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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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ESBWR SUBCOMMITTEE

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WEDNESDAY, APRIL 9, 2008

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ROCKVILLE, MARYLAND

The Subcommittee met at the Nuclear Regulatory Commission, One White Flint North, Room 0-1 G16, 11555 Rockville Pike, at 8:30 a.m., Michael Corradini, Chairman, presiding.

SUBCOMMITTEE MEMBERS:

MICHAEL CORRADINI	Chairman
SAID ABDEL-KHALIK	Member
J. SAM ARMIJO	Member
SANJOY BANERJEE	Member
DENNIS C. BLEY	Member
OTTO L. MAYNARD	Member
WILLIAM J. SHACK	Member
JOHN D. SIEBER	Member
JOHN W. STETKAR	Member

CONSULTANTS PRESENT:

MARIO V. BONACA

THOMAS S. KRESS

GRAHAM B. WALLIS

DESIGNATED FEDERAL OFFICER:

DAVID E. BESSETTE

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P R O C E E D I N G S

Time: 8:30 a.m.

CHAIRMAN CORRADINI: The meeting will come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, ESBWR Subcommittee.

My name is Mike Corradini, Chairman of the Subcommittee. Subcommittee members in attendance or soon to be in attendance are: Sam Armijo, Sanjoy Banerjee, Said Abdel-Khalik, Bill Shack, John Stetkar, Dennis Bley, Jack Sieber, and Otto Maynard, with consultants Tom Kress and, soon to be, Graham Wallis -- and I'm sorry, and Mario Bonaca. I'm sorry. You weren't on the list, and I'm trying to make sure I get everybody. I apologize.

Dave Bessette is the Designated Federal Officer for this meeting.

The purpose of today's meeting is to review portions of the ESBWR Safety Analysis Report. In particular, we will discuss accident analyses -- that is, Chapters 4, 6, 15 and 21 -- and human factors, Chapter 18.

We will hear presentations from the staff and from GE Hitachi Nuclear Energy Americas. The subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register, and portions of today's meeting will be closed for the discussion of proprietary information.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

A transcript of the meeting is being kept and will be made available, as stated in the Federal Register notice.

We request that participants in this meeting use one of the available microphones, hidden somewhere in the room, when addressing the Subcommittee. The speakers should first identify themselves and speak with sufficient clarity and volume so they can be readily heard.

I think we will start off with General Electric and Mr. Kinsey. Where did he go? Jim, do you want to kick us off?

MR. KINSEY: Sure. Just a few opening remarks. My name is Jim Kinsey from GE Hitachi. We appreciate the Committee's attendance today.

The purpose again, as Dr. Corradini mentioned, is to go through some follow-on questions or go through some follow-on clarifications that were based on our previous discussions around DCD Chapters 4, 6, 15 and 21. We are going to focus on thermal-hydraulics and containment performance in this morning's session.

Again, as Dr. Corradini mentioned, we currently plan some Closed activity, probably after lunch, but we will work through that on the agenda. Then at the end of the day, the last portion of today's session is for us to present and for the NRC staff to present information related to DCD Chapter 18 and the human factors arena.

So that is how we have the day laid out, again with some interaction or input from the NRC staff.

With that, I would like to turn it over to Chester Cheung, who is our first presenter. I think we distributed some slides for the first portion of today's session. Thank you.

MR. CHEUNG: Good morning. My name is Chester Cheung from GEH. The first topic of this presentation is the overview of containment response during a LOCA.

There are many questions related to non-condensable gas in the ESBWR containment and where they are coming from, where they are going, and how they go and what fraction of it go from drywell and wetwell, and then questions go on. We apply the PCC wind fan. How does it work, and what are the impacts on drywell pressure, and what causes the drywell pressure to go down.

All of these non-containable gas interact with the rest of the system, and the system interacts one system to the next.

This presentation is to try to address many of those questions, and I structured the presentation in such a way that -- and first, we are going to talk about overall the ESBWR passive safety system and going to describe the PCCS operational modes, how they work and in what time frame and how they work from one time frame to the next.

Then we are going to go into the detail of a main steam line break, and this is from zero to 72 hours, and the first calculation is for the first three days with no vent fan.

After the discussion of this calculation, then we go on to describe the vent fan, which is what we call a drywell gas recirculation system. After that, we are going to present the next set of calculations, which is from three days to seven days, which is a continuation from the first set. In this calculation, we --

MR. WALLIS: Can I ask you a question?

MR. CHEUNG: Yes.

MR. WALLIS: Are you going to describe how you analyze the wetwell gas space?

MR. CHEUNG: Yes.

MR. WALLIS: In detail?

MR. CHEUNG: Well, I could. Thank you.

And for the vent fan calculation, we are going to present two cases. One is six vent fans. The other one is only four vent fans.

After this discussion of seven-day calculation, then we will go on to describe the sensitivity on the bypass leakage flow area and the impact of this flow area on the drywell pressure, and at such time we can discuss a little bit about how we established the test acceptance on the bypass leakage flow area and how we established the licensing base leakage flow area.

Next slide, please.

Now this chart has been so many times described at the ESBWR as passive safety system, and the key point I want to make is at this time we could have -- Later on, we could describe the --

MR. WALLIS: We have seen this figure many times, but I was unable to find any detail about what the walls of the wetwell look like, when you have a picture there of a downcomer to the vent, which I understand is a pipe. Right? So it is a pipe in a wall, but this picture doesn't give any indication of how it fits in that wall, how thick the wall is or anything.

Now do you have plans that detailed yet?

MR. CHEUNG: Yes. It is a plan layout drawing in Chapter 6, one of those figures.

MR. WALLIS: So there is a detailed drawing of all those things and the thickness of the concrete and --

MR. CHEUNG: Yes.

MR. WALLIS: -- how the GDCS pool fits on top of the wetwell? All that kind of stuff is in detail somewhere?

MR. CHEUNG: Yes.

MR. WALLIS: Because I haven't been able to find it.

MR. CHEUNG: Okay, thank you. Since we are on this topic --

CHAIRMAN CORRADINI: Could we just take an action item and get to that specific question on the side, and just refer us to the right document. Go ahead.

MR. CHEUNG: But since we are on this topic, let me describe a little bit. We have about 12 of these vertical pipes, which we call main vent, and total flow area of detail. Vertical pipes is about 14 meters square.

CHAIRMAN CORRADINI: Point that out again.

MR. CHEUNG: The vertical pipe which is called main vent, and 12 of them. The total flow area is about 14 square meters, and we --

MR. WALLIS: They are in a concrete wall?

MR. CHEUNG: In the center of the concrete wall.

MR. WALLIS: And that concrete wall has a uniform thickness all the way around?

MR. CHEUNG: All the way around.

MR. WALLIS: How thick is it?

