: So it's a big, really big crack, something detectable. It's not down in the range of 40 percent through-wall and you have difficulty detecting that?

MEMBER SHACK: No, it's not.

VICE-CHAIRMAN WALLIS: So that puts it in some better perspective, I think.

MEMBER SHACK: The PRA people will have to come up with a distribution of flaws.

VICE-CHAIRMAN WALLIS: So the PRA people are going to predict that?

DR. MUSCARA: They have our modeling. And so they are going to exercise --

VICE-CHAIRMAN WALLIS: They are going to have to receive a distribution of flaws.

MEMBER KRESS: They have got some pretty good data. We're talking steam generator tubes. They've got some data on that.

DR. MUSCARA: We're providing the distribution of flaws, providing the integrity modeling. They will exercise these to see what are the probabilities of different size cracks.

MEMBER ROSEN: Let's talk about the three and a half minutes for a minute, talk about flawed and unflawed conditions. The three and a half minutes doesn't sound like a very long time. I mean, sometimes Mario gives us seven-minute breaks. They aren't very long. Three and a half minutes --

MR. BOYD: Here's an analogy. The rate of the heat-up makes that three and a half minutes significant. Let's say I took this laptop and I threw it into a vat of molten steel. The case would always melt off before the hard drive. But if you tried to make that calculation, they would be melting pretty close together in the grand scheme. That is the kind of heat-up.

VICE-CHAIRMAN WALLIS: I think this is right. You should not compare it with the 14,000 seconds. You should compare it with when things begin to start getting exciting. That is actually a fairly short time.

MR. BOYD: If I recall from some of these past transients, about 15 minutes when things really happen, temperature increase. Within 15 minutes, that whole transient is over. So 10 minutes out of 15 minutes is not too bad.

VICE-CHAIRMAN WALLIS: Something happens at eight, and something happens at nine, at ten and a half or something. That is a significant difference.

MEMBER ROSEN: So you are telling me to think about 8 minutes, think about 10 minutes, think about 15 minutes, and think about 3 and a half minutes in that context. At three and a half minutes, before the hottest tube failed, they have got that much margin out of the total transient that blasts from this time zero to speculatively the end of 15 minutes.

Is that right?

I think you are suggesting to me to be thinking that this is a lot of margin. Am I right?

DR. MUSCARA: Not necessarily. What I am thinking is that you should be comparing the failure of steam generator tubes versus other primary system components. Then if there is a difference of three, five, ten minutes, that is fairly significant. That is a whole transient. Where these things are failing is about 15 minutes.

MEMBER ROSEN: That was the answer to my question. This is a fairly significant amount of margin.

MEMBER RANSOM: Well, I certainly wouldn't consider it a significant margin. Knowing all of the uncertainties involved in these calculations, I can't imagine trying to differentiate between these two cases.

MEMBER SIEBER: What's most important in the sequence, as opposed to the amount of time that it takes? What you are trying to do is to avoid bypass. You didn't say you need to have high confidence that the failures will incur in the sequence that your calculations show, whether those are 3 minutes or whether those are 20 minutes. As long as the sequence is there, it makes --

VICE-CHAIRMAN WALLIS: What we heard yesterday -- you haven't told us the whole story -- is that there are these two predictions three and a half minutes apart, but there are uncertainties in both of them. And by changing your assumptions, you can actually get it to got the other way.

So there is an uncertainty overlap, which may turn out to be so big. We have got to assume you have an order of probability of having a lure from a set of one. That may not make that much difference.

MEMBER SIEBER: It may be that everything is driven by the same basic parameters as far as the failure times are concerned. So I would think that you may be some place on the uncertainty pan, but you wouldn't be in a situation where they cross.

DR. MUSCARA: That was the thinking behind my comment. If we are wrong on the temperature on the tubes, wrong in the same direction of temperature of the prime components.

VICE-CHAIRMAN WALLIS: Absolutely.

DR. MUSCARA: And if I do have three to five minutes difference --

MEMBER POWERS: It seems to me that I have seen a lot of evolution in our ability to calculate this time differential here and changes in the way they model the core meltdown, but I have never seen it switch over. It has always been the surge line first because the range of variations that people are making in the score degradation models are not very big.

Some of the recent stuff that has been coming out of things like the TEBIS test might change that, but those are things that are just not modeled in the core now.

VICE-CHAIRMAN WALLIS: Well, yesterday, actually, Joe presented that -- I think it was Joe -- the hot leg nozzle could fail before the generator.

MEMBER POWERS: It's the nozzle.

VICE-CHAIRMAN WALLIS: He did manage to get these folks together. He did manage to get that to fail before the --

MEMBER SHACK: I think the real thing here is the spread in the uncertainties of the failures. I think Dana is right. Certainly Chris is right. We know that the surge line is going to heat up before the tube.

The question is, do the failure spreads for those things overlap, how much, how broad those are? And those really haven't been addressed before. And they will be addressed as part of this program.

DR. MUSCARA: Again, the reason you haven't seen the SRD failing first in previous work is because it is not modeled.

MEMBER SHACK: But even here, the surge line, there is a spread. Actually, the uncertainty for the unflawed steam generator tube is relatively narrow, as these things will go in an uncertainty analysis.

The spread in the surge line will be wide. And the spread in the times for the flawed steam generator tubes will be broader yet. So you have to look at all of those uncertainties.

MEMBER ROSEN: The failure of an RTD nozzle, is that enough to protect the tubes? Does that result in depressurization?

DR. MUSCARA: It results in a two-inch hole. And that is estimated to be enough to depressurize.

CHAIRMAN BONACA: It's a weld.

DR. MUSCARA: Yes, it's the weld.

MEMBER SHACK: Yes, the weld for the RTD.

DR. MUSCARA: Not necessarily. The back weld sees high temperature.

MEMBER ROSEN: And that's enough to depressurize the primary system and perfect the tubes.

DR. MUSCARA: That's the earlier.

MEMBER SIEBER: I would think so.

VICE-CHAIRMAN WALLIS: Can we move on now?

MEMBER KRESS: I guess usually when you get around to doing these uncertainties with something like the Monte Carlo, you have to be careful about the parameters that are correlated, like maybe temperature coming out of the core, and have a similar effect on both of them.

So I guess when you do that Monte Carlo, you have got to look at the correlated parameters. Be sure you get those right because that could shift both of them at the same time. But, anyway, that is just --

MR. BOYD: Many changes we do make do just shift. Are you delaying the period of rapid oxidation if you do everything?

MEMBER KRESS: I think there will be such correlative parameters.

VICE-CHAIRMAN WALLIS: Well, let's look at the next slide. I think you are going to find something there which does make a difference.

MR. BOYD: So some sensitivity studies were completed. Not listing them all but listing the ones that had some --

VICE-CHAIRMAN WALLIS: The sensitivities to assumptions? Is that what you mean?

MR. BOYD: Sensitivities to assumptions, input parameters, boundary.

VICE-CHAIRMAN WALLIS: You don't have the mass flow and the hot leg in there as an assumption?

MR. BOYD: That's right. Now, when we change the percent of core power transported to the steam generators, that changes the hot leg.

