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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

MEETING OF THE SUBCOMMITTEE ON

THERMAL-HYDRAULIC PHENOMENA

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WEDNESDAY,

MARCH 19, 2003

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

PRESENT:

GRAHAM B. WALLIS	Chairman
SANJOY BANERJEE	ACRS Consultant
THOMAS S. KRESS	ACRS
DANA A. POWERS	ACRS
VICTOR H. RANSOM	ACRS Member
JOHN D. SIEBER	ACRS
MICHAEL R. SNODDERLY	ACRS Staff

A-G-E-N-D-A

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

8:34 a.m.

CHAIRMAN WALLIS: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Thermal-Hydraulic Phenomena. I am Graham Wallis, Chairman of the Subcommittee. Subcommittee members in attendance are Tom Kress, Victor Ransom, and Jack Sieber, as well as our contractor Sanjoy Banerjee.

The purpose of this meeting is to discuss thermal-hydraulic issues associated with design certification of the AP1000 reactor design. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full committee. Medhat El-Zeftway is the designated federal official and Mike Snodderly is the cognizant ACRS staff engineer for this meeting.

The rules for participation in today's meeting have been announced as part of the motives of this meeting previously published in the Federal Register on March 5, 2003. A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice.

It is requested that speakers first

identify themselves and speak with sufficient clarity and volume so that they can be readily heard. We have received no other written comments or request for time to make oral statements from members of the public regarding today's meeting.

This is the second in a series of meetings to support a future full committee meeting on the staff's draft safety evaluation report on the AP1000. The first meeting was to review the AP1000 PRA.

Before we get started, I would like to state that what I hope to see happen at this meeting is the focus on technical issues which may need resolution and understanding. Not a lot of other material.

In particular, I would like to see how the various formerly correlations and so on that have been pulled out of the literature and applied to this system, what the evidence is that they actually apply because we all know in two phase flow you can pull something from one area and try to use it in another and it may be that the geometry and the conditions are so different that you have to validate it very carefully and that's what I would like to see happen.

We will now proceed with the meeting. I call upon Mr. John Segala of the Office for Nuclear

Reactor Regulation to begin.

DR. SEGALA: Thank you. Can you all hear me okay?

CHAIRMAN WALLIS: I think it's most important that the transcriber hear you.

DR. SEGALA: I'm John Segala. I'm a new project manager for the AP1000 design certification review. Larry Burkhart, who was the previous PM, has left NRC to go work for the State Department. We now have a team of project managers to handle the design certification review to get our draft safety evaluation report out.

I'm going to discuss a little bit about the background. You are all probably very familiar with that, as well as a summary of the preapplication review. I'll talk about -- give a brief overview of what transpired during that review. A discussion or summary of where we are in the design certification review.

I'll talk a little bit about the status of the application issues that were identified during the preapplication review. And discuss a little bit about some follow-on issues. The way I define follow-on issues are issues that weren't identified during the preapplication review that could possibly be an open item in the DSCR report, the Draft Safety Evaluation Report.

As you are aware, the AP600 was certified in December of '99. Westinghouse expressed interest in applying for the AP1000 design certification using much of the AP600 design. Westinghouse and NRC agreed on a three-phased approach. The first two phases were during the preapplication review. The preapplication review is completed.

Phase I is the scoping review where we identified key review issues. Phase II we focused on four issues, acceptability of the DACR, design acceptance criteria, the acceptability of certain exemptions, and the applicability of the AP600 analysis codes and test program to the AP1000. We are currently in Phase III which is the design certification review and I'll discuss a little bit of that.

In terms of an overview of the preapplication review, I just wanted to highlight some key meetings that we had. We briefed the ACRS on Phase II. There was a joint future plant design in the Thermal-Hydraulic Phenomena Subcommittee in February.

We had a full committee meeting the

beginning of March. Based on the full committee meeting the ACRS issued a letter to the NRC on March 14th and they agreed in general with the staff's conclusions regarding the preapplication review.

Following that the NRC issued a letter to Westinghouse on March 25th where we reviewed the analysis codes and test programs for the AP600 and determined in general that they applied to the AP1000. However, we identified some exceptions to that which was the six issues that were brought out in that letter. I'll briefly discuss the status of those issues in a couple more slides.

Before I get to that, I just wanted to go over the summary of design certification. Westinghouse submitted their design certification application in March of 2002. The NRC staff reviewed and issued 714 RAIs. Westinghouse responded to the RAIs by December 2nd.

In the 714 we issued recently -- that includes the five additional ones we issued just recently. NRC staff reviewed the Westinghouse responses and we provided comments to Westinghouse.

CHAIRMAN WALLIS: I have a comment on these RAIs. We got hundreds of RAIs. If you look through them, some of them look very minor and some look very serious. It would be useful if you had green RAIs and white and red and orange or something, or some classification so we could say these ones are important and these ones really are very minor. Other ones you have to resolve. Otherwise, there is some real safety issue.

DR. SEGALA: I think those would be the ones that would be open in the Draft Safety Evaluation Report but that doesn't necessarily help you doing your review. I have a slide coming up that gives you an overview of the RAIs, not necessarily the thermal-hydraulic but the whole picture.

Following the conference calls and meetings, Westinghouse issued revised responses and as of February 28th we sent a letter to Westinghouse identifying 188 unresolved RAIs which we are working with Westinghouse to try to provide our comments on those so Westinghouse can provide responses.

I just wanted to point out that the staff has not finished their review and are still in the process of doing reviews so we haven't made any final conclusions yet on the acceptability of the AP1000 design certification.

This is the overview slide. Some key things is you could look at reactor systems as 187

RAIs and PRA has 99 RAIs. You focus in on where was the staff asking most of their questions. In the reactor systems arena we had 48 that were dealt with the analysis codes and test program and about 48 that dealt with the Chapter 15 analysis.

Getting back to the preapplication issues that were identified, and I'm just going to give you a little status of those issues. We had the liquid entrainment in the upper plenum or hot leg during ADS-4 actuation. This is one of our more significant issues.

Following the preapplication review Westinghouse submitted WCAP 15833. The staff reviewed that and we issued 48 RAIs on that. Fourteen of those came from NRR and 34 came from research. A lot of discussions and conference calls and RAI responses.

We have about 6 RAIs that are unresolved in the sense that they may become open items in the DSER. We just issued yesterday a letter to Westinghouse requesting new test data to support justification of the modeling of the entrainment process during a small break loca.

CHAIRMAN WALLIS: Does this include the level swell?

DR. SEGALA: I think so, yeah.

CHAIRMAN WALLIS: Because these are all contributors to carrying liquid out of the vessel.

DR. SEGALA: Yes.

CHAIRMAN WALLIS: And you have to get the level swell right as well as the entrainment presumably. They affect each other. It swells more it gets into the hot leg and can be entrained.

DR. SEGALA: Tomorrow we're going to have Steve Bajorek from research. He's going to go into this issue in a lot of detail.

CHAIRMAN WALLIS: We're not going to discuss this one today?

DR. SEGALA: No.

MR. CORLETTI: This is Mike Corletti from Westinghouse. Our presentation this afternoon will be dealing with the entrainment issue.

CHAIRMAN WALLIS: So you will be doing it?

MR. CORLETTI: Yes, this afternoon. I think Dr. Bajorek will be speaking to it tomorrow. It's the major focus of this meeting, I think.

DR. SEGALA: The next issue, potential steam voids in the RCS following main steamline break. Initially in the preapplication phase Westinghouse didn't provide a main streamline break analysis.

They provided that in the DCD or their

design certification document. The staff issued an RAI on the ability of LOFTRAN to evaluate steam voids. Westinghouse provided a response to that and the analysis showed that there were no steam voids. Walt Jensen is going to discuss this issue this afternoon.

The nonconservative boiling heat transfer correlation and NOTRUMP at high heat fluxes in the passive RHR heat exchanger. The staff issued an RAI on this. Westinghouse provided a response taking a 50 percent reduction in the passive RHR heat exchange or heat transfer area. Based on that, this issue is also considered resolved and Walt Jensen will discuss this in more detail as well.

The potential boron precipitation in the vessel during long term cooling. The staff issued an RAI on this. Westinghouse provided a response and the staff needed more additional information. I believe that Westinghouse has responded to this item. The staff has not had a chance to review that yet due to the timing.

Concern for core uncovery during small-break LOCA and performing complete break spectrum. The staff issued an RAI on this. Westinghouse responded and additional break sizes were analyzed and no core uncovery was -- it was shown that no core uncovery had happened. This one is considered resolved.

Except for the first one all the way down to this one are going to be discussed by Walt Jensen this afternoon.

MEMBER RANSOM: Can I ask a quick question? Why is boron deposition in the vessel of concern?

DR. SEGALA: I think --

DR. LOIS: This is Lambrose Lois of the Apple Systems Branch. There is so much water in the vessel. When the long term cooling phase initiates, the potential is that only steam can exit the ADS-4 so, therefore, the boron keeps concentrating. If you assume that the water is cycled only once, then you have enormous amount of concentration which will solidify and block the circulation of water.

MEMBER RANSOM: It seems like if you have solid boron in the core, it must mean you have a saturated mixture.

DR. LOIS: You do. The theoretical maximum is about 60,000 ppm in the water and 35,000 is the precipitation limit for those temperatures.

MEMBER RANSOM: At maximum concentration why would it matter? I'm not sure I understand why this is so significant.

DR. LOIS: Because when it exceeds 35,000 ppm the remaining will precipitate.

MEMBER RANSOM: Yeah, but to me that would say you still have the maximum concentration in the liquid and so the --

DR. LOIS: But the amount that precipitates will block the circulation.

CHAIRMAN WALLIS: It will block circulation of the circuit. That's what we're worried about.

MEMBER RANSOM: Oh, that's what you're worried about. I see.

DR. SEGALA: The last item, use of the approved WGOTHIC containment evaluation model to address large scale test shortcomings. We didn't issue any RAIs on this. This was addressed in the design certification document. Westinghouse developed a conservative model and the staff finds this acceptable. Ed Throm is going to discuss this this afternoon.

CHAIRMAN WALLIS: Is Westinghouse going to discuss that?

DR. SEGALA: I think so, yes. The follow-on issues, again, are those issues that weren't identified during the preapplication phase. We issued about 48 RAIs related to Chapter 15 analysis, both LOCA and non-LOCA. This is just a sampling of items. Westinghouse responded satisfactorily to all except for these few.

The feedwater line break analysis to identify limiting case. Is the double-ended rupture a limiting break for the feedwater line break event. Tech spec required flow to support adequate flow mixing in the RCS. The safety analysis assumes RCS dilution, volume, well mixed during the boron delusion event, and is the tech spec minimum flow adequate for the well mixing assumption.

The ATWS analysis to identify the limiting case Westinghouse needs to perform analysis of all applicable non-LOCA transients to identify the limiting ATWS case.

All these issues the staff feels that when they review Westinghouse's responses, they think that these will probably be acceptable and won't be open items. We just wanted to give you a feel for some other areas that we were looking at beyond the preapplication phase.

CHAIRMAN WALLIS: The last one could be important, the last bullet. What happened was that

Westinghouse did some ATWS analysis and it was not extensive enough. Is that it?

DR. SEGALA: I think so. Summer?

DR. SUN: This is Summer Sun and I'm a reactor system grange. ATWS analysis as presented in DCDs based on a limited case which is loss of normal feedwater. The basis for selecting limited cases is based on AP600 sensitivity study and, based on that, identify that loss of normal feedwater.

The staff asked them to extend their sensitivity study for AP1000 and it confirmed that the loss of normal feedwater is still limited and we are still waiting for the Westinghouse response on this RAI.

CHAIRMAN WALLIS: Thank you.

DR. SEGALA: Okay. That concludes my discussion this morning. The last slide I'm going to discuss tomorrow afternoon. That will be sort of the concluding summary remarks of where we plan to go in the future.

CHAIRMAN WALLIS: Thank you very much.

Mike, it looks as if you're on next.

MR. CORLETTI: Yes.

CHAIRMAN WALLIS: You're keeping the best for last? You're not going to talk about liquid entrainment?

MR. CORLETTI: We are keeping the best for last, or else we would probably never get through the easy ones, I think.

CHAIRMAN WALLIS: That's a photograph of a real AP1000?

MEMBER SIEBER: Yes.

MR. CORLETTI: Good morning. It's a pleasure to be here today. We're going to be talking -- seeing John's presentation there's a lot of similarities in the slides that I've prepared. I will go through them but I think maybe I'll just try to put where we see the issue.

CHAIRMAN WALLIS: Move right into the tentacle issues.

MR. CORLETTI: I think these objectives are pretty much in mind with what you're looking for. If you will, just let me go over where we see our scheduled objectives. We have provided our DCD application and we've gone back and forth on these RAIs.

We are now going through our RAI responses that the staff found they would like additional information. We're in that process of trying to revise our RAIs and provide supplemental information.

We are trying to do that this month time frame to support the staff doing the -- issuing the DSER in June. Our goal is really to address all the open items in this DSER to the extent that we can and to have as few of those going out of the DSER as we can.

CHAIRMAN WALLIS: That looks a little tight to me. I mean, if NRC is going to issue this on 6/16, and they will probably be late, then we have to read it and analyze it and then beginning of July we have to write a letter. Is this realistic?

DR. SEGALA: This is John Segala with NRC. I think we believe this is an aggressive schedule but we are putting as much resources towards it to try to achieve that.

CHAIRMAN WALLIS: If you could do it in 5/16, or even 6/1. Give us some time to study this. We want to avoid having to study it a week before we have to make a decision.

DR. SEGALA: I think the draft sections can be made available to the ACRS at an earlier time.

CHAIRMAN WALLIS: Some of us have vacations in June.

MEMBER SIEBER: We don't have a meeting in August.

CHAIRMAN WALLIS: Maybe that's all planned ahead of time. If there isn't enough time, then we won't be able to write the letter until August.

MEMBER SIEBER: There is no meeting in August.

CHAIRMAN WALLIS: There is no meeting in August. It would be September.

MEMBER KRESS: Or probably July.

CHAIRMAN WALLIS: It says July here but if they don't give us time, if the DSER comes too late, we won't be ready to write a letter in June. That's what I'm saying.

MEMBER KRESS: I see.

MR. CORLETTI: I think it's a good point and we'll see what we can do to facilitate that.

Okay. This was useful then putting up this schedule slide I think.

CHAIRMAN WALLIS: Yes.

MR. CORLETTI: Some of the future meetings, as we said, we had a PRA Subcommittee. This is the Thermal-Hydraulic Subcommittee. We're talking about an AP1000 subcommittee meeting or meetings. I guess we are still working on that.