MR. CHEUNG: As I recall, somewhere around maybe two or three meters.

MR. WALLIS: Maybe two or three meters. It makes a big difference whether it is two or three meters, doesn't it, in terms of transient heat transfer?

MR. CHEUNG: We have performed parametric cases that the heat transfer area there is not sensitive, have no significant impact on the end pressure, and later on I am going to describe what end pressure depends on.

MR. WALLIS: Well, that area is the area by which the suppression pool, if it is going to be heated by the drywell, is heated. If the heat comes in through the wall --

MR. CHEUNG: Yes, we modeled the heat coming through --

MR. WALLIS: -- with some source of raising the pressure in the wetwell, we have to know how to calculate it.

MR. CHEUNG: We modeled that heat transfer area.

MR. WALLIS: Okay. And you have to model the transient in the wall.

MR. CHEUNG: Yes.

MR. WALLIS: Okay.

MR. CHEUNG: It is a concrete wall.

MR. WALLIS: Yes, and it's got a lot of rebar in it. Do you provide the properties of that wall, activity and all that stuff?

MR. CHEUNG: Yes, we provide the properties.

MR. WALLIS: Could you put that down as an action item, too?

MR. CHEUNG: Okay.

MR. WALLIS: Thank you.

MR. CHEUNG: Now I am going to say that we have about 14 square meter of flow area in the vertical pipe. We have six of these PCC vent pipe, the total flow area of vent pipe is .3 square meter. So it's a large ratio, and the vertical pipe main vent is very effective way to condense steam for any extra steam in the drywell.

MR. WALLIS: Okay. Excuse me. Now you have these leaking vacuum breakers --

MR. CHEUNG: Yes.

MR. WALLIS: -- which, I understand, are in the ceiling of this area here?

MR. CHEUNG: Yes.

MR. WALLIS: Somewhere between where it says GDCS pool and this downcomer to the vents?

MR. CHEUNG: The next slide will show the location of vacuum breaker. It is somewhere around there, yes.

Next slide, please.

This slide is trying to describe the operational mode of a PCCS. Let me first go on to the diagram on the righthand -- on the top righthand corner.

The vertical scale is at this point -- at this corner is a drywell. The vertical scale is the delta pressure or the delta P between the drywell pressure reference to the wetwell pressure. Let's take a point --

MR. WALLIS: Are there units on this graph?

MR. CHEUNG: There's no unit.

MR. WALLIS: Well, you need to have units, if it means anything.

MR. CHEUNG: That's the reference point. Okay, the vertical seal -- You can see the middle of the seal. That means the drywell pressure equals the wetwell pressure at this line, and you move on all the way -- I mean, at this condition the water or the submergence of the vent pipe, a PPC vent pipe -- The water will go into the vent pipe and sitting at a level equalized to the suppression pool water level.

MR. WALLIS: So I see you have these things on the righthand side. When you say top vent opens, does that mean that the water level reaches the top of the pipe, the very top of the pipe, or what, because it's a big pipe?

MR. CHEUNG: The PCC vent pipe?

MR. WALLIS: Where it says top horizontal vent open.

CHAIRMAN CORRADINI: Your upper line.

MR. WALLIS: Does it mean that the water level reaches the top of that pipe? It looks like it in curve 5 here. So the instant the water level reaches the top of the vent, it opens?

MR. CHEUNG: Let me describe it this way. If the delta P is zero, that means the water level in the main vent pipe -- they are all sitting equalized, equal to the suppression pool water level.

Now if the delta P is equal to the submergence of the PCC vent next to almost the curve number 2, then the PCC vent will be almost clear to the end of it, the exit -- equal to delta P. Okay?

Now to go on, if the delta P increase all the way to, say, equal to the top horizontal vent submergence, then the main vent water level will be just barely touching the top of the horizontal vent.

MR. WALLIS: So curve 2 is after the initial blowdown and the vent clearing and all that sort of thing?

MR. CHEUNG: No. Curve 1 is a typical operation after that.

MR. WALLIS: After that?

MR. CHEUNG: Yes.

MR. WALLIS: Okay. Curve 1?

MR. CHEUNG: Yes. I will describe those curves.

MR. WALLIS: You want curve 2 a short term, 10 minutes. Right?

MR. CHEUNG: Yes. And if the delta P increased further, which is larger than the top horizontal vent submergence, under this condition then the water level in the main vent will go down to uncover the first horizontal vent or maybe even the second or the third one, and --

MR. WALLIS: So this is very sensitive to your ability to calculate the pressure drop through the PCC with condensation and in the presence of non-condensable gas?

MR. CHEUNG: Yes and no, and the next slide will tell you that it is not sensitive to all these things.

MR. WALLIS: Okay.

MR. CHEUNG: Let's move on to say on the other side of the scale that, if the delta P in the drywell is negative in such a way that it is below the wetwell pressure, but there is a limit that how much that can go. It goes all the way to the vacuum breaker setpoint. Once that happens, the vacuum breaker opens. That is nearby the end of curve Number 4. The vacuum breaker opens, then allows the non-condensable gas or gas mixture from the wetwell back to the drywell.

Now let's specifically talk about curve number 6, which is on the lefthand corner, upper corner. This is during the first blowdown period of say from zero to -- of around 10 minutes or so. A lot of steam blowing into the drywell. The drywell pressurized such that the submergence are higher than the submergence of the top horizontal vent, and during these periods that both the top vent will be uncovered, and the PCC vent would be uncovered.

Now you look at curve number 6 that moves from the left to the right. That describes the pressure drop from the drywell to the PCC inlet and the PCC outlet and all the way to the PCC vent line exit, that this curve number 6 is saying that there is a parallel flow.

MR. WALLIS: So I notice here, there seems to be no pressure drop across the PCC. Is that right?

MR. CHEUNG: Well, it is just a cartoon. There is some pressure drop, and just trying to demonstrate the pressure drop from the drywell all the way to the PCC vent exit. At the vent exit, it is clear, the water and the mixture, gas mixture, will go from drywell all the way to the suppression pool.

MR. WALLIS: So this pressure drop I see at the top of the curve here is from the drywell to the PCC Hx inlet.

MR. CHEUNG: Yes.

MR. WALLIS: That is through a valve or a pipe or something?

MR. CHEUNG: It is PCC pipe exit.

MR. WALLIS: Pipe -- That's through a pipe?

MR. CHEUNG: Yes.

MR. WALLIS: Okay.

MR. CHEUNG: Now you can see that in the cartoon that it's showing that the horizontal vent opens, and then some steam-gas mixture going out in the suppression pool.

MR. WALLIS: So that pressure drop depends on what the steam flow rate is.

MR. CHEUNG: Yes.

MR. WALLIS: Which has to be calculated

somehow.

MR. CHEUNG: Yes.