VICE-CHAIRMAN WALLIS: This is my point, and I have got to make this seriously, that you cannot make an assumption about that. That is something you have to calculate.

The whole thing is how much heat goes in the steam generator, how much heat goes into the main primary system. It is the whole issue here. You cannot say it is 30 percent or something.

As we discussed yesterday, if the steam generator had no heat capacity and wasn't cooled, there wouldn't be any power going into the steam generator. So you have got to think physically and predict this thing which affects things the most, not percent of core power.

I think if we wrote a letter, although you got the message, we are going to have to put it in that letter so that it is there.

MR. BOYD: Our dilemma we went over yesterday, we have got --

VICE-CHAIRMAN WALLIS: It is not just a dilemma. It is a fundamental foolishness in assuming the answer when you should be predicting it.

MR. BOYD: We have got the limited 1/7 scale test data, which gave us a value here. There were some calculations done. I hate to even bring it up. But they agreed to come up with some calculations. Argonne did those. So they are probably pretty good.

The problem is we talked yesterday about the core modeling. Do you think core resistances would affect this? When we change core resistance --

VICE-CHAIRMAN WALLIS: Do you see what I am getting at? The whole question here is heating up the steam generator to the point where it fails while heating up the primary system to the point where it fails. That is the key question.

If you are going to assume something about how much heat goes which ways, that is assuming the answer, isn't it, because that is what makes one of them happen before the other.

MR. BOYD: I guess my point is ideally we would have full-scale test data.

VICE-CHAIRMAN WALLIS: Don't say "ideally." Just agree with me that you have to protect it. You can't assume it.

MR. BOYD: We have talked about this. We realize that that is a weakness.

VICE-CHAIRMAN WALLIS: It is not. It is fundamental.

MR. BOYD: The question is how difficult that is to calculate.

VICE-CHAIRMAN WALLIS: I don't care. You ought to do it, difficult or not. If you don't do it, you're just fooling yourselves.

MEMBER KRESS: You're saying the one-scale test doesn't give you that?

VICE-CHAIRMAN WALLIS: The test helps you. The test helps validate your model.

MEMBER KRESS: But it doesn't give you the answer, right?

VICE-CHAIRMAN WALLIS: No. As you said there, the steam generator had no way of disposing of heat. There wouldn't be any power heat going into it. So it is obviously to take a limiting case. And then it makes a difference to how much heat goes. That is the whole problem you are trying to solve.

As a result, it is the key to solving the problem, which gets it first.

MEMBER POWERS: I'm sorry I was not at the subcommittee meeting. I notice that you are focusing a lot on these accidents with the loop seals intact. Are you doing anything with the loop seals blown?

MR. BOYD: What we're running is the sensitivity studies and trying to determine if the code predicts the loop seals to void out. And there are instances where that is possible in the past. Maybe if Don could help me on that. In the base case that we are running in the major sensitivities of the input parameters, we are not getting loop seal clearing in any of the loops.

MEMBER POWERS: That is a strong portion of what your loop seal clearing criteria are. Do you have good criteria for loop seal clearing?

MR. BOYD: Let me throw this one to Don Fletcher from ISL.

MR. FLETCHER: This is Don Fletcher from ISL. I did the SCDAP/RELAP5 analysis that is being discussed here. The model that we have has loop seals modeled. Those loop seals will blow if the conditions at the loop seals indicate that they will.

The model will calculate with the loop

seals filled or with the loop seals empty. With empty loop seals, the model is a flow-through loop through the hot legs, through the steam generators, and back to the core.

With the loop seals plugged with water, there is a circulation path through the upper part of the hot leg through the tubes of the steam generator and back to the core through the lower part of the hot legs.

The analysis done to date has been only on the TMLB' station blackout accident. And for that accident, the loop seals for all of the cases we run, including the sensitivity cases, have remained filled with water.

But we do anticipate that the PRA indicates we should look at other accident events, especially those that have depressurizations in them, that the loop seals very well could out. In that case, the model will be adjusted accordingly.

VICE-CHAIRMAN WALLIS: They're not just wet or dry. They're there. It's a hydrostatic edge. And we need to figure out whether we stop. Do you have enough hydrostatic edge to blow out, stop, going?

MR. FLETCHER: Yes.

VICE-CHAIRMAN WALLIS: Once they blow

through, it is not so easy to calculate how much liquid is left.

MR. FLETCHER: That is correct.

VICE-CHAIRMAN WALLIS: It is not a question of are they full, are the empty. They might be partly full. It can make a difference.

MR FLETCHER: Right. And the test that we make in the code is to look for void fraction. If the void fraction is greater than five percent, we assume it is blown out.

MEMBER POWERS: I mean, that's what I think I was asking. That model came from somewhere.

MR. FLETCHER: The model was developed at INEL originally.

MEMBER POWERS: Did that come from the mind of man or did that come from some experimental study?

MR. FLETCHER: For the loop seals themselves?

MEMBER POWERS: Yes.

MR. FLETCHER: Basically, the way it is modeled now is the standard way for modeling loop seals with a horizontal cell at the bottom and article cells on each side. That is the standard way of modeling loop seals for LOCA events. It has been around for 20 years or so.

MEMBER POWERS: That historical precedence, however, does not lend often --

VICE-CHAIRMAN WALLIS: Let me help you, Dana. If you go back to one of our letters on thermal hydraulics when we were talking about how well codes do. We actually see an example of loop seal clearing. And I think, if my memory serves me right, that was an example where some things were predicted pretty badly.

We actually cited in this letter an example of something which didn't work very well. I forget which context it was in, but it was one of the things where we were saying, "Look, the code is set to be okay, but for this particular application, it is off by a factor of three" or something. I remember. That is why we cited it. And I think it was a loop seal clearing.

So if the staff were diligent, they could probably find one of our letters on the thermal hydraulic evaluation of a code or something. The code is good enough for this purpose, but for some things like loop seal clearing, it doesn't do a good job.

I think we can find that somewhere. I don't know who is going to find it, but maybe we have --

MEMBER POWERS: We have staff who can pull it out.

VICE-CHAIRMAN WALLIS: Good.

MEMBER POWERS: I understand what the status is.

MR. BOYD: So we're back on the sensitivity studies. We will skip over the first one. I will say that we have made improvements. In the past that variable was not touched. That was a holy grail. At least we are burying it.

MEMBER POWERS: You could not have said a worst case.

VICE-CHAIRMAN WALLIS: I thought the holy grail was a religious belief.

MR. BOYD: We're burying the reactor coolant pump seal leakage. The steam generator out at the wall, heat transfer, these aren't the only sensitivities. These are the sensitivities that prove to have some significance. Some of the sensitivity studies showed no difference in the tube failure. Reactor coolant system heat loss to the containment and steam generator tube leakage itself.

So at this point, these are finishing up. We have got a few more sensitivities to do. And then we are going to continue work going into an estimation of the uncertainty.

VICE-CHAIRMAN WALLIS: I think you are going to fix that assumption and are just going to do a few more sensitivities.

MR. BOYD: We are probably going to march on into the uncertainty analysis because I am not sure we are going to get an answer to that question.