These are some of the additional issues that have been identified. I think we should come back to this at the end of the two days here to see are there additional items that we want to -- that comes out of this committee that we would want to discuss in these future meetings.

CHAIRMAN WALLIS: The last one is interesting, the man-machine interface. I'm not sure how we'll resolve it.

MR. CORLETTI: For design certification essentially it's really not resolved under design certification. AP1000 similar to AP600 in the other certified designs approved this as a future design acceptance criteria.

CHAIRMAN WALLIS: Are you using fewer operators than the existing reactor?

MEMBER KRESS: I think that was one of our major issues, was how many operators that you're talking about.

MR. CORLETTI: We are not using fewer operators than what is allowed by the regulations, although we have goals. We design it with those sort of objectives. As far as our licensing commitments, it is not.

MEMBER KRESS: That wouldn't be an issue then in that case.

DR. CUMMINS: This is Ed Cummins. The

utility requirements document for passive plants said that the passive plants should be able to be operated by a single operator and a single supervisor. We support that what is in the design certification is a process to determine the required number of operators, not a determination of the number of operators. It's really a deferral of a process to the COL stage.

MR. CORLETTI: Okay. John went over this. I think the part I would add will be that in this phased approach for license, the emphasis of the precertification review really was the applicability of the tests that were performed for AP600 to AP1000. Were those tests suitable for stealing purposes to be sufficient for AP1000 licensing.

Following that, were the safety analysis codes that were validated to those tests also applicable to AP1000 design certification. We wanted to address that early because we see that as a -- it can be a significant issue and can delay the overall schedule so we wanted to have some certainty going into licensing AP1000 that we were on solid foundation there.

I think the results of that generally were yes, the tests were applicable. We did significant scaling studies. We're going to talk a little bit more about those this afternoon. We did scaling studies of the AP600 test and showed how they were applicable, or not, to AP1000. Identified that most of them were applicable. The one issue that did come out of that was the liquid entrainment issue.

MEMBER KRESS: Are you going to do any more on supporting the range of pie groups that designates applicability?

MR. CORLETTI: We at Westinghouse have not done anything more on that. I think that was identified in the --

MEMBER KRESS: It was a comment to the staff.

MR. CORLETTI: Yeah, from the ACRS letter on the pre-cert, the pre-certification review. I think it was a comment really not for AP1000.

MEMBER KRESS: It was for the staff to get ready for all future scaling type events. You're right. I remember.

CHAIRMAN WALLIS: The assumption seemed to be that if the pipe group was within a factor of 2 everything was fine. This seemed to be an article of faith that a factor of 2 is okay but there is no real evidence that 2 is better than --

MR. CORLETTI: Or 200. Right. What was

the right number. It was the accepted practice and we continue to use it on 600.

CHAIRMAN WALLIS: It was not rebuffed. I don't know if it's accepted practice. You made the argument, I think, and then it wasn't challenged. Isn't that more description than to say it was accepted practice?

MR. CORLETTI: Maybe.

DR. CUMMINS: Ed Cummins. In the certification I believe the NRC and their consultants used a factor of 3 and we got certification so we sort of felt that there was some informal acceptance of a factor of 2. Though I think we understand your comments that the justification of that was not really provided.

CHAIRMAN WALLIS: I'd be in real trouble if I were evaluating the flight of a golf ball and I said the Reynolds number was six times 10 to the fifth and it actually turned out to be 12 time 10 to the fifth, I would have a complete different answer for sure.

MEMBER KRESS: Different phenomenon.

CHAIRMAN WALLIS: Different phenomenon. That's a simple case. Golf presumably is a simple thing.

MR. CORLETTI: You've never seen me hit a golf ball.

MEMBER RANSOM: Well, it seems to me there are two issues actually and the similarity argument that you don't often hear but one is qualitative similarity meaning the same phenomenon are basically there. That generally is this rule from, say, a half to two. You are relatively assured that the same phenomenon are governing.

Then the other aspect is quantitative similarity which means you must have some measure of just how close it really is. It seems like the argument here is stuck back on the qualitative similarity. I don't know that they have really answered this question of how quantitatively similar are the events.

MEMBER KRESS: The other issue is a lot of times the phenomena is not governed by a single pie group. It may be the composite of them and each one of them -- if each one of them is on the low side you're not sure how to add them up, how each contributes to the phenomenon.

MR. CORLETTI: The key factor in the integral system performance, he had all these competing phenomena and you try to design your facility that every one of them to be one. It's impossible to get them all at one.

DR. BANERJEE: Are you going to visit this issue of pie groups at all in this presentation?

MR. CORLETTI: No, not really.

DR. BANERJEE: So we're going to take it as a given that this sort of analysis was okay?

MR. CORLETTI: Yeah. I think this committee reviewed that analysis as did the NRC under the precertification review. We had not planned on reopening that issue of the scaling. We are going to focus it on the entrainment. We will talk about some scaling aspects of entrainment.

MEMBER KRESS: Sanjoy, our thinking on that was that the ECCS provisions in AP1000 are so robust that you almost always keep the core covered. The calculation for that using the codes does depend on this pie groups. But the experiments that they relied on also showed that you almost always kept it covered. There's just no way to uncover the core. We intuitively thought that the process was acceptable based on that.

CHAIRMAN WALLIS: What was the pie group you used for enjoy intuition?

DR. BANERJEE: There will be some pie

groups then that will come up in the entrainment studies. Right?

MR. CORLETTI: Yes.

DR. BANERJEE: So we can discuss it at that point because I guess that is the most critical issue on core level.

MR. CORLETTI: Not really the most critical issue on core level but it is the last remaining issue that we're discussing. I think there's -- we feel that it's not the most critical issue.

DR. BANERJEE: If I remember the AP600 top-down scaling, it really ended up being a group which dominated that determined outflow from the ADS-4 system and the friction in the line leading in. There was sort of a balance. If you didn't get enough, or got too much outflow, you couldn't get the flow in because of the friction in the line. I'm just thinking back now. This was like five or six years ago.

MR. CORLETTI: I think we're going to have a very detailed discussion of the phenomena involved in the IRWST injection phase and the ADS-4 phase. I think we're going to be able to adequately address --

CHAIRMAN WALLIS: We'll ask these questions when you get to that point.

MR. SNODDERLY: Chairman Wallace, if I could make a suggestion. This is Mike Snodderly. I would like to -- maybe we could ask John Segala and the staff if tomorrow maybe if Steve Bajorek could give us an update of how the staff plans to respond to the ACRS's letter because we did ask specifically how they were going to consider modeling of pie groups in the future and maybe they can give us the status of that and that may be the more appropriate time if Steve Bajorek briefs us tomorrow morning. John, would that be possible? You can get back to us later on that.

DR. BAJOREK: Yeah. Dr. Kress, what I'm planning to do, yes, in tomorrow's meeting where we have the point where RES is going to talk about its future actions, I have a few overheads where I would like to talk about the scaling and how we want to try to address this issue of .5 to 2.0. I'm not sure it's going to resolve the issue but I want to present out thoughts on it and some of the things that we might want to do in that area.

MEMBER KRESS: Thank you.

MR. CORLETTI: Okay. This slide is just

really telling you what was included in our application. Our DCD application includes what traditionally is called the Final Safety Analysis Report for an Operating Plan, or Standard Safety Analysis Report.

Also included the complete PRA, the plant specific PRA for AP1000 including the technical specifications for the plant. I have 20 topical reports. I think our number's above that. I didn't update that. You have probably been seeing the flow of topical reports across your desk.

CHAIRMAN WALLIS: Are you giving the staff your codes to run?

MR. CORLETTI: In the pre-certification review we had this issue and we have agreed that the codes that were approved for AP600 and AP1000, we didn't see the need to do that at that time. We did say that additional codes that we would develop --

CHAIRMAN WALLIS: I thought there was a new negotiation which occurred between you and the NRC.

MR. CORLETTI: That is right. What we said is new codes that we developed for AP1000, new applications, we would make those available.

CHAIRMAN WALLIS: Do you get on the source code?

MR. CORLETTI: Yes. We have not done it under this review, Dr. Wallis, but Westinghouse would make it available.

CHAIRMAN WALLIS: You're going through here sort of the things that you've done and given the staff so I just wanted to know --

MR. CORLETTI: The things we didn't do? Yes.

CHAIRMAN WALLIS: How much in the way of codes you gave the staff or intend to give the staff. Ideally I think our position is you should make everything open and they should be able to run your codes. Have you reached that point yet?

MR. CORLETTI: I think fundamentally we don't have a problem with that.

CHAIRMAN WALLIS: You don't?

MR. CORLETTI: I think the issue really was --

CHAIRMAN WALLIS: It's just that the legal people have a problem with it?

MR. CORLETTI: No. No. I think so. I think the issue is that under this review we had already approved the codes so we weren't reopening that code review and we had completed that under the precertification review. Any new codes that we would develop for this application we would share with the staff and for them to run that. I think that is consistent with what other vendors were doing as well.

CHAIRMAN WALLIS: I guess what I'm getting at is sort of the issue of public confidences reinforce tremendously if they can run your codes and get the same answers that you get.

MR. CORLETTI: Yes. Public confidence is also instilled when they can get the same answers with very independent codes.

CHAIRMAN WALLIS: That is also true.

MR. CORLETTI: Which they have done as part of this review. I think --

CHAIRMAN WALLIS: I guess we will ask the staff about that when we get to them.

MR. CORLETTI: There is also an ACRS letter on the pre-certification review. I think in general you endorse the findings in the precertification review from the staff in Westinghouse's contention.

This just really summarizes our position on the codes in coming out of the pre-certification review. Basically we agreed the AP1000 introduces no new phenomena compared to AP600. The separate effects and integral test were acceptably scaled.

The issue of upper-plenum entrainment, and we're going to talk a lot more about this today, we do believe that while it was interesting, we believe that it was a local effect that was somewhat self-limiting but I think we're going to talk in detail further about that.

We believe that additional code validation, or additional testing, was not required. We thought we would be able to resolve this issue by sensitivity calculations and analysis and we're going to be talking about that.

MEMBER KRESS: Does this apply to WGOTHIC also?

MR. CORLETTI: No. This was really the COBRA/TRAC, Westinghouse COBRA/TRAC sensitivity studies that we did.

DR. CARUSO: Dr. Wallis, this is Ralph Caruso from the staff. I would like to correct maybe misimpression that may have been left by the previous discussion about staff access to the Westinghouse computer codes. The staff does not have any Westinghouse computer codes in house at this point. None of them. And has not as far as I'm aware.

MEMBER KRESS: Have you requested them?

DR. CARUSO: They have been requested and they have not been provided to us. There is currently under negotiation an agreement with Westinghouse for them to provide the codes to us but that agreement has not yet been finalized.

CHAIRMAN WALLIS: So they will not be available by the time you're making the decisions.

MR. CORLETTI: Dr. Wallis, Ralph, forgive me for interrupting. They were not requested as part of the AP1000 design certification review by the staff.

DR. CARUSO: I would disagree, Dr. Corletti, because they were requested.

MR. CORLETTI: Mr. Corletti.

DR. CARUSO: Mr. Corletti. Excuse me. They were requested by the staff but because of management decisions, that request was not followed through on.

MEMBER KRESS: There was no official request then.

DR. CARUSO: There was a request made but it was not followed through.

MEMBER KRESS: Okay.

CHAIRMAN WALLIS: There was a letter sent?

MR. CORLETTI: This is during the

precertification review we discussed this and that was the request.

CHAIRMAN WALLIS: I knew that for some time there's been misnegotiation going on. I thought it had been resolved. It's still being done?

MR. CORLETTI: I believe it has been signed by RCEO. I thought we had actually signed it.

DR. CARUSO: The agreement has not been finalized

CHAIRMAN WALLIS: Okay.

DR. CUMMINS: This is Ed Cummins. In the verification review we thought the codes were already approved in AP600 and we believe that position was endorsed. In the circumstance where the codes are already approved, then we argued that it was not necessary for the staff to re-review or reapprove the codes for application of AP1000.

CHAIRMAN WALLIS: It's not necessary for you to hide your codes. There should be no reason why it can't be open. That's the thing. I mean, the fact that you can argue that you have enough basis is no reason to -- there must be some other reason involved in order to not supply code. Presumably the only argument you have there is some kind of commercial value to the code.

DR. CUMMINS: Right. I think the Westinghouse company and the staff are coming to agreement on that.

CHAIRMAN WALLIS: There is no safety issue which is helped by your not providing the code. It can only do good to provide the code to the staff in terms of public safety. There's no way I can see that public safety is enhanced by you not providing a code. If you have a good argument, then please make it, but I don't think there's anyway the public safety is enhanced. It has to be commercial safety or Westinghouse or something that's at stake.

DR. CUMMINS: -- Westinghouse is being resolved independently of this review by Westinghouse and the staff. I think it is essentially resolved. In the public management sense Westinghouse paid for the review and we don't think --

CHAIRMAN WALLIS: Okay. Should we move on now?

MEMBER KRESS: We didn't view our request as a new review of these codes. It was a new use of them actually where we were that staff could actually exercise them and look at them. We didn't intend for it to be a full review and reapproval.

CHAIRMAN WALLIS: Well, the rescue phase -

- we've got to move out of this, but when you do supply the codes, then the staff does run them. If something gets revealed then, then it might come back to haunt you.

MR. CORLETTI: It was not an issue of --

CHAIRMAN WALLIS: Okay.

MR. CORLETTI: This was from the letter, and I think we talked about this quite a bit. This was from the NRC's letter on the pre-certification review. Really talking that the separate effects interval test programs are appropriate for use in support of the analysis. The analysis codes validated for the design could be extended to that of the AP1000. This is from the staff letter from the pre-certification review.

The plant response during ADS-4 operation was raised. This is essentially the issue on the treatment of upper plenum and hot leg entrainment. That issue needed to be dealt with during the design certification.

MEMBER KRESS: There was a question about the NOTRUMP momentum model or non-momentum model and how you dealt with that.

MR. CORLETTI: Right. We are going to have -- I have a slide on that, but also in our

NOTRUMP presentation later this morning we are going to address that as well.

MEMBER RANSOM: Maybe you could give me an answer to a quick question.

MR. CORLETTI: Sure.

MEMBER RANSOM: I wonder why do you have to have this NOTRUMP code when you've got Westinghouse COBRA/TRAC which is presumably more sophisticated. It seems like it just makes issues.