MR. WALLIS: Through the condenser -- knowing how the condenser performs. Right?

MR. CHEUNG: Yes.

MR. WALLIS: And when you turn on the fans later on -- Well, we'll talk about that -- this influences that pressure drop, doesn't it?

MR. CHEUNG: When we turn on the vent fan, the pressure drop of these vertical vents and the horizontal main vent and the PCC vent is not going to do anything, because they are all covered. We will get that possibly in slide number 13 or 14.

MEMBER BANERJEE: What is the flow in the line that the vent fan is drawing from? What is the fluid that is flowing down the PCC vent line and the vent fan is drawing from? Is that single phase or is there some liquid in there?

MR. CHEUNG: In this page we have no vent fan.

MEMBER BANERJEE: Well, I mean in this picture that you have, the previous slide.

MR. CHEUNG: The previous slide.

MEMBER BANERJEE: Is there a vent fan or not?

MR. CHEUNG: There is a vent fan, but for the discussion of how PCC works, we left out the vent fan. We are going to discuss that later on, the vent fan, how they work.

MEMBER BANERJEE: Yes, I just want to understand. Is there a vent fan or is there not a vent fan?

MR. CHEUNG: For the first three days, we do not credit the vent fan.

MEMBER BANERJEE: Okay. But if the vent fan comes on there after three days, what is the fluid that is drawn by the vent fan?

MR. CHEUNG: Okay. If the vent fan comes on, the vent fan draws mixture, gas mixture.

MEMBER BANERJEE: Of what?

MR. CHEUNG: From the PCC vent line and --

MEMBER BANERJEE: Is there any liquid in it or is it just a pure gas?

MR. CHEUNG: The PCC vent line has no liquid.

MEMBER BANERJEE: No liquid at all?

MR. CHEUNG: No liquid at all.

MR. WALLIS: If the separation works properly in the PCC.

MEMBER BANERJEE: So the PCC separates out the liquid from the gas?

MR. CHEUNG: Yes. The next couple of slides, we are going to discuss that.

MEMBER BANERJEE: Okay.

MR. WALLIS: So we will get to the vent fan later?

MEMBER BANERJEE: And the separator in the PCC. Right?

MR. CHEUNG: Yes.

MR. WALLIS: And the little shelf into which they discharge? We'll get to that, too? Okay.

MEMBER ABDEL-KHALIK: Let's just compare curve 6 and curve 5.

MR. CHEUNG: Yes.

MEMBER ABDEL-KHALIK: The overall driving pressure difference for flow through the PCCS in curve 6 is higher than the overall driving pressure difference in curve 5?

MR. CHEUNG: That is correct.

MEMBER ABDEL-KHALIK: Okay. So you would expect that the heat removal capability during the period covered in curve 6, the PCCS heat exchanger, to be higher than that during period 5. Is that correct?

MR. CHEUNG: That's correct.

MEMBER ABDEL-KHALIK: And yet you are

saying that during period 6, which extends up to 10 minutes, which means decay heat is probably-- at 10 minutes is, what, three percent?

MR. WALLIS: Fifty megawatts or something like that?

MEMBER ABDEL-KHALIK: Yet the PCCS cannot handle decay heat at that point.

MR. CHEUNG: That's correct.

MEMBER ABDEL-KHALIK: What is the maximum capacity of the PCCS heat exchanger?

MR. CHEUNG: The PCC heat exchanger at rate of condition total is about 60 megawatt. So it takes a couple of hours that the PCC will take care of the decay heat or the steam generated by decay heat completely. It takes a couple of hours. Before that, which is curve number 5 --

MEMBER ABDEL-KHALIK: It has to drop to about one and a half percent decay heat.

MR. CHEUNG: Yes.

MR. WALLIS: And there is a sparger at the bottom of that line. It's not just a pipe. Right?

MR. CHEUNG: Yes. Let me continue with curve number 6. That means during this time period that the major heat sink is a suppression pool. The steam goes through the main vent and continue in the suppression pool, and part of the steam and gas mixture will go through the PCC vent and clear it and then de-charge the energy unit suppression pool that the non-condensable gas going up in the wetwell.

CHAIRMAN CORRADINI: Just to make sure that I am understanding, for the -- Your numbering got me backwards. So 6 is the first phase.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: So that's Phase 1.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: All right. So at phase 1 somewhere in the drywell is the high pressure on the left, and I have parallel paths. I am flowing down through the vent simultaneously through the PCC.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay. And when you said 60 megawatts, that's all units or one unit?

MR. CHEUNG: All units.

CHAIRMAN CORRADINI: Thank you.

MR. CHEUNG: That's a rated condition. When the pressure is higher, then the condensation capacity would be higher -- somewhat higher.

Now as time go on --

MEMBER BANERJEE: Just to understand, do you have somewhere a quantitative idea of where the heat is going, or maybe you can tell us, in these various phases? So in the first phase, clearly, your suppression pool is picking up most of the heat. Right?

MR. CHEUNG: Yes.

MEMBER BANERJEE: But there is heat going to other places as well, into the PCC pool and so on. Is any going into the GDCS pool?

MR. CHEUNG: I'll get to that.

MEMBER BANERJEE: Do you have any sort of a cartoon in each of these phases which tells us where the heat and the non-condensables are going?

MR. CHEUNG: Page number 7, 8 or 9. We will get to that.

CHAIRMAN CORRADINI: We are coming to it.

MEMBER BANERJEE: Okay. All right, I'll wait then.

MR. WALLIS: I have another question. I mean, this is going to get fairly complicated, it appears, with all the questions.

Do you have a written reply to our questions as well as this verbal presentation?

MR. CHEUNG: We have not yet prepared a written --

MR. WALLIS: Because I want to check a lot of numbers, which you are not going to present.

MR. CHEUNG: I have some numbers, but not all.

MR. WALLIS: I would like to have a written response, not just a verbal response that says everything is okay.

MS. CUBBAGE: Amy Cubbage, the Project Manager for ESBWR.

Hitachi is responding to some RAIs. We would be happy to provide those.

As far as some of the dimensions you were talking about earlier, they are in the DCD. There are detailed --

MR. WALLIS: If you can find them.

MS. CUBBAGE: I can help you find them. But as far as whether you need a written reply to what you have asked us, I don't think that is the process we are in.

CHAIRMAN CORRADINI: They will provide us all the responses to the RAIs.

MR. WALLIS: These are going to be real technical responses, not some of the usual responses, which simply say everything is okay?

MR. KINSEY: Jim Kinsey from GEH. We will continue to respond to the staff's interrogatories.

MR. WALLIS: This gets very frustrating for ACRS. We have to go through the staff and the RAI process, and then it looks as if the answers are not sufficient. Then we have to go through the staff again. This takes months and months.