VICE-CHAIRMAN WALLIS: Of course, it is. I have got a fire in my house. I have got kids in one bedroom. The adults are in the other. The question is, which of them gets suffocated first? How much heat goes to one room, and how much heat goes to the other?

You cannot legislate that 30 percent of the heat goes to the kitchen. You have to predict it. That is what you are looking at here.

MEMBER POWERS: You obviously have more affection for your steam generator than I do.

VICE-CHAIRMAN WALLIS: I am trying to put it in words that even someone who knows nothing about nuclear systems would say would have to be true.

MR. BOYD: Yes. So where we stand on that, we have 1/7 scale experiments that give us an answer. And then we have the SCDAP/RELAP code, which has a multi-task core model. It calculates your buoyancy-driven flows and resistances in the core. And it gives us an answer.

We have the hot leg CCFL limitations, which seem like the RELAP code is giving us answers that are in line with that. So that is where we stand. Your concern is that we would do a better job of calculating basically the vessel flows so that we could couple those in with the hot leg and the steam generator flows.

There have been discussions, and there are some plans to look into that in greater detail we have gone over today.

MEMBER SHACK: But, again, if that just moves everything back and forth, they all move together, you could argue that it is not a critical issue.

MR. BOYD: We had done the sensitivities to demonstrate that this is an important parameter. So we can do a better job of finding out where we are on that.

MEMBER ROSEN: Well, now, in this topsy-turvy world, that coolant pump seal leakage in these conditions is a good thing. Is that right?

MR. BOYD: That's right.

MEMBER ROSEN: More is better.

MR. BOYD: More is better.

MEMBER ROSEN: You lose inventory faster, and you fail the primary system. There will be RCFs before you fail the tubes.

MR. BOYD: You melt the core if it is big enough.

MEMBER ROSEN: It is a relief valve. It is set in the containment, instead of outside. That is this topsy-turvy world. Out there in the real world, the utilities are working day by day on many problems, one of which is to make sure the reactor coolant pump seals don't leak. They build more and more robust seals, better seals. This problem is not the right direction. Am I correct?

VICE-CHAIRMAN WALLIS: This illustrates the problem with saying making the seal better is good. It is conservative for one thing. It is worse for another thing.

MEMBER ROSEN: It is better for operational reasons.

MR. BOYD: At one point we wanted all the heat to go to the steam generators to save the cores.

VICE-CHAIRMAN WALLIS: Yes.

MR. BOYD: And now we want the core to melt and save the steam generators.

VICE-CHAIRMAN WALLIS: So you assumed 100 percent, then, for those days?

MEMBER ROSEN: When you go out far enough in the situation, yes.

VICE-CHAIRMAN WALLIS: That's a very good point.

MEMBER ROSEN: You have got to remember vessel failure is a triumph in this case, which is why I think the word "topsy-turvy" came to mind.

MEMBER POWERS: Not if you haven't depressurized. Vessel failure is not something that you want to have happen.

MR. BOYD: But the steam generator pulling all of this core heat away was initially the great thing to save the core from melting.

MEMBER ROSEN: That's what it normally does. It takes the core, turns it into steam, and drives the turbine.

MR. BOYD: Now we don't want it anymore. So we have got plans to continue on with an estimation of the uncertainty. In addition, we are going to do an analysis of a combustion engineering plant based on some updated mixing coefficients, and we are going to bring that analysis for those type plants up to speed with the quality of the analysis. We have improved the design of the Westinghouse plant.

Now we are going on to the last phase. This computational fluid dynamics work was completed to support the SCDAP/RELAP5 analysis. The one-dimensional SCDAP/RELAP5 code relies on input parameters to define some mixing in the inner plenum.

We have a set of 1/7 scale data, and we have used some computational fluids to look at that and extend that data into full-scale conditions and tube leakage effects and different geometries and things like that.

So the issues addressed by the CFD work were the applicability of the method, the scaling effect. These are issues that the scaling effect has been debated, the tube leakage effect on mixing. The sensitivity of the results to the governing parameters was studied in some detail.

We looked at geometrical distortions of the 1/7th's facility compared to a Westinghouse prototypical steam generator. And then we looked at a combustion engineering plant example, which is significantly different geometry.

What we found is that we have some confidence in the technique, at least for the described problem. The application to the full-scale steam generator gave us a good bit of insights into the mixing process. We have much better prediction now of tube to tube variations. Tube temperatures versus time are available from a fluctuating plume.

In the grand scheme of things, when you step back, the mixing is still similar to the experiments. That is where we landed there.

We looked at tube leakage in some detail, ran a whole battery of tests. I guess the summary there is that the tube leakage does not result in a complete bypass of the inner plenum. The hot plume rising to the inner plenum still mixes and still mixes rather well. The tube, the leaking tube, does not appear to pull the hot plume to itself.

Then we looked at a combustion engineering plant and found that the inner plenum mixing in this type of geometry is significantly different. Now, this is a specific geometry. They have some various designs. But in the one we looked at, which is common, it had very little mixing compared to the experiments.

This is the last slide, just to throw some red meat.

VICE-CHAIRMAN WALLIS: Are you going to have an animation? You are not going to have an animation of it?

MR. BOYD: I'll work on that.

VICE-CHAIRMAN WALLIS: Let me say, as I said at the subcommittee meeting, when you showed us animations of this kind of thing, too, this is really very, very good, the development of these tools. The thing which is wrong is that I think it has to do with the interfacing with SCDAP/RELAP, sort of failing to look at some of the key phenomena there and sort of forcing the assumptions, rather than calculations, on the solution.

If you had actually used CFD for both this and the core, which is not ridiculous -- this looks like a core here, not ridiculous at all. The core looks like this. So what happens to the steam generators? It is rather like what happens in the core upside down.

MR. BOYD: The difference is the steam generator is a simple geometry in the end. You have got a bunch of skinny tubes. We sort of know what the --

VICE-CHAIRMAN WALLIS: How many tubes did you model?

MR. BOYD: We modeled 200 and --

VICE-CHAIRMAN WALLIS: SCDAP/RELAP model

are five in the core, five passages in the core?

MR. BOYD: We can come up with --

VICE-CHAIRMAN WALLIS: Do you see what I am saying?

MR. BOYD: I know what you are saying.

VICE-CHAIRMAN WALLIS: The thing you guys have missed somehow, I think -- and I could, of course, be completely wrong -- is that the key questions about what is the flow in the hot leg come out of full CFD analysis, not out of an assumption. The power that goes to the steam generator has to be an output of the calculation. It can in no way be an input.

MR. BOYD: And the dilemma I talked to you about is that what you are asking us to do is a CFD analysis of a reactor vessel coolant.

VICE-CHAIRMAN WALLIS: There might be a simpler way to do it, but there is no way you can do away with the key question.

MR. BOYD: When you do simplified analysis, what you are doing is you are putting big tuning knobs in there.

VICE-CHAIRMAN WALLIS: I don't think so. I think if you knew how to do it --

MR. BOYD: If I knew the answer.

VICE-CHAIRMAN WALLIS: -- CFD properly to what happens in the top of the plenum there in the core, most of these questions would not be answered.