MR. CORLETTI: The NOTRUMP code is our license to approve small-break LOCA. The COBRA/TRAC code that we applied, the supplemental calculation of a COBRA/TRAC code really was a focused calculation at the lower pressure phase of ADR-4 IRWST injection. The COBRA/TRAC code has not been validated over that entire range of the condition for small break.

This is a summary of the WCAP 15833 which was our attempt at resolving the entrainment issue. We are going to have about two hours of presentation this afternoon. I believe that's the one you have there.

CHAIRMAN WALLIS: That's this one here?

MR. CORLETTI: Yes, sir.

CHAIRMAN WALLIS: That seems to me to be a lot of -- what I was saying when I started this meeting, a lot of stuff brought out of the literature, but I didn't see much in the way of validation of anything. I didn't see comparisons with data in here.

MR. CORLETTI: There actually is a section where we compared the predictions of the COBRA/TRAC calculation to the tests performed.

CHAIRMAN WALLIS: Maybe you could point those out later on today or tomorrow.

MR. CORLETTI: Okay. And we did a series of sensitivity studies really aimed at trying to range the -- see the effects on increasing the magnitude of entrainment, both hot leg and upper plenum entrainment. Really what we're trying to see can we see a sensitivity to the overall plant performance? I think in our conclusions we were not able to see appreciable difference in overall plant performance.

CHAIRMAN WALLIS: So what you're going to do is show us that even if you don't have a very good model, let's take some extremes of a lot of entrainment or not much and it doesn't make much difference because the level drops to some point and doesn't go any further. Is that what you're going to show us?

MR. CORLETTI: Essentially. I think another aspects of that is the models in COBRA/TRAC have very high -- already COBRA/TRAC had very high entrainment rates with the correlations that they have. We're going to talk about the basis for those models in COBRA/TRAC that we use and the analytical basis for that this afternoon.

CHAIRMAN WALLIS: If I recall, you did a sensitivity around the Kataoka-Ishii model. Right?

MR. CORLETTI: Yes.

CHAIRMAN WALLIS: And you're going to talk about how well that model applies?

MR. CORLETTI: Yes. We're going to talk about that model and the models that are actually in COBRA/TRAC and compare them.

CHAIRMAN WALLIS: And you have some comparisons with data to show those models are applicable?

MR. CORLETTI: We have some comparisons with data. The staff has not found those comparisons, I believe, to be sufficient. We will discuss --

CHAIRMAN WALLIS: Just comparing COBRA/TRAC to Kataoka-Ishii is not the same thing as validating it against data.

MR. CORLETTI: Yes.

DR. BANERJEE: Also, there was a concern, if I recall, with the AP600 that the OSU facility was probably the least well-scaled, particularly with regard to poor height. At least in the top-down scaling study that was done, there was concern about that. Have you compared this data, say, something like Rosa 4?

MR. CORLETTI: I don't think we agree that it was the least scaled facility. I think for high pressure phase of the transient the SPES facility in Italy was the best scaled probably. The lower pressure phase of the transient OSU was probably the best scale. We did in the pre-certification review in our scaling report we showed comparisons to SPES, OSU, and Rosa as well.

DR. BANERJEE: I was involved with Idaho study and our conclusion -- this is memory, which might be wrong, was that SPES had a problem with heat loss and it was, we thought, not all that typical. APEX and the OSU facility there was this problem with height that we were concerned about. The facility that was closest to being well scaled was the Rosa facility.

MR. CORLETTI: Was this a public NUREG that you did or was this something that you did for the --

DR. BANERJEE: I think so.

MR. CORLETTI: Okay.

DR. BAJOREK: No. This was a NUREG that you had done for the AP600.

DR. BANERJEE: AP600. Yes.

DR. BAJOREK: I think our conclusions when we did the independent scaling for AP1000 were more or less consistent with that. We think that SPES was okay for the high pressure periods leading up to ADS-4, venting. APEX was good for the long-term cooling in the period following that. Rosa may have been the best overall, but SPES was a little bit better for the early periods, APEX for the late periods.

DR. BANERJEE: I agree, Steve, but the issue of the lowest core level when that was reached, Rosa was the best scaled. That also was published as a paper in Nuclear Engineering and Design and given as a keynote paper at Nuretz which was held at Kyoto so it's public information.

MR. CORLETTI: In our scaling report that we did for AP1000 we did compare, I believe, some of the key pie groups of Rosa to AP1000 as well from the Rosa facility. We had independent scaling done by actually INEL. They had done the scaling before for AP600.

They went and did the scaling for AP1000 and provided that in our scaling report. I think it showed Rosa was adequately scaled for AP1000 when you look at the pie groups. So what we confirmed is that the confirmatory conclusions that the staff was able to get from Rosa could also be applied to AP1000.

DR. BANERJEE: Well, I think it's okay if you show us comparisons with data about whatever correlation you are using.

CHAIRMAN WALLIS: This is going to happen tomorrow?

MR. CORLETTI: Tomorrow we're going to talk about the scaling of --

CHAIRMAN WALLIS: And we are going to resolve it tomorrow?

MR. CORLETTI: That's a good objective for this meeting.

DR. BANERJEE: The core height has changed. Right?

MR. CORLETTI: Yes, it has.

DR. BANERJEE: So one of the concerns was the core height scale and that was what as the problem, I think, with OSU.

CHAIRMAN WALLIS: OSU is actually going to be here tomorrow.

MR. CORLETTI: Yes, they are.

DR. BAJOREK: I don't think we would use anything in APEX for what goes on in the core.

MR. CORLETTI: Right.

DR. BAJOREK: It wasn't scale for that. It's too short. In particular, I think they use like 1-inch diameter rods --

DR. BANERJEE: It was not the best scaling. Absolutely. That issue of what you are using to validate this quote needs to be resolved.

MR. CORLETTI: Okay. I think John spoke to this. I think Walt is going to speak to this as well so I don't need to belabor this issue. There was an issue with the LOFTRAN. I think it really wasn't -- I mean, the issue was and I think the staff concern was we know LOFTRAN is the transient analysis code.

You've been using it for a very long time. We know it is generally a single-phase code that allows two phases in the pressurizer and allows two phases in the upper head but it's typically not a two-phase code. The worry was the large steam generators that we were going to with the AP1000.

On the main steamline break would the depressurization be so significant that you would lose subcooling and then have questions about whether the code was adequate for that.

We did not provide the final analysis during the pre-certification review. We did provide that as part of the DCB analysis. I believe the item is resolved. I think we've provided those results to the staff.

There were several issues in the pre-cert review on the NOTRUMP. One was the heat transfer model. We have a fairly detailed presentation of that showing comparison plots of the heat transfer model in NOTRUMP compared to the heat transfer correlation we developed for AP600 and AP1000 based on the test.

This was another issue from the pre-cert which the staff had really not reviewed keyed-up methodology under AP600 for core uncovery cases because we didn't really have core uncovery. The issue was if you have significant core uncovery we would want to revisit this issue, if we had sufficient core uncovery for AP1000.

Our results for AP1000 are very similar. Any Gagnon is going to be presenting that this afternoon. There was one case that we didn't really have uncovery but we had very, very high voids which in our analysis we did a conservative -- assumed above a certain level, I believe it was over 90 percent, we would assume it would be uncovered and we did a very conservative adiabatic heat-up of the fuel rod to show that even in that case the PCT is well under the limits.

CHAIRMAN WALLIS: It has to stop. If you have a heat-up, something has to turn it around. What turns it around? The refilling of the --

MR. CORLETTI: Yes. It was a blow-down uncovery so it was a very short blow-down uncovery.

CHAIRMAN WALLIS: Instead of having that sort of V where the level goes down and comes up again, it actually goes down, uncovers, and then covers up again.

MR. CORLETTI: Yes, sir. Yes, sir.

The momentum flux model in NOTRUMP was also an issue. The issue there was the methodology that was employed for AP600 acceptable. I think the staff found that it would be. Westinghouse committed to do a supplemental calculation with WCOBRA/TRAC which is a more sophisticated computer code to show a relative comparison to assess the impact of our methodology. That is also in that WCAP 15833. We are going to talk about that later.

With regards to GOTHIC, I think here for AP1000 as we reviewed in the pre-cert review, the approved methodology for AP600 was found to be acceptable provided once we did the final analysis the important scaling numbers were still within the range.

We had done preliminary analysis during the pre-cert review and showed that we were in the key range of the important Rayleigh numbers and Grashof numbers. Rick Wright is going to be speaking to that. Generally we showed that with our final DCD analysis we were still within our scaling basis for --

CHAIRMAN WALLIS: Didn't you also do analysis of CFD type?

MR. CORLETTI: Yes, we did. Under the pre-cert review we showed the mixing characteristics with CFD analysis.

MEMBER RANSOM: Was WGOTHIC coupled with the COBRA/TRAC code or NOTRUMP?

MR. CORLETTI: Manually coupled but it's not linked. We do not have them linked. We do take the mass of energies either from COBRA/TRAC or other calculations and feed them into the GOTHIC containment model.

MEMBER RANSOM: As the calculation proceeds?

MR. CORLETTI: No, they are not linked. It's not a link.

MEMBER RANSOM: Independent calculation?

MR. CORLETTI: Yes.

MEMBER RANSOM: How can you do that then because I thought the source of energy --

MR. CORLETTI: Reiterate. We do them a couple of times essentially. You're right, it's not a link.

This issues was also -- I think Lambrose is going to speak to this. This really wasn't a code issue per se for the pre-cert. It was really a safety analysis results issue. As John mentioned, in PWRs, and especially for cold-leg breaks in PWRs the long-term boiling in the core, it's postulated that this goes on for a very, very long that boron could precipitate in the vessel and could impact core cooling if it finds a blockage of the core cooling.

We did a series of calculations and analysis where we actually calculate the long-term boron concentration in the sump and in the core. We take the output from our COBRA/TRAC LOCA analysis to get the steam qualities in that calculation. What we showed for our base case was peak boron concentration of 5,500 ppm in the core. The boron solubility limit, as Lambrose said, is about 3,500 PPM at that temperature so we are very far away from that.

We also do sensitivity studies to see what could the quality -- we range the quality and see the sensitivity. The RAI response asked us to do a different COBRA/TRAC analysis that was maybe select the way the assumptions that you made to minimize entrainment. We did that with a calculation COBRA/TRAC with a very high containment back pressure. All of the valves opened to minimize the velocities to see if that could have an impact on that.

I think John had this as unresolved, I think, yesterday or the day before. We are hopeful that our additional RAI response will resolve the issue. I think Lambrose hasn't seen that.

CHAIRMAN WALLIS: What are your sources of water? Your IRWST and your CMTs, do they all have the same boron concentration?

MR. CORLETTI: No, they don't. The IRWST is borated to about 2,500 ppm. It's refueling water. The CMTs and the accumulators are at the higher boron concentration. This is the system arrangement that you have long-term core cooling in the AP1000. You'll see that you're steaming out the ADS-4 and you're recirculation flow back through the containment recirc lines. Your team is concentrating. Your steam is condensing on the containment shell.

CHAIRMAN WALLIS: As long as it all

recirculates there can't be a problem.

MR. CORLETTI: That's right.

CHAIRMAN WALLIS: Where else would it go? You would have to have a leak in the containment or something.

MR. CORLETTI: Yes. The worry is -- I mean, there are worries that --

CHAIRMAN WALLIS: Holding up in parts of the structure or something?

MR. CORLETTI: Are you deluding in the sump. Are you concentrating in the core. You can do these -- we do these transfer kind of calculations to track long-term with the range of the concentrations. Operating plants do this as well. They do these sorts of calculations.

In an operating plant they actually have procedures that in 24 hours they switch connections from the RA jar pumps to back flush water through the core. I think a lot of them are going away from that because in the PRA risk significant it's hard to show this is a real issue.

CHAIRMAN WALLIS: Now, you have this recirculation screen. I think we visited that with AP600 but this has become a big issue with PWRs and debris.

MR. CORLETTI: Yes. The staff has asked us questions on that. We have answered those. Essentially with our passive plant we have very, very low velocities to the screen. In addition, we have taken out all fibrous insulation that contributes to this sump blockage.

We have metal reflective insulation. We are very robust in that area in regards to our sump performance. I'm waiting for the staff to tell us. These were late RAIs so we haven't really discussed them but we think our answers are --

CHAIRMAN WALLIS: Didn't you put something above the screen?

MR. CORLETTI: Yes, a plate above the screen to prevent things from falling on the screen and blocking the screen.

MEMBER KRESS: Your ADS-4 valves that aim into the containment, have you aimed those in a way that --

MR. CORLETTI: Yes, away from anything that could damage. They are actually in the loop compartment or the steam generator compartment.

MEMBER KRESS: Not a lot of stuff in there.

MR. CORLETTI: That's right. Because we

are designed to flood, we have to be very careful about where we put our safety related instrumentation and things that are located below the flood level have to be designed to be able to flood.

MEMBER RANSOM: Mike, could you explain for me again how the containment basically deborates water and it comes back into the IRWST and then drains back into the core. How do you prevent deborating core?

MR. CORLETTI: That's another issue. You have to do your calculation with everything skewed the other way. I think that is the mechanism that occurs. I think when you do the calculations you don't see that it -- because of all the born that we start with, you --

MEMBER RANSOM: How does boron get mixed back with this deborated water?

MEMBER KRESS: I would say it works the other way, Vic. At relatively high pressures when you blow off the steam you're enriching the water in boron and the steam is less rich in boron. It will carry some with it. Then when it condenses the boron may get left behind but it would take a long time at relatively high pressures. At low pressures you might be able to have a problem where the steam would carry more boron with it.

MEMBER RANSOM: I'm worried the other way around. The steam basically condensing on the containment deborates the water.

CHAIRMAN WALLIS: But then where is the boron? It's probably in the core.

MR. CORLETTI: That's right.

MEMBER RANSOM: How does it get back?

MEMBER KRESS: The steam leaves. That's only at relatively high pressures. As the pressure gets lower and lower you will take out more boron with the steam. If you're at low pressure and long-term cooling, there is a possibility of you carrying a significant amount of boron with the steam and then it ending up on the containment wall. I think that is the issue you worry about. It would have to be relatively low pressures for that to happen.

MEMBER RANSOM: Also it seems like the boron could wind up in that pool of water surrounding the reactor but not draining back into the reactor director.

MEMBER KRESS: That may be. That's a question of distribution.

MR. CORLETTI: But have we discussed it enough, or have we answered your question?

MEMBER RANSOM: You've done calculations to assure that you do not get a boron pollution?