MR. KINSEY: We are working to provide detailed responses --

MR. WALLIS: You don't want us to hold up GE's application.

MS. CUBBAGE: I guess this gets back to some of the discussion we had at previous meetings about early interaction and involvement with the Committee. This is an RAI -- GE did provide an RAI response just a few days ago on this topic. It is an ongoing evolving issue and, when we come with a final SER, all the issues will be resolved at that time.

So it's a matter of whether the Committee wants to be involved early or not, and I think this is the opportunity.

MR. WALLIS: Well, I think it's up to you, and if we get involved late and we still have significant questions, then you may have a problem.

MS. CUBBAGE: And that is why we are here.

MR. SNODDERLY: Graham, this is Mike Snodderly from the Containment Systems Branch, NRO.

I want you to be aware that we were aware of your questions and all the Committee's questions, and GE and the staff has spent a lot of time on these -- preparing for this presentation.

So what I would like to suggest is let us go through the presentation. Let us try to attempt to answer your questions. I think we can, and then at the end of the day let's see where we are and what actions are needed. But again we are aware of those questions, and please give us an opportunity to try to address them.

MEMBER ABDEL-KHALIK: Let me just try to anchor this graph into numbers so that we would be able to follow what you are talking about.

MR. CHEUNG: Okay.

MEMBER ABDEL-KHALIK: At 60 megawatts you essentially need to condense 200,000 pounds per hour of steam. What is the delta P required to push that much steam through the PCCS?

MR. CHEUNG: Now to condense that much of steam is not the PCC capacity can handle through the main vent and during the first blowdown period the delta P from the drywell to the wetwell is way over 20 psi.

MEMBER ABDEL-KHALIK: So when you refer to

60 megawatts, what are you referring to, the PCCS condenser capacity or the PCCS plus whatever sparger you have in the wetwell?

MR. CHEUNG: The PCCS condenser -- the PCCS tube capacity.

MEMBER ABDEL-KHALIK: So if that is the case, then you have to condense 200,000 pounds per hour to give you 60 megawatts. So how much delta P do you need to push 200,000 pounds per hour of steam through the PCCS tubes?

MR. CHEUNG: The delta P is curve number 5 that --

MEMBER ABDEL-KHALIK: I really would like a number.

MR. WALLIS: Maybe that should be an action item.

MEMBER BANERJEE: I think these cartoons are not very useful. If a graduate student presented this at his PhD oral, he would fail. You don't even have in the different phases the flow rates for the various components, the pressure losses across them, how much heat is being dumped where, where the non-condensables are going.

You can just take this thing, put some numbers on it, and show what the pressures are in different phases. You could have six of these, so that we have the pressure drops, the temperatures, the heat dump, the non-condensable concentrations. Then we would have some concrete numbers to look at.

This is just all qualitative stuff and --

MR. MARQUINO: This is Wayne Marquino from GE. We can provide numerical values for these curves to the staff.

MEMBER BANERJEE: Well, it would be nice if it was put on a chart like this so at different phases we could see where everything is.

CHAIRMAN CORRADINI: So let me just take a step back for a minute. So the purpose of this graph was to give us a qualitative or quantitative feeling on how the phases are?

MR. CHEUNG: It's qualitative.

CHAIRMAN CORRADINI: Okay. So are you going to get quantitative soon or else I'm going to lose my whole committee, and they will string me up after they do? I think that's what they are dying to see. They are dying to see some numbers on how this evolves.

MR. CHEUNG: Let's --

CHAIRMAN CORRADINI: Move on.

MR. CHEUNG: Okay.

MR. WALLIS: So we are still on number 6, are we?

MR. CHEUNG: Okay, let's move on to curve number 1, which is next page.

MR. WALLIS: Wait a minute. Five follows 6, doesn't it? No, no, 2 follows 6. It's really strange here.

CHAIRMAN CORRADINI: Six to 2 to 4 to 5 to one.

MR. WALLIS: Well, the thing that I want to get on is you either show the top vent open or closed. Some of the time, it's probably open. How do you calculate that? I can look it up, but it's something like .70 centimeters or something. It's a big vent.

As the water level changes, the flow rate changes a lot, and there are waves and things that go through this vent. How do you figure out what happens?

MR. CHEUNG: Actually, let me present the next slide and then come back.

MR. WALLIS: So that's somewhere between curve 6 and curve 5. It's partially open, right? There is a question of how does a partially open vent get modeled?

MR. CHEUNG: Let's move on to the next one, and then come back.

MR. WALLIS: Okay.

MR. CHEUNG: During most of the time -- this is curve number 1 -- the PCC work like this way. The PCC is so regulated, when the steam and gas mixture are coming in, the steam condenses. The gas mixture, the non-condensable gas, collects or accumulates in the bottom of the tube such that the bottom half of the tube, for that argument, and all the way to the PCC vent, they all significant or high percentage of --

MR. WALLIS: There has to be enough pressure drop to drive out the non-condensables.

MR. CHEUNG: Yes.

MR. WALLIS: Cannot be driven just be condensation.

MR. CHEUNG: It's not.

MR. WALLIS: It will fill up with non-condensables unless there is enough pressure drop from the drywell to the wetwell to blow out the non-condensables.

MR. CHEUNG: Yes. I agree with you.

MR. WALLIS: Okay. So it's not just driven by condensation. You've got enough pressure drop to make it happen.

MR. CHEUNG: It is so regulated. That means the pressure is controlled by other PCC action.

MR. WALLIS: But it's not true that it is driven by condensation. There must be a pressure drop to push the stuff through that pipe.

MR. CHEUNG: Yes. Let's move on to the upper half corner of the curve. For argument, say that the bottom half of the tube is filled with non-condensables to shut off all the condensation.

MR. WALLIS: So in curve 2 the pressure is not enough to drive it through the -- to push it through? I don't understand.

MR. CHEUNG: We are on page number 5.

MR. WALLIS: It seems to me the pressure drop through this pipe, number 6 there, the first stage is the same when you are condensing the same amount of steam, no matter which stage you are in. So if you are condensing 50 megawatts of steam, you have the same pressure drop through that pipe, whether it is driven by condensation or anything else.

How does it get to be so low in 2, because you are condensing so very much less?

MR. CHEUNG: In 2, that means the bottom half -- the PCC vent pipe is sealed off by the water submergence.

MR. WALLIS: Well, I don't understand why curve 2 is below -- What's the pressure necessary to overcome the submersion?

MR. CHEUNG: Pardon me?

MR. WALLIS: There has to be a pressure drop to overcome the submergence. Right?

MR. CHEUNG: Yes.

MR. WALLIS: And how much is that? I don't see it on this figure. Is that the dashed line which says PCC vent exit submergence? So how does 2 get to be below that? Maybe there is a simple explanation. I'm just trying to figure it out.