MR. BOYD: This is typically a simplified model. It works best if you know what the answer is. If we are going to calculate directly what the answer is, then what you are saying is we need to calculate in detail with all that complex geometry our reactor vessel.

VICE-CHAIRMAN WALLIS: I think you can do it. You have a very good model here. I think if you looked to how to model that interface between what you did and what happens in the core, -- and maybe SCDAP/RELAP can do the core all right; it's that interfacing there which is screwed up -- you would be predicting this percent of full power transport, not assuming it. That is what you need to do.

I think if you give that some thought with the talent you have shown in solving this problem, maybe in a week you will know how to solve the other one.

MR. BOYD: We have given it a fair amount of thought, though. That is the dilemma we face. We can definitely revisit it and try simpler models, but the truth is when you do a simple model, you usually

--

VICE-CHAIRMAN WALLIS: No. What I am saying is if you don't do that, you have got a bogus answer.

MR. BOYD: I will just put it out on the table. What we had planned on doing is we are running sensitivity studies. We were going to vary it through a significant range, the widest range seen in the 1/7 scale test. And then at that point, we can look at the kinds of calculations that you are talking about.

There is also a need to wait until we find out if it is significant or not. If we have ranged it through a pretty wide range.

VICE-CHAIRMAN WALLIS: The percent of core power --

MR. BOYD: And in the end, they find out that somebody's inability to determine where the flaws are dominates or something else because it is a bigger problem than just --

VICE-CHAIRMAN WALLIS: This flow rate in the hot leg, you have an input, MH in the hot leg flow, right? Supposed that flow was zero. There would be no heat transfer into the steam generator. So you are assuming something right away.

The way you are putting that is on the

subscale. So I think that is a good check, but when you get to a real reactor, you know you don't have a basis for assuming things.

MR. BOYD: I can guess that it is not zero.

VICE-CHAIRMAN WALLIS: I will drop the subject. I think I have said enough.

MR. BOYD: We understand. But I guess you need to look at it. We have looked at that, the vessel. It is so complex that it is difficult to model. So when you simplify it down into blocks that you are going to model, then you have got to put in coefficients. And if you knew the answer, you would know just what coefficients --

VICE-CHAIRMAN WALLIS: SCDAP/RELAP can do it with five channels. And you have umpteen in the steam generator. Surely you can, even with five channels, model the core or ten or something.

MR. BOYD: They have got five channels with knobs on them.

VICE-CHAIRMAN WALLIS: You don't have knobs in CFD. It is an honest calculation.

MR. BOYD: If you don't nodalize enough, then you have to put knobs in. I have got knobs on the tubes here. We talked about that yesterday. We are not even modeling the tubes in great detail, and I have got knobs on those.

But they are easy to figure out because it is just a skinny little tube in one-dimensional flow. It is really a much easier knob to set and be comfortable with.

We are willing to try, reevaluate this. There are also some other methods that we could apply. We could talk to you offline to couple the whole thing and have a closed solution.

MEMBER RANSOM: One other aspect of this, why are you using MELCOR for the severe core damage accident? I thought that was the NRC's standard code for severe accidents?

MR. BOYD: We are going to use MELCOR for this. Right now the ball was rolling with RELAP. RELAP was considered a little bit more advanced from a thermal hydraulic point of view. Our job in a simple way is to provide pressure, temperature, and heat transfer coefficients to the tube integrity guys. We thought SCDAP/RELAP had an edge maybe in that.

Now, MELCOR will be used because it can track the fission products. And we are going to try to repeat the SCDAP/RELAP5 analysis with MELCOR. And then we would be tracking fission product.

MR. BRADLEY: Good afternoon. I am Dave Bradley from SAIC. SAIC is a subcontractor to Sandia National Labs. My coworker from SAIC, Paul Amico, is our PRA guy. I am kind of a phenomenology person. And that is the aspect of the program I will be working on.

Dave Kunsman is the Sandia staff member that has overall responsibility and oversight for this effort for SAIC. Roy Woods is the research staff member who has responsibility from the NRC side for this effort.

The topic is PRA-related activities related to the accident-induced containment bypass due to steam generator tube rupture. I have got in front of me the full presentation that I made to the subcommittee yesterday. All I am going to address today are the last two slides, which provide an overview of the effort. So I am going to skip to the end. If you need additional discussion, I can always page back to the preceding slides.

We are developing a probablistic approach to treating containment bypass due to severe accident-induced steam generator tube rupture. The assumption that we made at the onset of this effort was that this would be part of a risk-informed application. What that means is that you need a PRA with certain capabilities. The capabilities can be established using the ASME PRA standard, which I think is out in draft or final. Is it final now?

MR. BOYD: Final now.

MR. BRADLEY: That's final? That standard provides a framework for establishing the capabilities that you need for PRA to meet certain objectives. We went through the standard. We provided a draft list of capabilities that we thought would be needed for a PRA to meet the needs of this project.

We also identified enhancements to the PRA that would be needed for the specific area looking at severe accident-induced steam generator tube rupture accidents and containment bypass that would result from that.

We prepared a draft methodology.

MEMBER APOSTOLAKIS: So what are they? I mean, the fact that you did it --

MR. BRADLEY: They are a long list of enhancements. We went through the ASME standard point by point, area by area, human factors.

MEMBER APOSTOLAKIS: But you felt you needed to enhance the standard?

MR. BRADLEY: No. Why don't you address

it?

MR. AMICO: Paul Amico from SAIC. It is not so much enhance the standard. The process says you have to have certain capabilities. It also mentions that in some cases for certain applications, you may need to do enhancements to the PRA that are not called for in the standard.

MEMBER APOSTOLAKIS: So give me a couple of examples, Paul.

MR. AMICO: Okay. A couple.

MEMBER APOSTOLAKIS: Well, here, for example, this particular issue. What kinds of --

MR. AMICO: Partial failures.

MEMBER APOSTOLAKIS: What?

MR. AMICO: Partial failures. There are some instances where partial failures; as an example, leakage on the secondary side after the steam generator goes dry. It isolates. It is not a stuck open valve. But you just get some leakage by some path. That generally is not included in a PRA because it is generally not relevant to the kinds of accident scenarios that we analyze.

But in this case, a small amount of leakage could depressurize the steam generator. And if that is a higher probability than a stuck open secondary valve, that is going to lead to higher probability of having the conditions where you could have a tube rupture because of the higher DP. That is an example.

So we specify in there. We go through the standard and say, "Okay. This part of your application, this part could be category I capability. This could be category II. Certain aspects would need to be category III. And, oh, by the way, it is not the whole thing. It is these specific areas within that, those things that are relevant to the specifics, like steam generator containment bypass scenarios that could cause a greater threat to the tube."

The reason we felt we needed to put those in terms of enhancements or special studies is because a person using the ASME standard probably wouldn't think of those things.

We are using a plant-specific PRA but not --

MEMBER SIEBER: In a generic sense?

MR. AMICO: In a generic sense, we are using the Comanche Peak PRA. We are using flawed distribution from another plant, the plant we have data for. We are using the thermal hydraulic responses from Zion because that is what all of the models were built for and we don't want the thermal hydraulic people to have to go back and do it. So it is a hybrid kind of a plant.