MR. CORLETTI: Or a boron -- that's right. We look at it in both -- we have selected the assumptions in both ways to show that either you do not concentrate or if you do it the other way, you do not dilute.

MEMBER RANSOM: Is NRR satisfied with that?

MR. CORLETTI: I think Lambrose is going to speak to that this afternoon, or this morning.

Lambrose?

DR. LOIS: This is Lambrose Lois again from Reactor Systems. The deboration of the vessel is accomplished by expelling water out of the vessel. In the long-term cooling phase, of course, you have steam going out as the steam takes some water out with it. If that's the case, then there's no problem. If the blast of the steam is so small, it will not be able to carry water with it into the containment and then there's a problem.

MEMBER RANSOM: The issue I was concerned with is the deborated water is being returned to the reactor.

DR. LOIS: Yes, it is, because it

continuously circulates through the core for the cooling.

MEMBER RANSOM: So it would seem like you have a net loss of boron from the core.

DR. LOIS: Not unless you expel water from the vessel.

MEMBER RANSOM: Right.

CHAIRMAN WALLIS: Are we going to address that later on?

MR. CORLETTI: We are not planning on a detailed presentation on this issue. We can arrange for that in the future if you would like. We could show you curves from our calculations where we did that. That is essentially what we do. We look at both the potential for delusion in the core and the potential for --

CHAIRMAN WALLIS: I don't think the staff has reviewed all this so we're going to have to stop.

MEMBER KRESS: The sorry about delusion is whether the core can go critical again. I don't see much potential for that.

MR. CORLETTI: That's right. If you've thrown in so much more at the beginning of the event that you really --

MEMBER KRESS: It would take a long time.

MR. CORLETTI: You can't get there.

CHAIRMAN WALLIS: You're concentrating boron really.

MEMBER SIEBER: Concentrating.

MEMBER KRESS: Except in the long-term cooling when you've got the pressure down you are deluding then. The steam will carry a significant amount of boron.

CHAIRMAN WALLIS: But if you leave it behind somewhere else.

MEMBER KRESS: And it will just stay on the containment walls.

MR. CORLETTI: But in your containment -- but you remember we had 500,000 gallons of borated water here which is in the sump now which is mixing with the condensation that returns.

MEMBER KRESS: I haven't done the calculations but my feeling is that it would take a long time to get down to boron concentration you would be worried about.

DR. BANERJEE: With regard to the recirculation screens, we were shown some results that even a very small amount of fiber causes a problem because you get this effect of filtration which catches the small particles. To handle that some rather clever screen designs have been --

MR. CORLETTI: Improved screen designs. Right.

DR. BANERJEE: Have you looked at this because this seemed like a real issue when we looked at this problem.

MR. CORLETTI: We have looked at those screen designs and we could the screen designs that would significantly increase the surface area given the same kind of footprint. It's not in our base design but we could use that. I think the staff is reviewing it.

When you look at the amount of fibrous material we have in our AP1000 because of the elimination of that sort of insulation, and you also look at the very low velocities we have here, the approach velocities to the screen, when you categorize is this an issue or not for AP1000, it didn't appear to us that it was. I think we wouldn't have a problem going to implementing the advance -- the one that I've seen, at least, which is --

DR. BANERJEE: What they do is they have velocities parallel to the walls rather than normal to them. They take care of the problem by design.

CHAIRMAN WALLIS: It has to go through

eventually, though.

DR. BANERJEE: Well, also there was this issue that could you separate -- at least have redundancy in the screens having two which is geometrically at different locations.

MR. CORLETTI: This is maybe an issue that if we want to talk about this more in our next meeting, we could show you drawings, the results of our calculations that we've done. I think it is an industry issue that's getting a lot of attention and I think we can show you what we've done. I think we've tried to address this with design.

DR. BANERJEE: You have an opportunity to take care of the problem before it occurs.

MR. CORLETTI: Yes.

MEMBER KRESS: And I think our committee -- I don't mean to speak for them but in one of the letters we expressed the opinion that an increased surface area screen is not a good fix if that's what you're talking about because it takes so little of this insulation to block even a large screen that we thought it wasn't the best kind of fix anyway.

MR. CORLETTI: We thought eliminating the fibrous insulation was the best thing.

MEMBER KRESS: That would be a good way to do it.

MR. CORLETTI: That was what we did.

CHAIRMAN WALLIS: I think our concern was with the paint fragments all coming down and floating around. They are sort of like leaves. That kind of material is very bad for screens, too. It doesn't take many sheets of thin stuff to block up a screen.

MR. CORLETTI: We have looked at the paint that we do use, the paint where they would be susceptible to blow-down forces. We've taken care to make sure we have the safety related paint that is required. I think these non-safety paints are an issue. They assume they all fall off.

CHAIRMAN WALLIS: Unsafety paint.

MR. CORLETTI: Or non-safety painters.

CHAIRMAN WALLIS: Okay. We should perhaps move on.

MR. CORLETTI: This is more of the same --

CHAIRMAN WALLIS: This is what you told us already.

MR. CORLETTI: -- of what you heard from John. We are trying to resolve the issues. I think John said a couple of these might be open. We are going to keep working hard to resolve as many of them as we can. I think staff has been accepting our input there.

I thought this was useful. It is hard, Dr. Wallis. To do a presentation of the RAIs is to get a sense of what were the important ones and what were the unimportant ones. I'll just touch on some of the key ones that we had. If this committee is interested, before I leave we can get you the numbers and point you to the ones that talked about these issues.

We did increased spectrum for the small-break LOCA. We did more complete spectrum on what we presented to the staff. We also did additional shut-down accident analysis. We did a loss of cooling accident initiated in a low power mode without the accumulators to see the robustness of the design for shutdown. Long-term operation of the passive RHR to show it is capable of cooling the plant long term.

ATWS analysis. This plant has a very robust design with regard to ATWS. One of the measures of acceptance is unfavorable exposure time. The amount of core light time where if you would have an ATWS you would actually exceed the reactor cooling system service level C pressure.

The acceptance criterias have that to be a very low number. For AP1000 we were essentially zero, I think, before we submitted our last RAI. We are not at zero at this time. We were 99 percent.

I think Summer Sun wanted us to do additional analysis to show not only did we do the worst case, but also can we meet the essentially zero UET. We are preparing that response. The staff does not have that but I believe our response will resolve that issue.

We did significant amount of PRA success criteria analysis. We discussed a lot of that at the PRA subcommittee meeting. The staff had asked for a multiple steam generator tube rupture analysis as well and we provided that in our RAI response.

And, finally, the low-temperature over-pressure analysis. This demonstrates that your cold temperature, your Appendix G pressure limits on the reactor vessel are not exceeded.

CHAIRMAN WALLIS: This multiple steam-generated tube rupture, is this based on simply assuming that several will break or is it talking about the mechanisms whereby the next one?

MR. CORLETTI: It assumes that multiple ones on an area break and then --

CHAIRMAN WALLIS: That just assumes so many break. You don't discuss how they might break simultaneously.

MR. CORLETTI: No, we don't. We don't postulate that. We didn't postulate that as far as to that analysis. Well, that summarizes my presentation.

CHAIRMAN WALLIS: You are way ahead of time here. I'm wondering if we could move up one of the next -- do one of the presenters have a presentation that might take half an hour?

MR. CORLETTI: The next presentation is the large-break LOCA analysis.

CHAIRMAN WALLIS: Would that take half an hour? We could then take a break after that.

MR. CORLETTI: I think that's fine.

CHAIRMAN WALLIS: Okay. Let's do that.

MR. CORLETTI: Okay. Very good. Thank you.

CHAIRMAN WALLIS: Thank you very much.

DR. KEMPER: Can you hear me all right?

MEMBER KRESS: The question is how advanced are you?

DR. KEMPER: Well, you may have your own judgment on that coming up. Am I able to be heard by everybody? Okay. I am Bob Kemper from the LOCA group at Westinghouse and I wanted to go over somewhat briefly with you the large-break LOCA analysis that we've done for AP1000.

For AP600 what we did was begin with the approved large-break LOCA best estimate technology using WCOBRA/TRAC. That had been approved for the three and four loop Westinghouse operating plants. Then reviewed that in the context of the AP600 design.

We concluded that basically it was acceptable to use it. The main things that showed up as different in a PIRT investigation were direct vessel injection feature of the AP600, now AP1000 design. In the work that we did for AP600 we did some simulations of a CCTF and a UPTF test to demonstrate code capability for phenomena associated with direct vessel injection during a large-break LOCA.

Ultimately, the AP600 methodology was reviewed and approved for that purpose in the NUREG shown. For AP1000 we are just building on that and using the same methodology to analyze a plant which is basically the same in design as AP600. As part of the approval, the NRC identified some limitations on the methodology which we followed during the AP1000 analysis.

A number of these are carryovers from the three and four loop model approval concerning natures of distributions and ranges and that sort of thing that are generic. There are a couple specific for the advanced plant design including consideration of the effect of core makeup tank or PRHR on the results obtained during the large break analysis.

To accommodate that we did a case eliminating the CMT which doesn't really play a factor of much significance in large-break LOCA, and also eliminating the PRHR from the model. In either case, the results were actually less limiting.

Large break is really very similar in this plant to the conventional plant. You have your doubled-ended cold leg rupture and the accumulators are the thing providing the inventory necessary to refill the vessel and recover the core.

This is one of the transients that we did during the large-break LOCA best estimate methodology. It calls for doing a series of like 14 global model cases in which we are varying parameters such as the discharge coefficient of the break and the resistance of the broken nozzle. There are some simplifications that we placed into the advanced plan analysis.

CHAIRMAN WALLIS: Could you show where the CMTs come in on this figure?

DR. KEMPER: The CMTs actually --

CHAIRMAN WALLIS: Or the accumulators.

Just show some of the key events here.

DR. KEMPER: Okay. The CMTs come on when you get an S signal which is maybe four seconds into the event.

CHAIRMAN WALLIS: So they are pretty early.

DR. KEMPER: They come on very early and inject for several seconds of time. The depressurization is so great that you then hit the accumulator set point. Once the accumulators begin to inject the CMTs shut off.

CHAIRMAN WALLIS: When are the accumulators coming on here?

DR. KEMPER: It would be about 10 seconds. Roughly 10 seconds.

CHAIRMAN WALLIS: So this heat up between 50 and 120, this is a an adiabatic heat-up?

DR. KEMPER: No, this is -- well, part of the time.

CHAIRMAN WALLIS: It's an uncovered core.

DR. KEMPER: The core is in essentially adiabatic heat-up --

CHAIRMAN WALLIS: Uncovered.

DR. KEMPER: -- until maybe 70 seconds or so on this scale. Then we begin to -- you refill the lower plenum.

CHAIRMAN WALLIS: But it's still on that track. It's pretty linear. There's about 70 seconds of linear heat-up and then 100 seconds of linear cool down. It looks like a very simple picture.

DR. KEMPER: This is actually more simple than a lot of large break transients. You have the big break, uncover the core. The AP1000 is equipped with capability to drain the upper head liquid very effectively into the upper plenum. A lot of Westinghouse plants don't have wholes in the upper support plate that permit this draining to occur. That enables you to get a very good cooling from 1,600 odd degrees down to 1,200 or so.

CHAIRMAN WALLIS: This is lightly the small-break LOCA in reverse. In one case you're worried about uncovering the core as they're coming down on some curve. Then you turn around and go up again. It doesn't quite uncover.

Here you go up on some heat-up and something has to turn it around. It's pretty key that you predict that turnover right. If it went on for another 30 seconds instead of turning around, you would be up in the danger zone. It's pretty important that you predict the turnaround right.

DR. BANERJEE: what's the pressure when the turnaround is occurring?

DR. KEMPER: Somewhere below 1,000 PSI. It would be going into the time when the accumulators are going to begin injecting.

CHAIRMAN WALLIS: So it's the accumulators that turn around?

DR. KEMPER: No.

CHAIRMAN WALLIS: They have already come on.

DR. KEMPER: The accumulators really turn around the second peak there when they provided enough water --

CHAIRMAN WALLIS: That's what I mean, the second peak.

DR. KEMPER: -- to refill the vessel. The initial blow-down heat-up is turned around by the blow-down cooling.

CHAIRMAN WALLIS: That's the second one. It's the accumulators. It's the balance of water coming in from the accumulators that turns it around at this elevation.

DR. KEMPER: That's correct.

CHAIRMAN WALLIS: Okay. So that's what it is.

DR. KEMPER: You essentially have to have enough accumulator and water injected to fill the downcomer and refill the core.

CHAIRMAN WALLIS: That is a pretty predictable thing. You've got a valve accumulated with pressure and you can predict with a lot of confidence how rapidly that water comes out of that accumulator.

It's not like some of these later events where you're balancing hydrostatic terms here, there, and everywhere and a little more uncertain about just what the flows are going to be. The accumulator flow is pretty certain.

DR. KEMPER: You've got to get the pressure right.

CHAIRMAN WALLIS: Right. You've got to get the pressure right.

DR. BANERJEE: That's why it would be interesting to see what the pressure was like.

DR. KEMPER: Well, the pressure by 30 seconds is down to containment pressure.

CHAIRMAN WALLIS: So it's down to nothing really and the accumulators are --

DR. BANERJEE: When do the accumulators come on then?

DR. KEMPER: Roughly about 10 seconds into the transient when you hit 600, 700 PSIA set point.

DR. BANERJEE: So what's the pressure at 125 seconds or something when the turnaround occurs? The second turnaround.

DR. KEMPER: The second turnaround.

CHAIRMAN WALLIS: It's containment.

DR. KEMPER: Containment plus pressure.

CHAIRMAN WALLIS: So is that the accumulators turning it around or something else?

DR. KEMPER: It's the accumulators

CHAIRMAN WALLIS: Just filling up the vessel. That's all it's doing. It would seem to be a pretty predictable thing. You depressurize and the water is squirting in and it's filling up and the simple analysis will probably get you that one.

DR. BANERJEE: So it's taking 120 seconds or something.

CHAIRMAN WALLIS: Just to fill up the vessel.

DR. KEMPER: Fill the core high enough that you get good enough cooling.

CHAIRMAN WALLIS: The physical things happening are pretty simple. It's not as if it's subject to a lot of uncertainties in the modeling. Do a hand calculation. Sanjoy could do it overnight and get the same answer.

DR. BANERJEE: If I knew the answer.

DR. KEMPER: I would agree this is more straightforward than some of the other events.

CHAIRMAN WALLIS: Right.

MEMBER KRESS: Is this COBRA/TRAC?

DR. KEMPER: This is COBRA/TRAC.