MR. CHEUNG: It's sucking up.

MR. WALLIS: It's sucking it up?

MR. CHEUNG: Now the tube in the very beginning has .75 meters submerging.

MR. WALLIS: How does the non-condensables get out, if there isn't enough pressure drop to overcome the submergence of the vent pipe?

MR. CHEUNG: Let's discuss page number 5 first, and then we'll come back.

MR. WALLIS: Are you going to come back to that?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: So I think we should let them go forward and present. Otherwise, we are going to -- we are really going to get fouled up.

I want to ask, just to push this: So Slide 4 is qualitative. The numbering at least lost me, but that's aside.

Five is what phase? Slide 5 is what phase in time?

MR. CHEUNG: Slide 5 represents most of the time that is curve number 1.

CHAIRMAN CORRADINI: Okay.

MEMBER BANERJEE: Okay. Six to 72 hours?

CHAIRMAN CORRADINI: So this is when the PCC is performing its functions solely.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: And there is no bypass parallel flow via an open vent into the suppression pool?

MR. CHEUNG: There is no bypass, no breaker open of how the non-condensables get moved from one well -- from drywell to the wetwell.

CHAIRMAN CORRADINI: So let ;me just phrase it this way. Before that time, there's too much decay heat, and there's parallel paths.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: After that time, at 72 hours now you are into this issue of whether or not you are going to provide an added means. So this is the dominant thing from 6 to 72 hours?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay. So at least, I think, you want to address quantitatively what Professor Wallis is asking relative to the flows, etcetera, in this.

MR. WALLIS: Well, I got to ask another question again. Above curve 2, third line, third bullet, it says no PCC vent flow, which is why curve 2 is below the critical thing to bubble into the pool.

MR. CHEUNG: Yes.

MR. WALLIS: What happens to the non-condensables then? Are there absolutely no non-condensables? It had to be vented somehow.

MR. CHEUNG: Let's move on to number 5 and come back.

MR. WALLIS: You can't just put in non-condensables into the PCC and not get them out of there. You cannot do that.

MEMBER BANERJEE: I guess your strategy is going to be to address first the one. Then they are going to come back and address the curves which are --

MR. WALLIS: Okay. So we are going to get to all that stuff.

MR. CHEUNG: Yes. Because a lot of those questions probably is answered in slide number 5.

CHAIRMAN CORRADINI: Okay. So we are looking at essentially the behavior of curve 1 on slide 5?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay.

MR. CHEUNG: Now during this time the steam and gas mixture go into the PCC tube, and steam condenses and non-condensable gas got moved through -- accumulate in the bottom of the tube, and all the way to the PCC vent line.

Now when the column of non-condensable gets about half of the tube, that means that will reveal the heat transfer area, reveal the PCC condensation power. Now if you look at the table side by side to the tube, and the first column is a non-condensable column that's the height of the non-condensable gas. That's plus or minus.

Plus-- that means if the column increased the length, then what are the impacts. The impact reveals the PCC condensation power.

Move on to the next one is: when the PCC condensation is reduced, that means the steam inventory in the drywell going to increase, because less condensed.

MR. WALLIS: I'm sorry. On the righthand side, the picture there, it says non-condensable gas flow to wetwell, zero. Does that mean there is none? What does that mean, that righthand upper picture there. There's a plus and then a zero, but what does that mean?

MR. CHEUNG: Well, I'll get to that.

CHAIRMAN CORRADINI: So let's just take the first column where you've gotten to it.

MR. CHEUNG: The first column --

CHAIRMAN CORRADINI: Just stay with me for a minute. So you've got NC Gas Column, plus/minus. Does the plus/minus mean the pink and the blue? I'm still a bit puzzled.

MEMBER BANERJEE: Plus means it's building up.

CHAIRMAN CORRADINI: Okay.

MR. CHEUNG: The blue is the column, and then the plus, that means the blue line is going to increase the height.

CHAIRMAN CORRADINI: Thank you.

MR. CHEUNG: Minus is going to reveal the height.

MR. WALLIS: Well, t his is misleading, because you can't get non-condensable gases out without getting some steam out as well. There's always some mixing.

MR. CHEUNG: Yes, there's some steam, water with a leftover steam in the vent line.

MR. WALLIS: Well, there is always some steam left.

MEMBER BANERJEE: So let's go on.

MR. CHEUNG: Then because the condensation power is down, the drywell -- the steam inventory is up, and then the consequence of that is drywell pressures go up. Drywell pressure goes up, that means the PCC pressure go up.

MR. WALLIS: The only reason the drywell pressure goes up is because the wetwell pressure goes up. The only reason it goes up.

MR. CHEUNG: No, let's say.

MR. WALLIS: Because you've got to supply the delta P through the PCC.

CHAIRMAN CORRADINI: No, I think, Graham, they are saying here that as they -- Unless I misunderstand what you are saying, you are building up non-condensables. So you are now degrading the performance. You wait. Pressure rises. You push it out, and you come back. So you have --

MR. WALLIS: It's self-controlling.

CHAIRMAN CORRADINI: Yes. That's why he said that.

MR. WALLIS: Well, we know it's self-controlling.

CHAIRMAN CORRADINI: But I think that's his point. Is that your point?

MR. CHEUNG: Yes, that is my point.

MR. WALLIS: The pressure in the whole system is determined by the wetwell aspects.

MR. CHEUNG: Yes.

MR. WALLIS: That decides everything.

MR. CHEUNG: But this column -- or this table is trying to describe how it is self-regulated.

MR. WALLIS: If you were venting the wetwell and lowering its pressure, you would just suck more non-condensable gases through the PCC. You would condense more, and the drywell pressure would go down.

MR. CHEUNG: Yes.

MR. WALLIS: Everything is determined by this rise of pressure in the wetwell, which is the big mystery of the whole story. Okay.

So I don't understand your picture on the right. Are you just saying that it is self-controlling? Is that what it says?

MR. CHEUNG: Yes.

MR. WALLIS: Well, that's self-evident.

MR. MARQUINO: This is Wayne Marquino from GE. In the long term, the wetwell pressure is -- and non-condensable gas pressure in the wetwell dominates the container pressure. I think what Dr. Cheung is trying to show here is that variations of the drywell temperature control venting of the PCC and the non-condensable gas flow out of the PCC through the vent line.

So as the PCC power drops below decay power, drywell pressure builds up. The level in the vent line goes down, and the PCC vents. And that is how its self-regulation works.

MR. CHEUNG: Let me go on to this first row --

MEMBER BANERJEE: Let me ask you a few questions about this. I think I get the picture. But now can you set our minds at rest that this really happens? Give us a brief review of the experiments that have been done to actually validate this mechanism.

MR. CHEUNG: I don't -- I did not dream up these pictures.