The similarities are enough that what we are trying to do here is develop a methodology. If I have certain information, can I implement this methodology and use that information in a way to calculate this, the release frequency from this kind of a scenario?

MEMBER APOSTOLAKIS: I'm sorry I missed the subcommittee meeting. The document is on its way?

MR. AMICO: The methodology was published in June, and it is on Adams, yes. It should be in your package. It was supplied to the subcommittee.

DR. MUSCARA: It was in the background information.

MR. AMICO: Yes. Okay. Thank you, Joe.

MEMBER APOSTOLAKIS: I don't have it. Can I get it? So that is not the point? You are describing a document that is since last June.

MR. AMICO: In June. And, as you know, when you are developing a methodology for something you have never applied before, you expect it to change. So we consider this to be a draft methodology.

The intent is -- and we call it risk-informed application -- when we are done, we want the methodology to say, "If you are going to do this, Mr. Licensee, then go to the ASME standard and evaluate." This is what we would expect to see.

So we are building the methodology, saying, "Use the ASME standard in this way, rather than writing a from-scratch methodology document."

MEMBER APOSTOLAKIS: Now, I am curious. Did you find any recommendations at this time that you felt were not necessary here? You said you went over all of the recommendations in the standard and you realized that certain things that we needed were not there.

Did you feel that you needed everything that is in the standard?

MR. BRADLEY: Yes. Essentially you still need to have a complete PRA. It is just certain parts of it can be at a low capability. I mean, you still need the complete model. You have to do the calculations. But some of them could be at a relatively low capability level, not so plant-specific. And you would still get a reasonably good result, plant-specific result.

So you would have to actually look at the document, where we say, "This probably isn't going to matter. So you can be capability level 1 in accordance with the standard." This area is extremely important. There were certain aspects of HRA that were extremely important, errors of commission, things like that.

And we said, "That is to be capability level 3. Here is why. Here is why." And that is in that document.

MEMBER SIEBER: Well, that's not your methodology. That is what is going on now.

MR. BRADLEY: The decision-making was documented in the methodology document. We are revising all of the decisions that were outlined there. As Paul said, we do expect the methodology to change, which is why it was issued as a draft and has not been issued as a final.

Our plan is once you completed the application, we know how the methodology will actually work in practice. We will revise the methodology document and publish it again with the application attached and described. That would be our plan.

I did want to point out that the methodology does use traditional PRA methods. For this effort, we are drawing very heavily on the work that was done for the PTS application, work very closely with the folks at Sandia and the other SAIC staff person, Allen Korkowsky, on the PTS.

MEMBER APOSTOLAKIS: I don't understand the second bullet, "Underlying assumption will be risk-informed." Why do you even have to say that?

MR. AMICO: I'm sorry. That should be worded a little better. Risk-informed as envisioned in the ASME standard. So what we are trying to say is we are going to apply that approach, as opposed to just doing a risk-informed.

MEMBER APOSTOLAKIS: That means everything we do here.

MEMBER POWERS: Right. What we intended -- and the bullet got shortened -- is that approach specifically and linking it to the standard is what we are saying.

MEMBER APOSTOLAKIS: G.E. intends to submit what they call a PSA. I got befuddled. I'm sorry. I'm sorry. I mixed it up with another project. Anyway, the risk-informed application is something someone else is doing.

MR. AMICO: Correct. So we are saying we are that person, and we are approaching it in that way so that when we are done, we can give it to somebody else and say, "If you are that person and you follow this path, you will get" --

VICE-CHAIRMAN WALLIS: So you are creating something that someone else can use in an application, --

MR. AMICO: Yes, an approach.

VICE-CHAIRMAN WALLIS: -- rather than something the staff can use for verification?

MR. AMICO: It is the same thing.

VICE-CHAIRMAN WALLIS: It is not. What the staff uses is quite different.

MEMBER ROSEN: What puzzles me a little bit, Paul, is what you are suggesting is that you are building a method so that every plant is going to do a plant-specific analysis of this.

MR. AMICO: We have to develop a methodology. And so what we decided to do is do it as we were following ASME's approach to submitting something to NRC.

MEMBER ROSEN: So the plan is this is a regulatory issue. It is going to be solved once one way?

MEMBER POWERS: Right. And what it means is that if the NRC says, like in PTS, we would like four examples --

MEMBER SIEBER: In any event, there is no harm in writing down what you are doing.

MEMBER POWERS: In the DPO document that we wrote, one of the issues that we had to focus on was, in fact, the human error rate in taking steps once a steam generator tube rupture had occurred.

The conclusion that the panel reached was what the staff had done up until then was consistent with the best standards and human error analysis that existed at the time.

We also recognized that had people used a different methodology, they would have gotten different results. It is really the rate of human error of omission in this case.

There is the famous Korean paper presented in an Italian forum probably by a German that shows people using --

MEMBER APOSTOLAKIS: Using a Finnish simulator?

MEMBER POWERS: -- using various models of human error, human error rates that they get different results. In your work on this PRA, is that kind of model uncertainty to be addressed or are you just going to accept whatever methodology is adopted in Comanche Peak analysis?

MR. BRADLEY: Well, that could be true, I guess, within the framework of the PRA itself, looking at uncertainty in the accident frequencies that would come out. I don't know what --

MR. AMICO: The answer is we will look at what Comanche Creek did. Also, we will be using the approach that was used in PTS. Allen Kolaczkowski is also working on this project. We are also going to have Bill Hanaman, who also is an HRA expert that looks at things a different way. John Forrester from Sandia is also going to be involved. And we are taking a very hard look at HRA and going to see what kinds of errors need to be and how they need to be included.

MEMBER POWERS: That would good because the document the committee produced in that area is a ringing endorsement to what the staff had, but it is not terribly satisfactory because what it says is the staff did what you could do at that time. It is just that that is not very good.

And so I am heartened that you are going to take a look at it and at least quantify or in some way describe if we are good or bad.

MR. AMICO: We're going to use an elicitation approach.

MEMBER APOSTOLAKIS: Not elicitation. I mean, elicitation is elicitation. But ATHEANA is presumably dealing with the NRC Commission.

MR. AMICO: And we will have some of those, yes.

MEMBER APOSTOLAKIS: That's not a ringing endorsement of ATHEANA. We are spending a lot of money on that. And we are going to have some of that.

MEMBER POWERS: I don't know too much about these models and whatnot but what I know is that for the steam generator rupture accident, you have to find out a period of time in which an operator has to take an action. That depends on the number of tubes that you have ruptured.

If I rupture enough tubes, there is no time at all for the operator to take an action, but if I rupture just a few, then there is a progressively longer, longer time. And you have got to understand that.

That was just an area that we came away saying, "Well, gee, you know, I know what the state-of-the-art is, but I don't know how to approve that very much." So you are going to take a look at it. I think that is great.

MEMBER APOSTOLAKIS: That's exactly what

ATHEANA is supposed to do: define the context first.

MR. WOODS: Let me spend 15 seconds. This is Roy Woods with the staff. Clearly we want to use the same expertise that we used on PTS. That involves Allen Kolaczkowski and Donnie Whitehead. They certainly were instrumental in developing the ATHEANA method. They know what they know. They know how to do that kind of elicitation. They know how to take the kinds of things into effect.