DR. BANERJEE: So it's not due to IRWST water or anything like that?

DR. KEMPER: No. Accumulators are still injecting.

CHAIRMAN WALLIS: The passive aspects have nothing to do with this transient really. This is just like the classical PWR.

DR. KEMPER: Only the ultimate classic passive system, the accumulator.

CHAIRMAN WALLIS: But that was there before.

DR. KEMPER: Yes. That's nothing new here. The result of the calculation is --

CHAIRMAN WALLIS: This is so reassuring that you have ADS-4 to create a large-break LOCA in the other transients.

DR. KEMPER: That is true. I mean, LOCA

will become a large break eventually.

CHAIRMAN WALLIS: This suggestion was made, it seems to me, about 30 years ago that since we no longer analyze large-break LOCAs, let's make everything into a large-break LOCA. Now it's finally going to happen.

DR. BANERJEE: The BWS followed that.

DR. KEMPER: I don't necessarily recall that. I do recall it being considered blow a hole in the hot leg to enable the venting.

CHAIRMAN WALLIS: This is a best estimate calculation?

DR. KEMPER: This is a best estimate calculation.

CHAIRMAN WALLIS: A realistic calculation.

DR. KEMPER: So then we proceed to consider the uncertainties and identify peak cladding temperature of the 50th percentile and at the 95th percentile. We need to meet the 10 CFR 50.46 regulatory requirements here for PCT as well as the cladding oxidation both local and core-wide. The 0.73 percent could also be called your core-wide oxidation or hydrogen generation number.

CHAIRMAN WALLIS: That's the 95th percentile as well?

DR. KEMPER: That is done according to the methodology that was approved for the three and four loop plants. It's really based on a calculation that exceeds a WCOBRA/TRAC transient whose cladding temperatures exceed the 95th percentile PCT value. Then there's a methodology that uses these elevated temperatures to identify what the cladding oxidation is.

MEMBER RANSOM: Were these results generated using a nonparametric statistical approach?

DR. KEMPER: It uses a response surface methodology.

MEMBER RANSOM: You then go back and sample, I guess.

DR. KEMPER: No. It's done by generating response surfaces from varying model parameters. Then based on identified distributions identifying what the 50 percent values are.

CHAIRMAN WALLIS: Since you're just filling a vessel from an accumulator, it would seem the uncertainty should be pretty small. Is it the uncertainty in the heat transfer coefficient that gives you this number?

DR. KEMPER: Part of the methodology is to look at things like ride internal pressure, heat transfer coefficient on the fuel rod, and things such as this which would be --

CHAIRMAN WALLIS: In fact, the rods cool before the level gets to them and you're going to pull that in there so it's the whole reflood basis of assumptions comes into play.

DR. KEMPER: That's right.

MEMBER SIEBER: Maybe you can help me understand a little bit physically what's going on. The clad temperature is a LOCA phenomenon.

DR. KEMPER: That's correct.

MEMBER SIEBER: You're looking for the hot rod and the point on the hot rod where the power history was the highest, which is assuming parabolic would be somewhere in the middle. On the other hand, during a reflood you have a level that's changing the location of where that hot spot is. Do your codes actually look at the fact that the hot spot physically moves?

DR. KEMPER: In doing one of these analysis we keep track along the length of the rod where the highest or hottest point is at any particular point in time.

MEMBER SIEBER: Okay. That will change the effect of -- the shape of the curve that you showed on slide 26. That probably has greater effect on what the slope and consistency of that curve is than just how many gallons you're pumping in or pushing in.

DR. KEMPER: That's also a function of the paper shape that you're assuming. What we've identified for this plant is a top skewed shape which is the most limiting and that's what is analyzed here. One simplification that we introduced for the advanced plan analyses is to do some shape studies and use the bounding shape. In our conventional plan analyses we sample power distributions and consider a variety of them and the uncertainty methodology.

CHAIRMAN WALLIS: Sample in an aleatory way the time after refueling. The power profile changes. Do you sample that in an aleatory way?

DR. KEMPER: Well, the sampling in the three and four loop methodology is from a number of shapes. It's not necessarily tied to a given burnup. That methodology does assume maximum start energy so it's early in life.

CHAIRMAN WALLIS: So if you change your fuel management scheme for this right after you built it, you would have to redo all the stuff?

DR. KEMPER: We would have to, I think,

verify the shape that we looked at is bounded. That's our intent here. That is another reason to go with what we believe to be a bounding shape so that we're not -- we don't have a distribution based on shapes that ultimately might --

CHAIRMAN WALLIS: So there's an additional conservatism in this then?

DR. KEMPER: Yes, definitely.

CHAIRMAN WALLIS: Besides this 95th percentile is the fact that you've used some kind of what you think is a bounded shape for the power profile.

DR. KEMPER: Definitely.

MEMBER SIEBER: And there's other factors there, too, because you have to make an allowance for misaligned broads and tilts and things like that which is also built into that calculation

DR. BANERJEE: How much volume do accumulators have compared to the volume of the vessel?

DR. KEMPER: Accumulators are 2000 cubic foot tanks and the water level nominal level is 1,700 cubic feet. With two of them there's like 3,400 cubic feet and that's certainly larger than the lower part of the vessel and the core.

DR. BANERJEE: So that would cover the core, 3,400 cubic feet?

DR. KEMPER: Yeah. I'm thinking maybe there is 1,200 or 1,500 cubic feet to the hot leg elevations in the reactor vessel.

DR. BANERJEE: And roughly how many cubic feet do you lose out of a cold leg break?

DR. KEMPER: The initial part of the transient while your accumulator is injecting and the pressure is still high you do have bypass and lose most all of the accumulator water at that point in time. I would guess that it's less than 20 percent of the total water in the accumulators for this plant that would bypass during this point.

CHAIRMAN WALLIS: Well, this shouldn't be an issue. This is an old PWR analysis and there's nothing new about AP1000 presumably.

DR. KEMPER: Yeah. That's --

CHAIRMAN WALLIS: Except the CMTs don't have a role.

DR. KEMPER: CMTs really come on the first few seconds but then it's all accumulators and they don't contribute.

So for AP1000 we have performed a large-break LOCA analysis as we are required to according to the regulations and followed the restrictions that had been identified by the staff both in terms of those carried over from the methodology as a whole for Westinghouse best estimate large-break LOCA. And also the AP600 restrictions from the SER issued for that plant design.

CHAIRMAN WALLIS: So you do this calculated 95th percentile. Presumably there's some PCTs you calculate which are higher than that. Is that your disparities to get to a distribution and then cut it off at the 95th percentile?

Or are you going to say the nonparametric method is to say we'll calculate a lot of things and make sure we've got a 95 percent confidence that we've got at least something in 95th percentile and then we use that value and it may be above or -- it may be way up above the bound of the 95th percentile if you did billions of calculations, but at least it's a number you can use.

DR. KEMPER: Well, this methodology uses response surfaces and sampling to identify that. I believe some of my colleagues are going to be speaking with you hopefully soon about the approach you're indicating that we are aware one of our competitors has adopted. That doesn't apply to AP1000.

MEMBER KRESS: With the response surface at 95 percentile means that 5 percent of the results are above that number.

DR. KEMPER: Five percent are --

CHAIRMAN WALLIS: That's right. So you do calculate some numbers higher than 2,124.

DR. KEMPER: Yes.

CHAIRMAN WALLIS: What's the highest one you calculated then?

DR. KEMPER: Really our codes aren't set up to necessarily identify them.

CHAIRMAN WALLIS: They have a loop that says if it gets over 2,200 --

DR. KEMPER: No, no. They print out the 95th percentile value when you're doing your Monte Carlo sampling. I'm not --

CHAIRMAN WALLIS: I guess someone else might address that. It's a generic problem with these codes and it's a problem with the realistic code approach is what are you going to accept as being good enough statistically.

MEMBER KRESS: I think it's already been decided.

CHAIRMAN WALLIS: I think it's already been decided so we can't do anything about it. I think this committee might want to revisit that in the future generically for all reactors. It's all been approved so we can't do anything about it.

DR. KEMPER: I won't argue with that.

MEMBER KRESS: The point is you want to keep the core cool and this is a conservative number anyway to keep the core cool.

DR. KEMPER: So in the way of RAIs our initial presentation of this material was, I'll call it, rather sparse consistent with some of what the operating plants had been providing for their three and four loop methodology. They wanted significantly more information so we provided that.

Another request was to continue running the large grade beyond the time at PCT out beyond the point the accumulators are empty and you have the CMTs now providing the injection. They are the source of injection until such time that you reach the low level in the CMT tank to permit IRWST to come on. We performed that analysis and the injection is adequate to maintain the core quenched.

CHAIRMAN WALLIS: Maybe this is a good time to take a break before you move on to the next topic.

DR. KEMPER: If you think so.

CHAIRMAN WALLIS: I think it is. We'll take a break. We'll come back at 10:30 which will bring us back to our original schedule. Okay. We'll take a break until 10:30.

(Whereupon, at 10:14 a.m. off the record until 10:33 a.m.)

CHAIRMAN WALLIS: Okay. Let's get started again.

DR. KEMPER: Bob Kemper speaking again.

DR. CARUSO: Bob, before you start. Dr. Wallis, I had one other piece of information to add to my last comment about code availability. I determined there is one Westinghouse code that the staff does have in house. It's called the Map 5 code. It was submitted by an operating reactor licensee to support a change in containment licensing basis and we do have a copy of the source code in-house. That's the only one I'm aware of at this point.

CHAIRMAN WALLIS: This is not the code that --

DR. CARUSO: I believe it's the Map 5 version of that code, yes.

CHAIRMAN WALLIS: The one that we had considerable questions about?

DR. CARUSO: I believe so, yes.

CHAIRMAN WALLIS: In terms of the handling of the mixing?

DR. CARUSO: Yes, I believe so.

CHAIRMAN WALLIS: And you never came back to us with an improved explanation?

DR. CARUSO: I don't want to go there.

DR. THROM: Dr Wallis, Ed Throm with the staff. I'm in the group Plant Systems that will be looking at that Map 5.

CHAIRMAN WALLIS: We need to look at Map 5 again in this committee.

DR. THROM: Yeah, but we do have -- just to address the issue of code availability, we do have the code. We have the source term and we may exercise it as necessary.

CHAIRMAN WALLIS: Okay. But presumably this licensee is intending to use it.

DR. THROM: Yes, and we are still very early in the stages of the review.

CHAIRMAN WALLIS: We need to see that code again. I think our staff will follow up on that.

DR. THROM: Yes. Thank you.

CHAIRMAN WALLIS: Sorry to interrupt.

DR. KEMPER: All right. I'm going to proceed to talk about long-term cooling analysis that we performed for AP1000. As a large break what we're doing is applying a methodology that had been developed and approved for use on AP600. This is another analysis that uses our WCOBRA/TRAC code in a very much less detailed nodalization and approached than is used for the large-break LOCA event.

In the approval for AP600 the staff did identify some limitations for the application. We have adhered to those doing the AP1000 analysis. Nodalization is the same as it was before so it is still consistent with the validation calculations that we did to support the application on AP600.

CHAIRMAN WALLIS: Did you do sensitivity studies on nodalization? The idea that you could fix a nodalization on OSU and then use it for this large scale device is quite a step, if that's what you're doing.

DR. KEMPER: That's indeed what was done for AP600 that we are doing here. In doing OSU they did investigate some things regarding to the code. I honestly don't recall if they were noting sensitivity studies as a part of that.

MEMBER RANSOM: You mean you have a longer vessel. You didn't use any different nodalization in the vessel than the AP600?

DR. KEMPER: The vessel below the hot legs is approximately the same length. The core is now 14 feet instead of 12 feet. No additional node was used for that.

MEMBER RANSOM: I thought there was a longer distance between the top of the core and the bottom of the hot leg.

DR. KEMPER: I believe that dimension is the same.

MEMBER RANSOM: That's the same?

DR. KEMPER: Yeah. I think that was the only thing we wanted to definitely preserve for this. We took some volume out of the lower plenum to accommodate the additional two feet of active fuel length.

MEMBER RANSOM: How many nodes are used between the top of the core and the bottom of the hot leg?

DR. KEMPER: This is a very coarse model so there are two nodes within the core and one node within the upper plenum range. These transients are very long duration with slowly changing phenomena. The idea here was to come up and validate a simple model that we could use and make it feasible to do in computer running time space.

MEMBER KRESS: Refresh my memory on the window mode. What you did was took a window in time and looked at the transient and then extrapolated that to some other window in time?

DR. KEMPER: Okay. Window mode was another thing that was implemented, again, because these transients are so long. The idea of the window mode is to focus on the time of most interest or the time of lowest capability of the system.

Typically that has been when the IRWST is drained down to the point that sump injection or containment recirculation of water begins. This can be for some breaks well out there in time.

The window mode methodology is developed and validated against OSU to look at that point of time that you're interested in, specified boundary conditions for the containment pressure, the levels in the IRWST and/or sump, and temperatures associated with the liquid present there.

Then start with those boundary conditions and begin initializing the reactor vessel and primary system with a set of identified initial conditions that were deemed reasonable. Now, this is a boundary value type of problem.

The way we've approached it is you run the code for a period of time just until it settles out to its determine condition and overrides the initial condition that you specified. Then you proceed to analyze the transient.

CHAIRMAN WALLIS: This is long-term cooling?

This is when you have already filled the sump?

DR. KEMPER: This is --

CHAIRMAN WALLIS: The picture we just saw that Mike showed a picture of water everywhere around the reactor. Is that what is meant by long-term cooling?

DR. KEMPER: That would be during long-term cooling.

CHAIRMAN WALLIS: So nothing exciting is going to happen. Is it?

DR. KEMPER: Probably not if you have your --

CHAIRMAN WALLIS: You've got water everywhere and it's higher than the core and its got access to the core. The question might be can you get rid of the heat to the environment?

DR. KEMPER: It should be very benign given that you have properly sized ADS stage 4 valves pass the safety system.

CHAIRMAN WALLIS: That's all over. Isn't it?

DR. KEMPER: Still your ADS-4 --

CHAIRMAN WALLIS: Yeah, but it's open. It's a huge opening.

DR. KEMPER: It's been open for an extended period of time. You're draining water from the IRWST and/or recirculating it from containment.

CHAIRMAN WALLIS: And the velocities at that valve are relatively modest, aren't they, by then? Or are we still dealing with fairly high flow rates out of ADS-4?

DR. KEMPER: Well, the velocities at the time of sump injection, which was the picture Mike showed, depending on your assumptions regarding single failure of the ADS-4 valve that we would need to assume.