MEMBER BANERJEE: Well, you don't have -- Just give it qualitatively. What experiments have been done to support this mechanism?

MR. CHEUNG: PANDA testing saw that.

MEMBER BANERJEE: So PANDA has been done, and it showed this. And did you do some full scale experiment as well, or not?

MR. CHEUNG: PANDA is --

MEMBER BANERJEE: Was it full scale?

MR. CHEUNG: PANDA is full scale.

MEMBER BANERJEE: Full height, but it wasn't full scale. Didn't you do some other experiments somewhere else or was it only PANDA?

MR. MARQUINO: This is Wayne Marquino. We also did the PANTHERS, which is a full height, full volume representation of one PCC unit with two headers.

MEMBER BANERJEE: Okay. I was trying to get to that. And did you then have some sort of a code or an analysis or a simulation done to compare the calculations with these experiments?

MR. CHEUNG: Yes. We have performed a whole series to check these the qualification against the PANDA the test, PANTHER test.

MEMBER BANERJEE: I suppose TRACG had a condensable field added to it or it was already there, and you then simulated these experiments using TRACG.

MR. CHEUNG: Yes.

MEMBER BANERJEE: What did you find?

MR. CHEUNG: We find that the PCC is self-regulated by --

MEMBER BANERJEE: What did you find in the comparison between TRAC and the experimental data?

MR. CHEUNG: In a simple sentence, that it is well qualified and compare data real well.

MEMBER BANERJEE: And this was made available to all of us to look at, these relations? Okay.

The issue then with regard to the separation at the bottom there of the liquid from the non-condensables -- how did TRACG handle that?

MR. CHEUNG: We simulated by a T component, and the SI branch simulated the drain line as higher than the bottom line of which -- went line. So the water will come down to the drain line and --

MEMBER BANERJEE: So just gravity separation?

MR. CHEUNG: Yes.

MR. WALLIS: Do you have another presentation besides this one?

MR. CHEUNG: No.

MR. WALLIS: Because this is curve 2. Right? The key thing that's happening here is --

MEMBER BANERJEE: This is curve 1.

MR. WALLIS: This is curve 1? This is curve one, right. Now the key thing that you have to figure out is what is the pressure in the wetwell, and the pressure rises because the temperature rises. If you look at your curves, the reason the pressure rises in the wetwell is because the temperature of the gas base rises.

So you have to present a very careful analysis of what controls the temperature in the wetwell. I don't see it anywhere here, and the leakage of steam through the vacuum breaker is a very important actor in this. Now I want to know where it goes. Does it slide along the roof and condense? Does it mix?

The walls are very key actors. If they are two or three meters thick, then they cool the gas. They don't heat it. They are still cold. And yet when I see a MELCOR calculation, it appears that they are heating the gas.

So there are a huge number of questions about what controls the temperature and pressure in the wetwell, and I don't think, looking through your slides, you are going to get to that.

MEMBER BANERJEE: In fact, that was the discussion that was going on at the last meeting.

MR. WALLIS: Right.

MEMBER BANERJEE: Sorry. That was the discussion -- That was part of the many things that were discussed at the last meeting, precisely the question that Graham raised.

MR. CHEUNG: Let me finish slide number 5, and then tell you why --

MR. WALLIS: There is nothing about the energy in the wetwell you are going to talk about here this morning?

MR. CHEUNG: I am going to touch base on that.

MR. WALLIS: You are going to touch base? You are going to analyze it?

MR. CHEUNG: We have analyzed it.

MR. WALLIS: You are going to tell us how you analyzed it?

MR. CHEUNG: We used TRACG, and I'm going to tell you the delta or the impact of the leakage hitting on the wetwell.

MR. WALLIS: Okay.

MR. CHEUNG: And I can show you the Hancock ratio in slide number --

MR. WALLIS: Well, I'll tell you what I think happens is that the steam oozes through the vent valve at the vacuum breaker and condenses on the ceiling. I don't know if that is what you predict.

MR. CHEUNG: In the calculation, because of conservative, we do not assume any condensation in the top vent line.

MR. WALLIS: Then you are in real trouble, if there is no condensation.

MR. CHEUNG: There is no condensation, and on top of it, the vacuum breaker -- well, actually, the water leakage on the top of the wetwell, they stay at the top and do not mix --

MR. WALLIS: Don't mix with the gas.

MR. CHEUNG: -- with the gas in --

MR. WALLIS: So it stays at 260 degrees or something? Does it cool down?

MR. CHEUNG: It cools down on the side wall, only on the side.

MR. WALLIS: It cools down without condensing?

MR. CHEUNG: Well --

MR. WALLIS: Okay. Okay.

MEMBER BANERJEE: I am still a little troubled by the drain line. so let me ask you the question in a way that maybe I understand.

Imagine that the operation is sort of sporadic as the pressure rises and that non-condensables are driven out and then condensation stops, and so on. Is there any possibility of non-condensables getting into the drain line during this operation and getting trapped?

MR. CHEUNG: No, because the drain line has a U-tube at the end of it, and it takes the gravity to move the liquid out, and the gas will tend to go back up, any gas in the drain line.

MEMBER BANERJEE: Maybe if you could clarify why it doesn't get -- So your pressure is rising, right, because you've built up non-condensables. Now when it rises enough, it drives the non-condensables through, and it starts to condense steam again. Right?

In this period, what happens to the liquids that are -- or what is the detailed geometry of the drain line which ensures that no gas gets into that?

MR. CHEUNG: Let me comment on that. If a gas going back to the treated pool, it is not going to affect anything.

MEMBER BANERJEE: No, no. I am not worried about that. I am worried about it getting trapped in the drain line and stopping the flow.

MR. CHEUNG: There is no -- The design of the drain line is such that there is that U-tube at the end, and only water can go through it. The gas will go -- If anything, on the inside it would go back up to the lower drum of the PCC.

MEMBER BANERJEE: Are there any horizontal or near-horizontal runs?

MR. CHEUNG: If any near-horizontal runs, they are going to slope.

MEMBER BANERJEE: So that any gas which gets trapped is going to get vented?

MR. CHEUNG: Yes.

MEMBER BANERJEE: In some way.

MR. CHEUNG: Go back to the -- one way or the other.

MR. WALLIS: This cartoon, I don't think, is complete. I mean, sometime during Stage 1, curve 1, the GDCS drains. I think you have a separate pocket there into which the drain line goes, which is still filled with water, and I think you also have a loop in there. You have a loop in it --

MR. CHEUNG: I did not show the loop.

MR. WALLIS: -- like the loop you have below your sink to prevent liquid gas getting sucked up. This isn't a complete figure. I think you have a -- what do they call the thing?

MR. CHEUNG: Seal loop.

MR. WALLIS: Loop seal. You have that, don't you?