And clearly there is an awful lot of ATHEANA that is going into this. You can call it ATHEANA or you can call it something else, but it is that method, taking those things into account. You guys have made us a little nervous.

MEMBER APOSTOLAKIS: No, but you are making us nervous, too.

MR. WOODS: Then we make each other nervous. We are using what we learned from that and --

MEMBER POWERS: We'll give you a huge form to complain about ATHEANA in a different context today. Let me ask a question, Roy, or just make a comment.

Developing your expert elicitation, I will tell you that when the group that prepared the document for the ACRS on the DPO came to this issue, in our thinking on this that we certainly were influenced on our opinion by the eyewitness accounts of what went on during the Turkey Point blow-down, you might want to in thinking about doing your elicitation try to reproduce that kind of information for your elicitees so that as you try to develop context, you have some understanding of what a blow-down of that looks like.

MR. AMICO: Yes. One of the issues here, of course, is that this particular study, we are looking at the steam generator tube failing after the severe accident progression has started. It is going to kind of be an interesting --

MEMBER POWERS: You'll still get this screaming, whistling, shocky, shaking, rattling rollercoaster kind of event if you have ever been around a tube that blows. They are noisy. And it surely must have some impact on the human, perhaps minor.

MEMBER APOSTOLAKIS: So when do you think you will have a PRA, Paul? That's okay. No questions.

MR. BRADLEY: Well, Paul already said something about this, the first bullet on the next slide. We are using an updated Comanche Peak PRA. This is a 2002 version that they prepared and were kind enough to --

MEMBER APOSTOLAKIS: Excuse me. Has this PRA gone through the peer review process, the PRA process?

MR. AMICO: No, it has not yet.

MR. BRADLEY: So we have identified some enhancements, as we mentioned earlier, that will be required to meet the needs of the project. We are going to incorporate those enhancements into the existing Comanche Peak PRA model.

We will use the PRA to determine the frequency of conditions that could lead to containment bypass, the result of severe accident-induced steam generator tube failures.

That is sort of the front end of the analysis. The back end of the analysis is trying to estimate the probability that the tube would fail before other RCS components under severe accident conditions.

We have also taken on the task of doing that by rolling in all of the existing tube failure models that have been generated at Argonne -- we talked a little bit about those a few minutes ago --

incorporating a full spectrum or at least to the extent that we can the full spectrum of modeling uncertainties that go into the tube failure modeling. We are also going to look at once a tube fails, what the leakage rate is from that tube because a single tube may not give you a large release in a large containment bypass type of accident.

So we need to accumulate leakage until you have got a sufficient level of leakage that you have a concern for off-site consequences. So we are going to actually calculate tube failures in sequence until we get to that leakage level that is critical.

What we will do is the outcome of this analysis would be an uncertainty on the time at which you have reached that critical leakage level as a result of tube failures. We want to then couple that with the uncertainty distribution for failure of other RCS components.

There may be some overlap between these two distributions. And that would be a condition in which the tubes could fail before you fail other RCS components. The outcome of this effort would be what the conditional probability of tube failure is.

VICE-CHAIRMAN WALLIS: This looks like a major operation to me. Putting together all of these physical models and doing a Monte Carlo analysis is not a trivial task.

MR. WOODS: Yes. I think the NRC is learning that these things really are multi-disciplined. I mean, a lot of safety problems are multi-disciplined. PTS was. And if you want to tackle it, then you have to take into account the different areas that affect what you are doing. These become huge tasks. Yes, they are.

MEMBER POWERS: If you can do it as well as PTS, you will score big points.

VICE-CHAIRMAN WALLIS: If we spend that much money, we will be broke.

MEMBER POWERS: Well, yes. That is true, too.

VICE-CHAIRMAN WALLIS: The risk here is, of course, if you just say, "We need" more and more and more information to get a better and better and better understanding of the uncertainties. So someone has to maintain a management understanding of are we focusing on the right things?

MR. BRADLEY: Well, as we go through, we are going to hope to identify the things that are most important and try to simplify things a little bit. It turns out that one aspect --

VICE-CHAIRMAN WALLIS: You can simplify. You don't have to get this tremendous knowledge base about everything.

MR. BRADLEY: That is the whole thing because I think the problem is very challenging.

MEMBER ROSEN: What are the key operator actions, the risk-significant operator actions that you are looking at?

MR. BRADLEY: At this point we don't know. Anything that affects conditions on the primary or secondary side, it is a wide variety of potential operator actions and things that the operator might do as a result of the severe accident management guidelines.

MR. AMICO: That review has just started. As of about two weeks ago, we started the review of the HRA that is in. Plus, we are reviewing the procedures, Westinghouse procedures, the severe accident guidelines, and trying to determine what needs to be done. So that started about two weeks ago.

VICE-CHAIRMAN WALLIS: May I ask, Dr. Ford, if you think we will be finished.

MEMBER FORD: You will be finished at 3:00 o'clock.

MR. BRADLEY: The last point on this slide is simply to indicate, as has been mentioned already, that this is an interdisciplinary effort. We are going to require a lot of input and a lot of interaction between us and the thermal hydraulics folks, a lot of interaction with the tube integrity experts and Argonne, a lot of interaction with the experts that are looking at failure of other RCS components. So this is like the PTS effort. We will involve this interdisciplinary team and a lot of integration between these efforts. That is all I have.

MEMBER POWERS: I guess I want to correct my question to you, Roy. We have the steam generator integrity DPO stuff, but this seems to go afield from that quite a bit. I mean, it looks like you are addressing another question.

Can you evolve ordinary accidents into bypass accidents is what I think you are trying to address here. Is that correct?

MR. WOODS: This is quite a bit beyond, but we hope to eventually kind of back up and include more of what is in the DPO, main steam line breaks and that sort of thing.

MEMBER POWERS: It seems to me that one of the things we would like to know out of that, in that context of the DPO, is, are there flaws that we currently find acceptable that in severe accident space considerably exacerbate our risk? Is that one of your targets here? Are you going to give us some information that answers that question?

MR. WOODS: I am not sure we are looking at it that way, but we will produce information that could be used for that if that is what you want to do.

MEMBER POWERS: Yes. I mean, it seems to me that is what I would like. This whole idea of the alternate repair criteria is we can identify flaws that we can continue to allow to exist in the steam generator tubes without exacerbating the risks exceptionally.

We have done that using a variety of classic metallurgical analyses, but we never took that onto the severe accident space before and asked the question that has always nagged on people, do we get an evolution of severe accidents by whatever initiation? They will go to the containment bypass accident. Are there flaws that we augment the probability of that evolution in an unacceptably large way?

I mean, it seems to me that in that world of alternate repair criteria, that is information they would really like to have because it might not ever be revealed by these more classic metallurgical kinds of analyses.

MR. LONG: This is Steve Long with the NRR staff. Let me assure you that is one of the things we are highly interested in, not so much that we think that the 9505 ARCs are subject to a problem because they are limited to areas of the tubes that are confined by structures.