CHAIRMAN WALLIS: It can't be very high. It would have a big pressure drop and then you wouldn't get the water in so there must be a very low pressure drop for that valve. Or is it a few feet of water or something?

DR. KEMPER: No. It's a PSI or two. It's not large.

CHAIRMAN WALLIS: A few feet of water?

DR. KEMPER: Yeah.

DR. BANERJEE: Did the OSU tests show any oscillations in the long term?

DR. KEMPER: There were some.

DR. BANERJEE: Could you explain those?

DR. KEMPER: Well, a lot of effort went into explaining those. I was not part of that. I don't think they were considered safety significant. I know there was something that went on in the core makeup tanks in one of the tests but I'm not really familiar with all of what was determined from that.

MR. CORLETTI: Perhaps tomorrow Dr. Reyes from Morgan State will be here as will some of the other people that we have involved with the test program and we could revisit some of that question as far as the oscillatory behavior.

CHAIRMAN WALLIS: So do you think that behavior was peculiar to that facility or would it be expected?

MR. CORLETTI: Not necessarily. I think it's characterized by flood of water and filling up the system and then burping out of the ADS valves and filling the system and burping out. It is an oscillatory behavior that you can see. We even see some of that in our calculations for the plant as well.

DR. BAJOREK: Bob, weren't those due to condensation on the outside shell of the CMT in the tests and it was condensation inside the CMT that was stagnating the flow periodically and that was feeding back on the oscillation.

MR. CORLETTI: I think that was associated with one set of oscillations. I think there may have been some other things going on, too. I never personally looked into that to a great extent.

DR. BANERJEE: And your codes model this for this calculation?

MR. CORLETTI: The codes will show behavior of a slug of liquid enters the ADS stage 4 and then you pressurize the system. Once that passes the pressure drops back. That type behavior is observed in the code level.

CHAIRMAN WALLIS: Are you discussing this now because this was some point of issue with the staff?

MR. CORLETTI: No. Just basically that we've --

DR. CUMMINS: This is Ed Cummins. Maybe I could give a context to long-term cooling. The safety issue or the safety significant question is that as the IRWST empties and transitions to injection to the sump you have less driving head and is the driving head sufficient at that stage to cool the core with your ADS flow.

We had to prove that to the staff and we used this analysis to prove it to the staff. The sequence was modeled in the OSU test and we benchmarked the codes against the OSU test and then predicted the plant.

DR. BANERJEE: I guess the issue is whether a bubble short of grows and there's liquid held up in the hot leg in the ADS system which has to be pushed out. Then this bottle sort of vents and then starts that process again. Is there something like that happening or is it just the CMT sucking? There was that, too, wasn't there, that the CMT motivated?

DR. KEMPER: Slugging of portions of liquid flow through the ADS-4 valves were observed in the tests but it was never to an extent that you were doing anything significant to the water inventory.

CHAIRMAN WALLIS: I think your argument has to be that if you get water into the ADS-4 line, there must be water above the core and there is no problem.

DR. KEMPER: Exactly.

DR. BANERJEE: Well, it could be a growing steam bubble. You see, you've got stuff there in the hot leg ADS and you could be growing this until it breaks through and vents and then it starts again. That's why I'm asking what is the phenomena? If the phenomena was something different, that's fine, but what was the basis of this phenomena? Did they see oscillations in core temperature?

DR. KEMPER: No, I don't think so, not in any of the -- nothing significant in my recollection occurred in the way of inventory in the vessel during anything that was causing these small fluctuations in pressure.

DR. BANERJEE: Anyway, maybe tomorrow he could just briefly address it.

MR. CORLETTI: Dr. Wallis, one question you asked is when are we presenting this. This is one of the safety analysis that is in the Chapter 15 of our DCD and we were providing it.

CHAIRMAN WALLIS: But I thought we were going to go over today the areas where there might be some tentacle problems we had to think about.

MR. CORLETTI: The only issue that was raised by the staff during the pre-cert review was in addition to this window mode that we talked about where we looked at key windows, they had asked could we do a continuous transient calculation from the beginning of the transient and we did do that.

Some of the transients are so slow. We can't run a 30-day transient that way but we did run some that are -- we did run a limiting one in that way and provided that also to the staff. That was, I think, the one issue from the pre-cert review.

CHAIRMAN WALLIS: What you're predicting is that you've got this sump full of water, water flows into the core, there's a two-phase flow in the core but what comes out into the ADS-4 line is steam.

MR. CORLETTI: It's a mixture, yes.

CHAIRMAN WALLIS: It is a mixture?

MR. CORLETTI: Yes.

CHAIRMAN WALLIS: So maybe you have to get the two-phase flow right.

MR. CORLETTI: Yes, I believe you do.

DR. BANERJEE: It's not steady.

CHAIRMAN WALLIS: It's not steady.

MR. CORLETTI: In the oscillatory behavior that you are referring to here on these tests was kind of a filling and venting kind of a long-term operation. The other oscillations about the core makeup tanks and condensing in the core makeup tanks, that's a very early time. The core makeup tanks before they start to inject --

CHAIRMAN WALLIS: If the core were to be drying, you wouldn't get two-phase flow out the ADS-4 line. Would you?

MR. CORLETTI: That is correct. When we do have water in the hot leg, we think this is a good sign.

CHAIRMAN WALLIS: So if you analyzed that case where you began to dry-out and showed that you were okay then, maybe you wouldn't need to do all the other work.

MR. CORLETTI: That would be a bounding calculation. Yes, I agree with that.

CHAIRMAN WALLIS: I think that would be more convincing to us if you could show a couple of pictures about what's happening and say, "We make this bounding calculation and it can't be worse than that and everything is okay," we can believe it. But when it's sort of just words like this, we don't quite know what we're looking at.

MR. CORLETTI: Maybe, Bob, if you continue.

MR. SNODDERLY: I'm sorry. Mike, before

we continue, Dr. Wallis, when we developed the agenda I thought it would be useful for Westinghouse to just give you an overview of the large-break LOCA, small-break LOCA and the containment analyses. What we accomplished in bullet No. 3 was really what the major open issues that were identified during the preapplication process except for liquid entrainment which we're going to do later and to try to give some idea --

CHAIRMAN WALLIS: Four is just a review of some of the major safety analysis results which were not subject to RAIs.

MR. SNODDERLY: They were subject to RAIs and there may be some open items that will be covered, but I think what I wanted to try to do here was just to provide you an overview of those analyses.

CHAIRMAN WALLIS: I think it would always help this committee if instead of getting this presentation which says, "We did this and everything is fine," if you could sort of give a better picture of, "We had to consider these phenomena and this is what happened. The RAI analyses were secure," and so on.

DR. BANERJEE: Well, in particular with this the collapsed liquid level is six to eight feet or eight and a half. That's about 50 percent of the core roughly. Oh, sorry. You were going to come to that?

DR. KEMPER: Yeah. Well, we can come to that.

CHAIRMAN WALLIS: Can you just keep going until you get that picture?

MR. SNODDERLY: I'm sorry, Bob. Before we move on, I hate to interrupt again, Graham, but could we go back to assist me in my notes. Dr. Banerjee's question, I don't know if we clearly answered that when he asked can COBRA/TRAC model the oscillations that were seen at the OSU test. It wasn't clear to me whether they could or they were.

DR. KEMPER: Yeah, WCOBRA/TRAC models oscillations are comparable to those that occurred in the test with regard to ADS-4 liquid and steam flow.

MR. SNODDERLY: Thank you. Bob.

DR. BANERJEE: And that's documented in some report?

DR. KEMPER: Yeah, there's a large inch-thick WCAP about Oregon State University.

DR. BANERJEE: Do you know that number?

DR. KEMPER: 14776 Rev. 4. Okay. So the one thing with condenses and the time since AP600 we did have the capability to run a DEDVI line break case from the end of the NOTRUMP run onward out into the sump injection phase and did not at this point have to use window mode to do this. This is one of the results from that run. As Dr. Banerjee noted, it's core collapsed liquid level.

CHAIRMAN WALLIS: What is times zero on this plot?

DR. KEMPER: Times zero on this would be the end of the NOTRUMP run which would be 4,000 second maybe.

MR. CORLETTI: After IRWST injection.

DR. KEMPER: Once the IRWST is on and has established itself as a consistent source of input of water to the vessel.

DR. BANERJEE: But this level is calculated by COBRA/TRAC?

DR. KEMPER: Yes. This is COBRA/TRAC result for collapsed liquid level.

DR. BANERJEE: It's a 3-D calculation?

DR. KEMPER: No, it's essentially a 1-D calculation.

DR. BANERJEE: And this is with the two nodes or something or more nodes?

DR. KEMPER: Two nodes in the core.

DR. BANERJEE: If I remember, you have some large bundle tests, right? Fourteen-foot bundle tests and 12-foot bundle tests, G2, G1?

DR. KEMPER: There's blow-down heat transfer.

DR. BANERJEE: No, I'm saying boil-up collapse liquid level. When do you get dry-out? At what sort of collapsed liquid levels?

DR. KEMPER: Dry-out was not observed during this phase in any of the AP600 tests at OSU.

DR. BANERJEE: No, no. OSU is not the same height. This is a 14-foot bundle. Do you have tests showing first that you are getting the right collapsed liquid levels and, second, getting about 50 percent there that you don't have dry-out? The numbers are around 30 or 40 percent that you get dry-out with collapsed liquid levels.

CHAIRMAN WALLIS: You're meaning the level of the two-phase mixture which you're looking for.

DR. BANERJEE: Well, that's where it goes to. If you have about 30 percent collapsed liquid level, for sure you get dry-out. At about 40 percent the jury is out. Maybe you do get dry-out.

CHAIRMAN WALLIS: You get two-phase swell that you wet the top of the core.

DR. BANERJEE: And that's a function of the height of the core. Actually, it's quite easy to show analytically.

CHAIRMAN WALLIS: There is a situation here where if you had too little heat produced, you might be worse off because you might actually not so much swell so you might actually dry-out the top.

MEMBER KRESS: Is the 14-foot the top of the active core?

DR. KEMPER: That's right.

MEMBER KRESS: So your two-node break line is at the seven-foot level?

DR. KEMPER: That's right. This is the overall collapse level which is at like 60 percent.

CHAIRMAN WALLIS: It's a pretty crude model with two nodes and you're trying to predict this level.

DR. BANERJEE: And also what's the validation of this? If you get things a little bit wrong in terms of flow resistance this could be dropping so there's an issue of sensitivity as well.

DR. KEMPER: There were some sensitivities looked at in the WCAP that I mentioned earlier concerning the OSU predictions in terms of implementation of this methodology.

DR. BANERJEE: Remind me of the height of the OSU core.

DR. KEMPER: It's three feet. Quarter scale of 12-foot core so three feet.

DR. BANERJEE: Do you feel that those experiments were really applicable to a 14-foot core?

DR. KEMPER: I would say no. Less so than to a 12-foot core. You're still looking at a height-scaled facility no matter.

DR. BANERJEE: You have experiments which are with the 14-foot core and a 12-foot core, don't you, with bundles?

DR. KEMPER: I'm not really familiar with 14-foot core.

DR. BANERJEE: Only 12-foot cores? One of these big bundle experiments for level swell, how many feet were they?

DR. KEMPER: They are all older experiments. My recollection of the height would be 12-foot.

DR. BANERJEE: Okay. So let's say 12-foot. That's closer than three-foot. How do the -- what did you find in these level swell experiments? I mean, how much collapsed liquid level was required to give no dry-out?

DR. KEMPER: I don't really know the answer to that.

CHAIRMAN WALLIS: But you're still having two-phase flow-out the ADS-4.

DR. KEMPER: Yes.

CHAIRMAN WALLIS: So what you're predicting is that this two-phase flow go all the way through the core and above it and that's what cooling it.

DR. KEMPER: Right. You have two-phase flow.

CHAIRMAN WALLIS: The reason this level is so low is because you're making a lot of steam in the core.

DR. KEMPER: Yeah. You still have significant decay heat.

DR. BANERJEE: Also whether it's steady is important or not. I mean, in the long term. Do you just have a steady boiling with flow out or are you getting some sort of jogging phenomena which is going back and forth?

If there is jogging, how much further down is it going and what is the period? I think those are things which your code can probably calculate but it has to be validated against some database which is representative. A three-foot core maybe tells you something but it's not the same as a 14-foot core.

CHAIRMAN WALLIS: Don't you have to get the bubble rise velocity or the interfacial drag or something right to do this? Isn't that the key thing you have to get right to get the level swell?

DR. KEMPER: The interfacial drag would be what you're looking at to get the level predictions good in the vessel in the upper plenum, yes.

MEMBER RANSOM: Two analogies don't have enough detail really, I would think. I was going to ask you does the fuel also only have two axial nodes, the core?

DR. KEMPER: That's right.

MEMBER RANSOM: So you have lumped the upper region and the lower region into relatively low power type situation whereas you're missing the point of the highest power where you're more likely to get dry-out.

MEMBER SIEBER: That's true.

MEMBER RANSOM: I really don't know that you could look at these kind of calculations and draw any conclusion about whether or not you have seen dry-out.

CHAIRMAN WALLIS: The dry-out that we're

talking about, I think, is not DMB type dry-out. It's just simply the water doesn't get to the top of the core. Is that what you're talking about?

MEMBER SIEBER: Right.

CHAIRMAN WALLIS: There isn't water at the top level of the core so it's just steam cooling and that might take off. I would think this is a simple problem and the staff could do some of its own checking calculations or something. Well, it has. You want to ask the staff? Is this a problem here? Are we spending too much time with it?

DR. BAJOREK: I think it's a valid question. I do kind of question having only two axial nodes in the core for this. Now, I think in answer to the question, yeah, we have looked at this type of phenomena.

Generally what you find by looking at tests like Oakridge, the G2, which is a 14-foot bundle, G1 and, I believe, Theta which I haven't looked at, is that at lower-type pressures your level swell, which can take like a ratio between your two-phase level and your collapse level, is about a two with some uncertainty.

That would say in these calculations you would start expecting dry-out at the top if you got below about seven feet. Now, it appears that there's enough level in this one that you're probably not drying out.

Maybe not by a large amount but, there again, the way that is nodalized you may be cheating yourself of some liquid because you aren't getting a good axial discretion in the void fraction. I mean, this is saying that you're getting basically a 40 percent void fraction on average in the core.

My guess is without looking at the plots, we're seeing something that's on the bottom cell of .1 void fraction with something fairly high. That is going across too many flow patterns for COBRA/TRAC to really do a good job on.