MR. CHEUNG: I did not draw the loop seal.

MR. WALLIS: And you also have a pocket as shown in the earlier slides. In slide 3 there is a pocket shown on the side of the GDCS pool into which things go. Right? All these data are important.

MEMBER BANERJEE: Well, we just want to be sure that all this is sort of an oscillatory operation where you are pushing in and out, that there is no likelihood that gas will get trapped and, therefore, block the drain line or reduce the flow to the drain line.

If now the flow through the drainline is reduced, you will build up the drain level, and you might be able to get water into the vent line eventually, starting to make a mess.

MR. CHEUNG: That is not happening by design, because the elevation difference and the water is --

MEMBER BANERJEE: I realize it doesn't happen unless the flow through the drain line is severely reduced, and it could be -- The thing is in these systems you've got all this gravity vents driving the flow. So if you manage to get a pocket of air in, something which didn't clear, you could reduce the flow quite a bit.

MR. WALLIS: Well, that is why you have to have this loop at the bottom. When the GDCS drains, you've to keep the bottom of the drain line covered.

MEMBER BANERJEE: Well, that is one end, the water going in. The issue is can stuff get in from the other end.

MR. WALLIS: Yes.

MEMBER BANERJEE: If you aren't condensing much steam and you have some flow of non-condensables, then eventually the drain line will drain out. Right? Because there is no water coming there, and yet you are pushing non-condensables. So some non-condensables could get into the drain line at that point.

MR. MARQUINO: This is Wayne Marquino from

GE. I would like to address the concern about vapor blocking the drain line.

MEMBER BANERJEE: Non-condensables; not vapor.

MR. MARQUINO: The drain line will have gas or vapor in it. It could be steam or a non-condensable, but the condensate will drain through the gas and reach the bottom of the drain line. When the loop seal fills up to the design elevation, any further condensate will overflow into the GDCS pool.

MR. WALLIS: So the loop seal has to be big enough, have enough hydrostatic head to overcome the sort of transient behavior that my colleague, Professor Banerjee, is talking about. So how you design this loop seal might be important.

These things are important. I think this looks like a very nice design, but there are three or four key elements that need to be designed and analyzed properly.

MEMBER MAYNARD: I think also the drain line -- the actual geometry and specifications would be nice to know, because the current plants are finding some problems with horizontal runs of pipe that are supposed to have a slope and, due to construction tolerances and long pipe, you find some areas that actually turn out higher and can trap.

So I think that is one of the concerns, is what is the real geometry of this, and is it for sure that it is always sloped to where the water will be draining the condensation through the gas as opposed to a trap being there.

MR. WALLIS: What is also very confusing is that we see all these cartoons. I have a whole stack of them at home, and they are all different. Sometimes there is a horizontal line. Sometimes there is a line with a loop in it. Sometimes there is a slope, and sometimes there is a pipe that goes down and up again. These vary, depending on which cartoon you look at.

This is very confusing. You ought to have a consistent picture of what is there.

MEMBER MAYNARD: What you are asking for is architectural drawings?

MR. WALLIS: Well, have the cartoons represent reality.

MEMBER BANERJEE: Or a safety measure which would vent the drain line if anything got in there.

MEMBER SIEBER: These cartoons -- They won't show all the details. I think to answer these questions, you would need architectural drawings, and I'm not sure GE has those.

MR. MARQUINO: This is Wayne Marquino of GE. We have isometric drawings of the piping that we are prepared to show you. I believe they are proprietary information, but we can go over and provide them to the staff for your review.

MEMBER BANERJEE: I guess, to go back to -- sorry -- this question: We have come up against these gas bubbles often in the past. It would be nice to know that, if by some means that we can't imagine today gas bubbles got in, you would be able to take care of that problem without having the drain line have a very reduced flow through it. But if that happens, then you would build up condensate, and eventually it will start to go into the vent line. There is no other place for it to go.

MR. CHEUNG: The drain line is designed such that there is no possibility for the gas to stop somewhere and hide somewhere.

MEMBER BANERJEE: We've heard that about many lines. That is a problem.

MR. WALLIS: Well, what you need to supply us with is not some architectural drawings, which are so complicated no one can figure them out, but enough detail to justify the analysis that was performed. That's all we need.

MEMBER BANERJEE: Well, we have voiced a concern.

MR. CHEUNG: Let me try to make a point.

MEMBER BANERJEE: I'm sure you can handle it.

MR. CHEUNG: This slide is trying to say that the PCC is self-regulated.

MR. WALLIS: We know that.

MR. CHEUNG: Okay.

MR. WALLIS: That is not the problem.

MR. CHEUNG: There were questions about seal on one of these. The column is negative or reveals an other way that the water in the suppression pool go back into the PCC vent line, and then stop. I mean, the gas is not going anywhere under this condition. So whatever that non-condensable coming in is going to fill up the non-condensable gas column.

MR. WALLIS: So another question. When you turn on these fans you are going to show us later, do they suck water up through the drain line?

MR. CHEUNG: No.

MR. WALLIS: Well, you can explain all that, too.

MR. CHEUNG: Because the line is so long, and if there is any --

MR. WALLIS: Unless they are filled with water.

CHAIRMAN CORRADINI: You are going to have to make a decision. You have qualitatively taken us down a path, but I -- at least for me, I want to see the main steam line very quantitatively. Are we at a point where we can quantitatively talk about something?

MR. CHEUNG: Okay. Let's move on, number six. The main steam line break is -- For the first three days, we have bypass leakage one square centimeter. The bypass leakage rate is leaking this drywell energy in the wetwell, top of the wetwell, and in this calculation no credit for PAR, and in these calculations, the next couple of slides, there is no vent fan and no other systems.

CHAIRMAN CORRADINI: So let's stop here for a minute, because I want to understand the -- I want to go back to some questions Graham is asking to get clear.

In the DBA calculation, can you assume condensation on cold walls or do you -- are you prescripted to assume essentially an adiabatic boundary? I want to understand some boundary conditions.

MR. CHEUNG: The wall has condensation. The inner wall of the drywell and outer wall of the wetwell, they have condensation.

CHAIRMAN CORRADINI: And you are modeling condensate?

MR. CHEUNG: We model the heat straps.

MR. WALLIS: All on the ceiling?

MR. CHEUNG: Not on the ceiling.

MR. WALLIS: The ceiling is the most important thing.

MR. CHEUNG: Because -- Well, we are not modeling that.

MR. WALLIS: That's where the steam is, and that is where it will come down.

MR. CHEUNG: Yes. We are very conservative, because the energy to trap in there is not mixing.

CHAIRMAN CORRADINI: I am going to interrupt you, Graham, for just a minute. But just to back up: So in the DBA calculation you are partially modeling condensation. It is not totally adiabatic.