We don't expect them to rupture or even leak anything other than a potentially very large blow-down force that would actually displace the confinement for the support place. But for other types of flaws for evaluations we do for the significance determination process for the RLP, this is a very important question. We have our eyes squarely on it.

We do intend to get that information out of this study.

MEMBER POWERS: Okay. That would be nice if that kind of showed up on a viewgraph someplace.

MR. LONG: As soon as we think we have the answer, we will let you know.

MR. BRADLEY: The model will provide the

flaws that are bad from the standpoint of failing early and also from the standpoint of large leakage. So that will come out of our analysis.

DR. MUSCARA: And the study point, of course, is flaw distribution, so flaws that are potentially there and generate the normal operation.

MEMBER APOSTOLAKIS: Is this where you have your meetings? Is this where you have your meetings?

MEMBER SHACK: It's ACRS' computer. That is where we have our meetings.

MEMBER FORD: Okay. I think we're moving on right now.

DR. MUSCARA: Yes. The NRR staff will be presenting the next two issues. The first one will be the iodine spiking issue and then if there is time, we will talk about the voltage correlations.

VICE-CHAIRMAN WALLIS: But we will finish by 3:00. We just have two more issues.

MEMBER FORD: We're taking the next one definitely now, the iodine spiking. If we don't have the time to do the next one, we will not give it. We will finish at 3:00.

MS. HART: This is Michelle Hart. I am from the NRR staff, and I will be here to talk to you about what we have done on iodine spiking so far. As I said in the subcommittee meeting, we had looked at the raw data from studies that you all had previously looked at as well. And we did not come up with anything that would show that our spiking factors are non-conservative considering the conservatisms in our dose analyses overall.

There was a question from Mr. Kress on whether with the higher spiking factors that are in the NUREG if we would still meet Part 100 limits. We went back yesterday and looked at that just to make sure. We did add in that square root of ⌂P adjustment factor to scale from the steam generator to rupture to the main steam line break. I can show you --

MEMBER POWERS: Did that square root of ⌂P factor -- I guess I am struggling with what test did that come from.

MEMBER KRESS: That was going to be my next question.

MEMBER POWERS: I mean, how can we know that the square root of ⌂P is the scaling factor to use?

MS. HART: We don't. It was given to us by Dr. Adams, who did some of the tests. He said that he thought that, all things considered, that would be the most that the scaling factor, the adjustment factor would be --

MEMBER KRESS: Is there a technical rationale for that?

MS. HART: I was not involved with that portion of it. And there are no words behind that. I pulled it directly from the staff's response to the DPO.

MEMBER KRESS: When you say "⌂P," which ⌂P?

MS. HART: The change in reactor pressure to depressurization.

MEMBER KRESS: Change with time or difference? It is a difference in pressure.

MS. HART: Difference in pressure.

MEMBER KRESS: What difference is this that we are talking about?

MS. HART: Before and after the main steam line break. Pre versus post is my understanding.

VICE-CHAIRMAN WALLIS: Do you mean the maintenance only --

MEMBER KRESS: So it's the starting pressure, and then to come down, you've got an ending pressure. And it's those two?

VICE-CHAIRMAN WALLIS: Well, the next

table is the square foot of ⌂P is 4. Does that mean that ⌂P is 16 psi?

MS. HART: That number I actually pulled from the NUREG, from the ad hoc subcommittee. And that is the --

VICE-CHAIRMAN WALLIS: Is it the square foot of megapascales or something? What is it?

MR. DOWNIG: Excuse me. This is Bob Downig. I am the section chief of containment accident and dose assessment. We are kind of pleading nolo contendere on the ⌂P, square root of ⌂P. And that is one of the reasons why you see in the third bullet up there the need for additional data.

If one wants to have a defensible firm basis to go forward with whether we want this to do something immediately, to take a conservative approach immediately, or down the road to come up with something mechanistic, either way we are going to need additional data.

And that square root of ⌂P factor, as far as I can tell, won't bear scrutiny.

MS. HART: Nevertheless, if we take the spiking factors that you all had determined in the subcommittee, ad hoc subcommittee paper, the NUREG, and applied that to a main steam line break analysis with the tech spec limits and the 500 time spiking factor that we assume gives you a 30 rem thyroid dose and then you apply the new spiking factors with the pressure adjustment factor, all of those resulting doses do remain below the full Part 100 limits.

And I do have the next slide is a chart of that. I understand the chart is not necessarily intuitively obvious.

MEMBER KRESS: What is the relationship between the four and the nine? Are those two different accident sequences?

MS. HART: That was just the range that was given --

MEMBER KRESS: That was a range.

MS. HART: -- in the NUREG paper that the square root of ⌂P was thought to be somewhere between four and nine.

MEMBER KRESS: It was between four and nine.

MS. HART: Right.

MEMBER KRESS: Your note at the bottom on the off-site thyroid dose acceptance criteria had been 30 rem for steam line break?

MS. HART: That is correct.

MEMBER KRESS: Which of these does that

compare to?

MS. HART: Overall any main steam line break with the accident-induced iodine spiking, we would expect the licensee to show that they are within 30 rem thyroid.

MEMBER KRESS: Is that 73 rem there in that?

MS. HART: That does not meet that lower acceptance criteria, but it is within the 300 rem thyroid Part 100 limits.

MR. DOWNIG: This is to address your concern from yesterday, where we were trying to figure out margin to Part 100. So we went back, and we said, "Look, we will just take the numbers that are in the NUREG. We will apply the adjustment factor for the pressure shift to scale this data from trips to main steam line break, this hypothetical figure, and we will see where we come out on this thing."

It was to address your concern about where are we sitting here today if we take that as the way things really are in nature. So that is what we did.

The purpose of this is to demonstrate that we still -- I mean, we are not meeting the 30 if this is true. We have places where we are going to go over that but still within the 300 and again reminding everybody that these are accident doses and not anything that is supposed to be the acceptable dose. This is a design dose. So that was the purpose of this.

The other point, I believe, is that we have one plant that is at the .1. Everybody else is above that. Most plants have the one. So that is where we are today. Hypothesizing, we take the NUREG results and lay it on. And where do we come out?

MS. HART: It is mostly the plants that have implemented the alternate repair criteria that are at 30 rem thyroid because they have got to calculate to see how much leakage they can get.

The other plants, the majority of plants, the ones that are at one microCurie per gram, are nowhere near 30 rem thyroid right now with the standard SRP assumptions and the lower leakage. They are on the order of .1.

MEMBER KRESS: It still seems to say that you are bucking up against where you would think about whether or not you are meeting the design basis criteria or not. That is the way the table looks to me.

MR. DOWNIG: Go to the next slide and show him.

MS. HART: To help address some of that concern, there are several conservatisms in a design basis accident analysis. We use a 95 percentile meteorology. The dose is the middle of the plume.

MEMBER POWERS: When you made the decision to use 95 percentile methodology, did you make that decision because you wanted to compensate for your uncertainty in the spiking factor?

MS. HART: No.

MEMBER POWERS: You compensated for something else with that?

MS. HART: We are compensating for the fact that any meteorological condition could happen at the time of the accident. That is what that conservatism is really about.