DR. BANERJEE: Just another question. Does COBRA/TRAC have a drift flux model built in to get the level swell or how does it do it?

DR. KEMPER: Well, this is in the COBRA vessels where you have representations of interfacial drag. It's not a drift flux model.

DR. BANERJEE: Two fluid?

DR. KEMPER: Two fluid.

DR. BANERJEE: Then how does it get the level swell right? Two fluid models are notoriously bad at getting level swell right as far as I know.

How does it get the level right?

DR. KEMPER: Well, again, in the WCAP by reference that shows that for this application that was done right. The COBRA/TRAC expert will be here this afternoon if you would like to pursue that further.

DR. BANERJEE: Who is the expert?

DR. KEMPER: Dr. Ohkawa.

CHAIRMAN WALLIS: I think it would be good if they could show more detail than just this curve. This doesn't show us much.

DR. BANERJEE: Really what is the basis for the belief in this?

MEMBER RANSOM: Well, it would be helpful to see the void fraction profile, too. At least the voids in the three different nodes that they have above the core and the two core.

CHAIRMAN WALLIS: But they are very crude models.

MEMBER RANSOM: Oh, extremely.

CHAIRMAN WALLIS: If you're worried about whether it's six or seven or eight feet, I would think the model is too crude to really distinguish that.

MEMBER RANSOM: Well, standard approach in 1-D codes use about a one-foot node, you know, so you would have like 12 to 14 nodes.

CHAIRMAN WALLIS: Doesn't your window do that? Doesn't your window mode use more number nodes or not?

DR. KEMPER: No.

CHAIRMAN WALLIS: It's so easy to do, though. Just take a look at it at one point there and calculate as it it were steady state. It should be easy.

DR. BANERJEE: Well, the only thing I don't know is whether, first of all, this is right. Even if it is off by a little bit it doesn't really matter. If it gets to six foot, for example, then you are going to be drying out a significant part of the top of the core if it's not eight but six.

CHAIRMAN WALLIS: It must depend on the power level. If there's no power at the six-foot level, it's dried out the rest of the core.

MEMBER SIEBER: It doesn't make any difference.

CHAIRMAN WALLIS: If it's a very low power level, then the bottom is just water and the top is dry and heating up.

DR. KEMPER: Yeah.

CHAIRMAN WALLIS: It's primarily worse off than it was a long time in the future and you just don't have enough power to keep the level of the swell up there. It's all tied up to the ADS-4 flow rate, pressure drop through that and how much that depressures.

The whole picture isn't here at all. Where do we go from here? I think someone has to look into it in more detail because we're not getting enough detailed answers here to be reassured. I don't think we're going to get them right now.

MEMBER RANSOM: The other part that is helpful is the hear transfer mode in each of these nodes here.

DR. BANERJEE: This is almost a steady state calculation. Right? Virtually. There's going to be a calculation which is almost possible to do by hand.

MEMBER KRESS: Hot water bottle with a line feeding in.

DR. BANERJEE: As long as you know the resistance.

MEMBER KRESS: Resistance coming in and going out.

DR. BANERJEE: The only thing is if you do get this oscillatory mode of chugging, that needs to be dealt with, too, to either explain it or something.

MEMBER KRESS: You would have to have momentum equations so you couldn't do that by hand very easy I don't think.

DR. BANERJEE: Very slow probably.

MEMBER KRESS: Yeah.

DR. BANERJEE: You might be able to do a number of steady states.

MEMBER KRESS: You might.

CHAIRMAN WALLIS: Where do we go from here? Are you guys going to come up with something that is more convincing today or tomorrow or are we going to ask the staff to look into this with more detail? I don't see why you just don't do a 20-node model. Stay the same would be trivial to do it. There's not much going on. What's the problem?

DR. KEMPER: Well, the original problem was computer resources for a very long transient. That has changed over the years.

CHAIRMAN WALLIS: There's a big pool of water and it's coming in through DVI line right into a vessel and it's essentially sort of one dimensional flow up through the vessel.

DR. BANERJEE: It may not be so one dimensional.

CHAIRMAN WALLIS: Is it wet at the top or not?

MR. CORLETTI: Dr. Wallis, this is Mike Corletti from Westinghouse. We'll be talking a lot about WCOBRA/TRAC this afternoon and the models in the code. Not on this code but in the other that we have that we've done our supplemental calculation. I think that maybe we can bring some questions there about how this COBRA/TRAC really handled that. Then we can go from there to see whether we need a future action after we discuss that this afternoon.

CHAIRMAN WALLIS: I don't think looking at the models in the code is going to help very much. You have to look at what they are predicting in more detail.

MR. CORLETTI: In our DCD we have quite a bit more plots than this plot here. Also we can get with Bob and see what is the best way to present that.

CHAIRMAN WALLIS: Maybe you could give Dr. Ballenger a homework problem where you can tell him some of these levels and the power level and the resistance to the ADS-4 valve and he can come back tomorrow and say it's okay or it's not.

MR. CORLETTI: I can give you the resistances.

CHAIRMAN WALLIS: It's not a complicated problem. That's why it's really puzzling me why you are saying you are limited by computer resources. I could do this overnight it seems to me with a PC.

DR. BANERJEE: You should get an analytical solution.

CHAIRMAN WALLIS: Analytical solution. Okay.

MEMBER RANSOM: Another question that I think would be interesting to ask is when they resist crude nodalization and one-dimensional in a multi-dimensional code, do they use the same constitutive package for the interface drag?

The floor regimes are quite different that you must use from a 1-D representation versus a multi-dimensional that uses the radio distribution across the core. Is it the same constitutive package then that is being used in COBRA/TRAC for both of these calculations?

DR. KEMPER: Again, that would be a question -- if you want to pursue it, I think you need an expert.

CHAIRMAN WALLIS: Well, suppose we told you we don't think a two-node model is good enough. Show us something more detailed. Wouldn't that be a fair position for us to take? It doesn't have to be transient. You have quasi-steady state at 2,000 and 8,000 second or something. So where's the details with the quasi-steady state model? Should be able to do it in a couple of days.

DR. CUMMINS: This is Ed Cummins. I think the question is can you use another tool to predict this result. It doesn't have to be COBRA/TRAC. It can be Dr. Banerjee's or Westinghouse's hand calculation. We can handle that kind of a question.

CHAIRMAN WALLIS: But not with two nodes. Two nodes seem much too crude for this problem. Did the staff let them get away with two nodes?

Steve, did you let these guys get away with a two-node model for this thing?

DR. BAJOREK: Well, I want to hesitate because I don't really feel I should be answering your question, but I think the answer is no, you should not be using a two-node core for something like this.

The reason being, and I think Katsu can give you more explanation this afternoon, is that in subroutine interfere where these interfacial drag correlations are done, it will break up this core or this process into several discrete flow patterns. Embedded in those interfacial drag correlations are

RAMS that go between delta alphas of about .2 to .4.

Now, I think just by doing a mental calculation on the delta void, what the code has done in this is it has jumped over a couple of these flow patterns. You've gone from bubbly up to annular and you've mushed out everything else in between. The interfacial drag in those regimes are drastically different. Much higher down on the bubbly and the slug than it is up in the annular.

I think by not having the nodalization there, you've missed several of the bubbly slug churn pattern which would probably give you or retain a higher froth and more liquid in the core. I think that's what you would wind up seeing in a more detailed calculation.

Secondly, I think maybe what you might want to think about are, I think, some of the simulations that were done with the G2 and I think G1 and Oakridge to kind of show that COBRA-TRAC does kind of model level swell. I think there is a basis there but I think you're going to have to pull that out.

DR. KEMPER: Yeah. Well, as Dr. Bajorek mentioned, we have these simulations. Now, this is a no core uncovery situation so it's a different condition from some of these tests that were core uncovery tests literally.

CHAIRMAN WALLIS: It seems to me we have some new RAIs here and somehow or the other these 700 RAIs didn't pick up these matters that we're discussing now.

DR. BAJOREK: I think 440 164 alludes to that.

DR. KEMPER: Well, this is long-term cooling as opposed to --

CHAIRMAN WALLIS: This is long-term cooling. Did you discuss the long-term cooling issue with the RAI's? Did you have this sort of discussion with them that we're having now about the two nodes?

DR. BAJOREK: I guess you would have to ask the NRR reviewer who was doing the long-term cooling.

CHAIRMAN WALLIS: Apparently not.

DR. LOIS: This is Lambert Lois, Reactor Systems. Within that question of the two-node solution that they proposed, we do have some outstanding questions regarding the model that they used generally in the long-term cooling.

CHAIRMAN WALLIS: We just have two samples. We have large-break LOCA and long-term cooling that we've looked at a little bit today. One of them looks as if we have some important questions about. From a sample of two, one of them we've got important questions about. If we had a sample of 50, I wonder how many we would have important questions about.

DR. BANERJEE: Just as a matter of information, what is the velocity of the steam and the hot leg and through the ADS valves? This is almost atmospheric pressure.

DR. KEMPER: Right. Now, the velocity depends on how many valves you are presuming to have open and what conditions. It would be on the order of 100 feet per second. For a single failure case you could be maybe size 300 feet per second at some point steering this transient.

CHAIRMAN WALLIS: This is in the hot leg?

DR. KEMPER: This is in the ADS-4 line.

DR. BANERJEE: And the hot leg?

DR. KEMPER: The hot leg would be lower because of its significantly higher area.

CHAIRMAN WALLIS: It's a lot less. What's the area ratio?

DR. KEMPER: Let's see. Maybe a factor --

DR. BANERJEE: Two to one. Let's say 50 to 100.

DR. KEMPER: Two and a quarter to one.

CHAIRMAN WALLIS: And what's the velocity coming out of the core?

DR. BANERJEE: Top of the core.

CHAIRMAN WALLIS: Steam velocity coming out of the core.

DR. KEMPER: There you have a wide area.

CHAIRMAN WALLIS: Is it one or 10 feet a second? Twenty? .1?

DR. KEMPER: Order of 10 feet per second I would say.

CHAIRMAN WALLIS: So it's reasonably significant. It's above the bubble rise quite a bit. It's probably carrying over liquid. If it's carrying over liquid, then double the core is wet. It seems to me all these answers ought to be there just like this without having to dig for them.

DR. BANERJEE: But, as Graham says, if the velocities are at 10, 15, 20 feet per second, you are probably getting droplets coming out.

CHAIRMAN WALLIS: No problem at all. You may have no problem. But you may have a problem at 2,000 seconds or something, or 20,000 seconds. When the power level has gone down, you don't have enough velocity to carry the liquid up. This long-term cooling may be a problem several days later. I don't know. Did you pursue this out much longer in time?

DR. KEMPER: We've got a calculation that was done at 28 days, 30 days.

CHAIRMAN WALLIS: Is this okay 100 days in time?

DR. KEMPER: The 38-day calculation assumes low levels as well within the containment so it's a minimum driving head type of situation. That case was adequate.

DR. BANERJEE: Why is it lower?

MR. CORLETTI: In 30 days we assumed that there are passive leaks inside the containment and that the water actually falls to a lower level. It's what we call a wall-to-wall flooding case where we assume that all the compartments flood to an even level and that's a reduced level compared to the design basis case earlier.

CHAIRMAN WALLIS: When I looked at this figure, what concerned me right from the start is you've got a collapsed level that starts out at something like 7.5 and it slowly goes up to something over 8. Then at around 8,000 seconds it starts to wiggle more and come down. You wouldn't expect that, would you?

DR. KEMPER: That's when you have reached the point of minimum driving head. The IRWST is emptied to its level where you begin self-recirculation. That's a low-driving head situation and you begin to have warmer water come that's been from the sump. Instead of the highly sump cool water from the IRWST, you are now having warmer water being injected into the sump.

CHAIRMAN WALLIS: So it makes more bubbles, makes more steam, makes more voids.

DR. KEMPER: You have a little more voiding in the core.

CHAIRMAN WALLIS: This curve really should be continued out until the level is 14.

MR. CORLETTI: In the 30-day case, the wall-to-wall flooding case actually shows collapsed level of about 14 feet.

CHAIRMAN WALLIS: Thirty days?

MR. CORLETTI: Yes. We do this window mode for some time periods in between so this shows that we're --

CHAIRMAN WALLIS: And it never goes -- does it steadily go up from eight to 14 or does it go down part of the time?

MR. CORLETTI: This is the window modes

that we're doing. I believe if you look at the windows that we did --

Bob, do you have an answer to that trend? Is that the trend? Or did we do enough windows in that trend?

DR. KEMPER: I would expect that to be the trend but there's no specific calculation done for AP1000 under that.

CHAIRMAN WALLIS: To be reassured about the safety of this thing, I would like sort of more positive answers.

MR. CORLETTI: Yes. I understand.

CHAIRMAN WALLIS: I thought you guys had it all sewed up.

MR. CORLETTI: This methodology is the methodology we did use on AP600 and that we reviewed during the pre-cert.

CHAIRMAN WALLIS: I don't really care about methodology. I just care about convincing arguments that this thing isn't going to have any problems.

MR. CORLETTI: Okay. I understand.

CHAIRMAN WALLIS: That's all I care about. I only care about approved methodology and all that stuff.

MR. CORLETTI: I misunderstood your question. I think --

CHAIRMAN WALLIS: You can always take refuge in approved methodology. If I'm not convinced that it's going to work, it doesn't help me.

DR. BANERJEE: But what is approved for a 12-foot core at a lower par density and different floor regimes may not be approved for this.

CHAIRMAN WALLIS: Okay. So this is going to be resolved before you come before the full committee? Maybe we have to have another subcommittee meeting. Maybe there is something we're just missing here.

MR. SNODDERLY: Graham, I think the meaning is objective in the sense that we want to try to identify issues so that in the summer when we write this letter on this draft SER the staff will have identified certain open items.

We would confirm and say that they have identified the proper open items or issues or they haven't. This may be an example of an area where the staff is inadequately -- not the staff but the models used for long-term cooling are inadequate. Maybe we should use more than two nodes.

These types of comments I would see going in to the letter where the staff would either have to come back and say, "No, we don't think that rises to the level of an open item," and they will have to convince us.

CHAIRMAN WALLIS: What concerns me is that we were supposed to focus on sort of the tentacle issues that the staff had problems with with the RAIs and all of that. We weren't supposed to discuss this at all but I understand that Mike said, "Why don't you go and review some of these other things." By this sort of randomly picking this, we seem to have run into some major problems already. We wouldn't have seen it at all unless you happened to present it.

MR. SNODDERLY: What I would like to suggest is with the time we have we could spend a half an hour on the small-break LOCA analysis and then a half hour on the containment analysis.

CHAIRMAN WALLIS: I think we should move onto something else having identified this as a problem. Let's move on and see what we get on the next one. But we're not reviewing everything by any means. This is just a few things. Maybe we should look at the next presentation and see what comes up with that. Are you ready for another one?

DR. GAGNON: Good morning. Can you hear

me fine? My name is Andre Gagnon and I'm here to talk about the AP1000 small-break LOCA analyses and NOTRUMP.

First of all, we're going to look at some of the open items from the pre-certification review. Not all of these were specifically identified by the NRC but were issues that the ACRS also had related to NOTRUMP. The first one is the ADS-4 momentum flux issue. The second issue is the existence of upper plenum and hot leg entrainment.

The third issue is the passive RHR heat transfer model, what we are doing to account for nonconservatism in the nuclear boiling correlation. Next is the noncondensable -- treatment of noncondensable gases in the modeling for the simulations. The last issue is the treatment of core uncovery.

ADS-4 momentum flux. The NOTRUMP model itself does not contain the detailed momentum flux model. It does not -- it has the standard evaluation model package which does not deal with changes in area and density. For most instances for small-break LOCA the velocities are low enough --

CHAIRMAN WALLIS: This can't be true in the break. The break is all momentum flux so it must be only in the pipe that you do it. In the valve it's all momentum flux.

DR. GAGNON: And that's treated as critical flow models.

CHAIRMAN WALLIS: So your concern is that the valve is big enough compared with the pipe that the flow velocity in the pipe is big enough that there is momentum flux in the pipe which needs to be considered in comparison with the other pressure drop terms.

DR. GAGNON: And of the paths where this is an issue, ADS-4 was shown to be the biggest issue. ADS-1 to 3 was shown to have a relatively minor effect but ADS-4 was shown to have a relatively large effect. Now, to deal with this --

CHAIRMAN WALLIS: I'm really puzzled. For 40 years or something we've been neglecting these momentum flux terms or something, and now all of a sudden we have to worry about them. It seems to be so easy to get them right the first time.

DR. GAGNON: Anyway, continuing. To address the ADS-4 issue in the AP600 program, what was done was to utilize an IRWST level penalty. That was a penalty based on scaling arguments and --

CHAIRMAN WALLIS: That's a very round

about way to do it.

DR. GAGNON: Yes, it was.

CHAIRMAN WALLIS: Because momentum flux is wrong in the pipe so you change the level in the tank?

MEMBER KRESS: Gave you a bigger driving edge.

DR. GAGNON: That's what was done originally for AP600. What was done as part of the latter ACRS reviews, if you remember, Dr. Kress, was that we developed the stand-alone momentum flux model to model the ADS-4 flow path from the hot leg to determine the effect.

We then compared that to the IRWST level penalty to show that they were comparable. But what we are doing in terms of AP1000 is to utilize that same methodology which is the detailed ADS-4 momentum flux model to generate a resistance adjustment for the ADS-4 flow to more directly attack the problem which is ADS-4 pressure

CHAIRMAN WALLIS: Is this a problem in the long-term cooling or is this a problem in earlier part of the transient?

DR. GAGNON: This is a problem particularly from the transition from sonic to subsonic.

CHAIRMAN WALLIS: So it's an earlier part of the transient.

DR. GAGNON: Yes.

CHAIRMAN WALLIS: Through the ADS-4 valves?

DR. GAGNON: Yes.

DR. BANERJEE: And is that based on steam flow or two-phase flow?

CHAIRMAN WALLIS: Two-phase flow.

DR. BANERJEE: Two-phase flow? High quality?

DR. GAGNON: We actually have run the model from low quality to high quality and then do a regression to get a fit and an adjustment factor. The adjustment factor that we came up for AP1000 was approximately 70 percent increase.

CHAIRMAN WALLIS: I'm not quite sure. The way that people often argue about momentum flux is, "If I get it wrong, it doesn't matter because the momentum flux that comes out of one node goes into the next one. If I get too little here, I pick it up in the next one." It also works out in the end. If you model momentum flux in the pressure drop in one node and you take that momentum flux to the next one, you can get that momentum flux back.

DR. GAGNON: But what this is is there's a single flow link with fluid node that represents the ADS-4 pipe and then we model the squib valve which is a break link so there's nothing downstream.

CHAIRMAN WALLIS: But the momentum flux that you have in the pipe, the pressure drop in the pipe, you can pick up again in the valve if you take the incoming random flux into the valve as part of the momentum balance for the valve.

DR. BANERJEE: It depends how they do the critical flow calculations.

CHAIRMAN WALLIS: Take the incoming momentum flux --

DR. GAGNON: -- based on stagnation empathy.

CHAIRMAN WALLIS: Stagnation empathy? It's not stagnate, though. Is it?

MEMBER RANSOM: Well, is NOTRUMP like a tube and tank type of model in which the flow from node to node is really a quasi-study phenomena? You know, ignore inertia and momentum flux and just consider resistance type formula?

DR. GAGNON: Yes. I believe that's true.

MEMBER RANSOM: So you don't even have the acceleration effects in this kind of model, let alone the momentum flux part.

CHAIRMAN WALLIS: I'm not sure I want to see another momentum equation.

DR. BANERJEE: But this is a drift flux model.

CHAIRMAN WALLIS: It's a drift flux model?

DR. GAGNON: Yes.

CHAIRMAN WALLIS: For EDS pipe at high velocity?

DR. BANERJEE: No, no. You are modeling that separately. Right?

MEMBER RANSOM: This is modeling the slip between the phases with drift flux model.

CHAIRMAN WALLIS: The drift flux model doesn't apply to this sort of situation.

DR. GAGNON: Not at the valve, no.

CHAIRMAN WALLIS: Not even in the pipe.

DR. BANERJEE: At the core it does.

CHAIRMAN WALLIS: Yeah, in the core it might but pipe? This is the pressure drop in the ADS-4 pipeline you're talking about?

DR. GAGNON: Yes.

DR. BANERJEE: They have a separate model.

CHAIRMAN WALLIS: They have a drift flux model for that?

DR. BANERJEE: They have a separate model.

CHAIRMAN WALLIS: This is all, I suppose, old stuff. This is what you did for AP600?

DR. GAGNON: Yes. What is in the DCD for AP600 is the IRWST level penalty cases. We also ran the ADS-4 resistance change cases to show that they were comparable. But for AP1000 we went with directly attacking the problem rather than changing something --

CHAIRMAN WALLIS: This is all written up in some document somewhere?

DR. GAGNON: They are in RAIs.

CHAIRMAN WALLIS: This is all in the RAIs? What is the actual number?

DR. GAGNON: This is an AP600 RAI which is RAI 447.

CHAIRMAN WALLIS: Does that give equations and things or is it just talk?

DR. GAGNON: Yes.

CHAIRMAN WALLIS: It gives equations. Okay. The staff accepted these? Did the staff accept these?

DR. JENSEN: Yes, the staff has accepted this.

CHAIRMAN WALLIS: Okay. So if I looked at these momentum equations I would accept them, too?

DR. JENSEN: I think so. It's back out from the momentum equation what an equivalent resistance would be.

DR. GAGNON: This was developed by Mike Young in the AP600 and was reviewed by the ACRS.

CHAIRMAN WALLIS: We can't review everything in detail, though.

DR. GAGNON: I don't remember for sure but I believe Dr. Schrock --

CHAIRMAN WALLIS: So momentum flux is treated as an equivalent resistance in some way.

DR. BANERJEE: I guess you're integrating over the whole pipe. Right?

DR. GAGNON: Yes. The detailed momentum flux model has approximately 440 cells simulating the entire piping down through the squid valves.

DR. BANERJEE: Dr. Watson fatal. That's not good. And so that adjustment would change depending on the length of the pipe and so on.

DR. GAGNON: Yes. Yes. And this is specifically for AP1000.

CHAIRMAN WALLIS: Is this just a theoretical calculation or is it related in some way to evidence or data?

DR. GAGNON: It was compared to data for OSU.

DR. BANERJEE: I thought they got slugging.

DR. GAGNON: Well, we're talking early phase.

CHAIRMAN WALLIS: Okay. So there's a comparison and it shows that your new model is better than the old model?

DR. GAGNON: Yes.

MEMBER RANSOM: This could have been accepted by NRR and have been benchmarked against some of the scales, some of the classical blow-down experiments and basically accepted as a licensing tool?

DR. JENSEN: Yes. The code was compared to experimental data primarily in the AP600 review. It was benchmarked against a wide range of data, SPES, OSU, and the staff accepted the code. Then we looked at the application of the code to AP1000 and had some additional questions. Yes, we believe the code has been appropriately benchmarked against experimental data with the exception of the entrainment coming off the ADS-4.

CHAIRMAN WALLIS: This code that was

benchmarked had no momentum flux terms in it?

DR. JENSEN: No. At one time it did have momentum flux long ago and Westinghouse for some reason took the momentum flux terms out for the purpose of reviewing the advanced plants probably because of low-pressure problems.

CHAIRMAN WALLIS: What's been benchmarked, this one with the momentum flux terms put back in again?

DR. JENSEN: The one that was benchmarked against SPES and OSU is the same code that is used for AP1000. It does not have momentum flux.

CHAIRMAN WALLIS: So what assurance do we have that these momentum flux calculations or corrections are valid?

MR. CORLETTI: I think if we go over the presentation it will answer that.

CHAIRMAN WALLIS: You'll get to that? Okay. You don't see comparisons with data in here, though. I'm just leafing through the slides.

DR. KEMPER: For the ADS-4 momentum flux?

CHAIRMAN WALLIS: Going back to AP600 we had a lot of questions about the code and the more we looked at the code, the more we said gee whiz. But then what eventually convinced the bulk of the committee was the evidence, the comparison with SPES and so on, saying that, yes, there's all these hocus pocus in the theory but it works. That's what you need to do here, too.

MR. CORLETTI: Our overall approach was we were going to also benchmark this NOTRUMP against COBRA/TRAC and show COBRA/TRAC to the test, which I think Andy is going to get to next.

CHAIRMAN WALLIS: Those figures show very different protections by the two codes.

MR. CORLETTI: That's where were are next.

DR. BANERJEE: So there was a point made that the momentum flux terms were taken out because you had problems at low pressure?

DR. GAGNON: I don't believe that's the case. I believe at one time -- this is all from memory so don't take this as gospel. Where the code used to run was on the CDC when you had small core memory, large core memory and it was a space issue. At that time the momentum flux models weren't being used. They took them out and they have never been reintroduced.

DR. BANERJEE: But with low pressure there's a large change in volume going from water to steam. Acceleration has to be somewhat important more at low pressure than at high pressure so what is the logic of taking it out at low pressure when it was in at high pressure?

DR. GAGNON: It's been out for a year.

MR. CORLETTI: That predates --

DR. GAGNON: It's not a recent removal.

CHAIRMAN WALLIS: Sometimes it gives yo problems. Momentum flux sometimes gives you nonphysical oscillations.

DR. BANERJEE: It's a nonlinear term.

DR. GAGNON: Anyway, in order to support the missing pieces of NOTRUMP, which is basically the ADS-4 momentum flux, or to supplement what we're doing with NOTRUMP which is using that detailed ADS-4 momentum flux model to calculate a resistance, we proposed to perform supplementary calculations with the COBRA/TRAC code for the ADS-4 and IRWST initiation phase.

That code does contain the momentum flux terms in the momentum equation. It also contains upper plenum and hot leg entrainment models which NOTRUMP does not. It also contains horizontal flow models, flow regime.

DR. BANERJEE: Was this a 3-D model you used it with or not for the core in the upper plenum?

DR. GAGNON: Yeah. I believe the core upper plenum is 3-D, yes.

DR. BANERJEE: Or is it the three-node model that we talked about before?

DR. BANERJEE: No, no, no. This is in the ADS-4 IRWST phase. Right?

DR. GAGNON: Right.

DR. BANERJEE: So you had a detailed model in COBRA/TRAC for this?

DR. GAGNON: I'll let Dr. Kemper answer that question.

CHAIRMAN WALLIS: So NOTRUMP has no hot leg entrainment models. It just assumes that whatever quality goes in comes out or something like that?

DR. GAGNON: What is modeled in NOTRUMP is the pipe diameter that is attached to the hot leg is extended into the hot leg by that pipe diameter so it's rather arbitrary.

CHAIRMAN WALLIS: There's no change in quality or anything. Whatever comes along hot leg goes out there.

DR. GAGNON: Whatever comes along. It's a circular contact so whatever mixture is in there will determine what the flow quality will be as a function of level.

CHAIRMAN WALLIS: Now you think you have a more physical model than WCOBRA/TRAC?

DR. GAGNON: That's correct. We will be discussing that more in detail.

DR. BANERJEE: You're going to tell us the model in COBRA/TRAC later?

DR. GAGNON: That will be this afternoon, yes.

DR. BANERJEE: So how many nodes did you have for the core in rough terms?

MEMBER RANSOM: In the COBRA/TRAC model for this ADS-4 initiation phase there are four nodes in the core for this application.

DR. BANERJEE: And then the upper plenum?

DR. JENSEN: The upper plenum we actually looked at sensitivity to having one node there and three nodes there. The sensitivity studies we performed have three nodes in the upper plenum region.

DR. BANERJEE: Okay. And was this all 1-D or did you do some 3-D?

DR. JENSEN: There's no radial representation in here.

CHAIRMAN WALLIS: Okay. Please go on.

DR. GAGNON: The idea with the supplementary COBRA/TRAC calculation was to demonstrate that the adjusted NOTRUMP model provides a conservative prediction of the IRWST injection phase. As part of, I believe -- is that WCAP 15883? Is that the entrainment?

COBRA/TRAC comparisons to the NOTRUMP models or NOTRUMP simulations were performed for the DEDVI line break inadvertent ADS case. What was shown was that COBRA/TRAC predicts a much higher entrainment rate through the ADS-4 flow pass than is predicted by NOTRUMP. We have some curves that will be demonstrated here shortly.

COBRA/TRAC also depressurizes much more rapidly basically because of NOTRUMP's break flow blending model that restricts flow as it approaches subsign.

CHAIRMAN WALLIS: How does it predict much greater entrainment? I thought that NOTRUMP sort of assumed what goes in comes out so there's no mechanism for de-entrainment.

DR. GAGNON: Only when it gets into contact with the pipe elevation. As the mixture level stays below, the contact elevation --

CHAIRMAN WALLIS: Gives no entrainment at all. Okay. Until you take this pipe and stick it in a little bit further.