MR. DOWNIG: Our general practice is where there is a choice of two things, we pick the worst, but we drive it to the farthest extent that we can. So I don't think there is any coordination to manage the overall uncertainty in any of this. It is just conservatism laid on conservatism laid on conservatism.

MEMBER KRESS: But this is the nature of design basis accidents.

MS. HART: Right.

MEMBER KRESS: Specify these things. When you specify acceptance criteria, then they all work together.

MS. HART: Right.

MEMBER KRESS: So claiming conservatisms doesn't help me in there because it is part of the design basis concept. They are there for some reason. I don't know why. Maybe we have over-specified the acceptance criteria, but suppose we have acceptance criteria that goes along with these conservatisms.

MS. HART: I don't know if that is exactly the case.

MEMBER KRESS: But you know that is the general nature of a design basis accident.

MS. HART: That is the general concept. The major ones, of course, you know, for this spiking is we do have a lower acceptance criteria for their design that they are supposed to meet the ten percent of the full Part 100 is what they are supposed to meet.

MEMBER KRESS: Where did that come from? Do you know?

MS. HART: That I don't know. There is nothing that says what that is about. There are several accidents that if they have a higher probability of occurring, they lower the acceptance criterion. And I think that that is the major reason why those exist, those lower acceptance criteria.

That is the list of analysis, conservatisms, and ones that mainly are related to this particular accident so that we don't take credit for the plate out of iodine on steam generator surfaces. We don't take credit for retention or dilution in the building that it is released to. And partitioning of the iodine is not fully credited.

MR. DOWNIG: Basically, what we intend to do from this point on is I think, number one, in response to the concerns yesterday about what did we do with the analysis in the NUREG and how did we respond to that, the term "reduce" was used.

I think we need to go back and take what we have done. And we have to go through your NUREG point by point and lay that out and take our data set and lay it against your data set and see why we are coming out somewhere different.

MEMBER POWERS: I would certainly hope that our data set and your data set were the same. Considering the struggle we had to find out what your data set was, that may not be the case. You know, the DPO document comes in and says, "Is there a linear correlation with the coolant activity and the spiking factor? What is the issue?" and the staff says, "Not enough to worry about and the different professional opinion says, "There is one to worry about," our document comes back and says, "Well, it had not analyzed the data set correctly. There are two sets of data here two different populations here," and if we look for a correlation, the problem that they have in the interpretation is the time the data were presented, nobody was looking for such a correlation. They thought they were sampling a particular number, instead of sampling from a slope.

It doesn't really matter. We didn't like the way they had done the slope. We thought that they were taking the independent variable as having zero uncertainty; whereas, it had at least as much uncertainty as the dependent variable.

We came back and said, "The fundamental problem is they don't have a phenomenological understanding of the source of this spiking." So you are taking a stridently empirical approach.

I take it from this response that what you are saying is "Don't care. We are going to take a stridently empirical approach on this."

MR. DOWNIG: No, we are not saying we

don't care. What we are saying is that this is a tough call in the sense that to put this to bed, to understand it fully, we think that it requires additional data. We don't have any particular basis for the square root of ⌂P thing.

We have limited data sets that were collected under certain circumstances. And their pedigree is not for steam. To put this to bed, we would need to think about, examine ways to get additional data to address these areas.

So one of the things that we think is necessary is for us to work with some folks and research and others as necessary to see what it would take to have a defensible and empirical base to build a model from to address the situation and see what that looks like.

MEMBER POWERS: But you have people who have advanced models already out there. I mean, I believe the first model I found in this regard was published in 1968 or '9, something like that. And there has subsequently been some work by Fernando Iglesias and Brent Lewis put together a model on that.

I mean, isn't that where you want to start and say, "Are these models any good looking at the data I already have before I go off and try to get more data?" because Lord knows collecting data in this particular area is a very tough job to do. I mean, collecting good data in this area is a very tough job.

MEMBER KRESS: I might be willing to say that maybe we have got a bad rule on the books and go back and make some sort of risk-related analysis to see if it is really worth going to all of this effort to get this additional.

Intuitively one looks at this thing and says, "This doesn't look like a real risk to me." Although the numbers when you do this exercise, you are bucking up against some criteria, I think I would think about maybe challenging the rule a little bit.

I know that is not normally done. You have got rules on the book that have to be met. But we are in the risk-informed world again. I think maybe if you take a risk-informed look at this, maybe it is not worth going to spending all of this money to really put this to bed.

I think I would think about that first and then maybe you might decide differently.

MR. DOWNIG: Okay. Well, there's obviously more to come. We will take the next step. It is our objective to address your concerns.

MEMBER KRESS: We appreciate that.

MEMBER FORD: Are there any more comments on this particular issue?

VICE-CHAIRMAN WALLIS: Has anything been resolved? There is some more work. Okay. Okay. I thought so.

MEMBER SIEBER: They said it requires additional data unless you are going to generate experiments.

MEMBER KRESS: My data says it is expensive to do that.

MEMBER SIEBER: Yes. And that is an alternative, which is --

MEMBER POWERS: Once more, I think you run into the problem Bill has on the leakage voltage curve for some of his tubes. Even if you collect some more data, you have got this hugely scattered preexisting database. And unless you collect data to overwhelm that preexisting database, all you have done is to add a little more scatter to an already scattered database.

I am not sure you get anywhere with data. I think you have got to to do two things. I think you need to do the question and say, "Is this risk worth meeting on? Is there something I am trying to achieve here more than what is transparently obvious?"

And you come back and say, "Well, no. I am going to go beat on this one." Then I think you sit down and say, "Can I understand why this is coming about, even if I only get things in round numbers? I mean, if I only understand trends here, before I go off and launch into another database, it is just like your tubes. You have got a shotgun pattern. How many hundreds of tubes would you have to get data on to turn that shotgun pattern into a straight line if you have got data that was from a population to fill on a straight line?"

I mean, it would be a block. You could overwhelm what you have already done.

MEMBER KRESS: Good point, Dana.

MEMBER FORD: I would like to unless anybody wants to continue this discussion bring it to a close. Joe, would you like to have any closing remarks?

DR. MUSCARA: I don't think beyond what we had yesterday.

MEMBER FORD: I think my closing remark is thank you very much, you and your colleagues. The presentations of the last three days were meant to be for informational purposes. And the staff, at least, are not requesting a letter. Is that my continued understanding?

On that point, I turn it back to you, Mr. Chairman.

VICE-CHAIRMAN WALLIS: We're going to take a break. And then we come back. We are going to take up the matter, I understand, of the research, Paul?

MEMBER POWERS: I think we are going to take up the research reviews.

VICE-CHAIRMAN WALLIS: The research reviews. Okay, research reviews, rather than research report.

MEMBER POWERS: I think we can go off the transcript.

VICE-CHAIRMAN WALLIS: We can go off the transcript or we are going to have something else later on?

MEMBER POWERS: No.

VICE-CHAIRMAN WALLIS: We don't need the transcript after now. Thank you very much. We will take a break until 20 minutes past 3:00.

(Whereupon, at 3:04 p.m., the foregoing matter was recessed, to reconvene in closed session at 3:20 p.m.)