MR. CHEUNG: No.

CHAIRMAN CORRADINI: But it is adiabatic

on the ceiling. So that's question one.

Question two is the one square centimeter bypass leakage. That's a big thing. You are going to come later to that and look at a sensitivity.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay. Third question: On your -- What do you mean by no credit for PARs?

MR. CHEUNG: We have PARs, but we do not take credit. PARs -- the first three, we are not taking any credit.

CHAIRMAN CORRADINI: Okay.

MR. CHEUNG: The PARs, some, not gas.

MR. WALLIS: These are recombiners?

MR. CHEUNG: Yes. Passive recombiner.

MR. WALLIS: They are, what, catalytic?

MR. CHEUNG: Yes. Can I have slide number seven?

MR. WALLIS: Number 7 is very interesting, yes.

MR. CHEUNG: Now on the lefthand side is showing the initial condition. Initially, the drywell is full pretty much of a non-condensable gas, and in the table below that is a time series showing all the non-condensable gas mass.

Initially, the drywell had about 8,000 kilograms, and the GDCS gas space is a very thin layer initially, only 300, and so on. Now the interesting thing is the PCC tubes is a very small one and only holds 12 kilograms. That's the thing that we have to see that -- or remember that. Very small amount of non-condensable gas generated by radiolytic gas will go into that and supply the cell recreation process in the PCC.

CHAIRMAN CORRADINI: So may I ask you about that, because that came up in the audit calculations, and I wanted to understand.

This is a prescribed model?

MR. CHEUNG: Of that radiolytic gas?

CHAIRMAN CORRADINI: Yes.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay. Which is based on Reg. Guides?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Which is essentially required from a DB analysis standpoint?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Got it. Thank you.

MR. WALLIS: But then the MELCOR model gives quite different answers, doesn't it, seems to me?

CHAIRMAN CORRADINI: I think we will get to that.

MR. WALLIS: Okay.

CHAIRMAN CORRADINI: I just wanted to make sure of the source of the radiolytic gas, so I made sure I understood.

MR. WALLIS: So somebody said that nitrogen can stay up in the drywell head, although it is denser than the steam below it. Somebody said that can happen?

MR. CHEUNG: Let's look at the drywell head. You can see there is a very little, narrow or small passage.

MR. WALLIS: Well, it doesn't matter. The nitrogen is cold, and it is denser than the steam. So the steam is going to push it out, isn't it?

MR. CHEUNG: The steam below in the DPV or the main steam line will push anything above it trying to get a way into the PCC inlet. So anything in the way that it is trying to push it out, push it out into the drywell head --

MR. WALLIS: So are you going to show us the nodalization of this thing and how the mixing between the various regions is modeled or is that something that --

CHAIRMAN CORRADINI: I think that is in Chapter 6. I have Chapter 6 up of the DCD.

MR. CHEUNG: That is in Chapter 6, Nodalization.

MR. WALLIS: But this is a very key thing. Where are the non-condensables go and how they get there and how they get conserved and everything is very important.

MEMBER BANERJEE: Is there some experimental data that shows you what happens in the drywell and how this gets pushed into the PCC?

MR. CHEUNG: In the PANDA test we show that, how the non-condensable gas push from the drywell and the wetwell through the PCC and accumulation of non-condensable gas in the bottom of the PCC tube.

MEMBER BANERJEE: And was it sort of a scaled representation of what you have in the real situation?

MR. CHEUNG: The PANDA tests are full scale -- full height. Not full scale -- full height.

MEMBER BANERJEE: Full height. And so you have -- You simulated a main steam line break in smaller scale?

MR. CHEUNG: Yes.

MEMBER BANERJEE: You had a representative drywell of some sort with some features of the geometry that were there with regard to height, and you pushed the non-condensables out in a representative manner into the PCC. Is that correct?

MR. CHEUNG: Yes.

MEMBER BANERJEE: Did you validate your codes against the PANDA experiments?

MR. CHEUNG: Yes.

MEMBER BANERJEE: And which was the code?

MR. CHEUNG: TRACG code.

MEMBER BANERJEE: And it showed that you could push out these non-condensables. Right?

MR. CHEUNG: Yes.

MEMBER BANERJEE: Was it a mixing with the steam and then the mixture went or was there like a piston-like thing or what happened?

MR. CHEUNG: In the first period of the blowdown or the -- that the steam was well mixed with the non-condensable gas.

MEMBER BANERJEE: And then?

MR. CHEUNG: And then the mixture will go into the PCC, steam condense, non-condensable gas trying to find a way to push it into the wetwell sooner or later. But in the meantime, they just collect in the bottom.

MEMBER BANERJEE: So the non-condensables started to collect in the PCC, and then sort of eventually the pressure built up, then again was pushed through.

MR. CHEUNG: Yes.

MEMBER BANERJEE: But if you say early stage, clearly, the PCC did not have the capacity to condense all the steam that was being generated. So did PANDA have a simulation also of other flow parts and other condensation?

MR. CHEUNG: The PANDA start at one hour after the LOCA.

MEMBER BANERJEE: So what happens in the first hour?

MR. CHEUNG: The first hour, we more or less simulated the curve number 5 or so that the PCC cannot handle.

MEMBER BANERJEE: Do you have any experimental validation of that period?

MR. CHEUNG: Yes.

MEMBER BANERJEE: Where did you do those experiments?

MR. CHEUNG: The PANDA test.

MEMBER BANERJEE: The PANDA starts one hour after. Right? What about the first hour?

MR. CHEUNG: We have the suppression pool blowdown test.

MEMBER BANERJEE: Right. But here you have a combined effect. Some of the heat is going to go to the PCC. Some goes into the suppression pool, and this fraction is changing over time, and eventually after some long period of time, the PCC is doing all the condensation. Right?

MR. CHEUNG: Yes.

MEMBER BANERJEE: So how do you -- What experimental validation do you have of this period which starts immediately after the break and goes on to the time when the PCC takes over and does all the condensation? There is a complicated set of events going on at this point. Right?

MR. MARQUINO: This is Marquino of GE. In the initial blowdown period we have separate effects heat transfer tests that allowed us to qualify the code against heat transfer coefficients developed at UC Berkeley, MIT. So we do have --

MEMBER BANERJEE: These are very small scale experiments. Right?

MR. MARQUINO: Yes, those are. So for the blowdown into the suppression pool, as Dr. Cheung mentioned, we have pressure suppression tests, and during that period we have flow force through the PCC by the large differential pressures, and we have heat transfer tests that qualified the heat transfer calculated by the code in that period.

MEMBER BANERJEE: In the PCC?

MR. CHEUNG: In the PCC, yes.

MR. MARQUINO: Yes.

MR. CHEUNG: The PANDA test done in Italy is a full scale PCC, too.

CHAIRMAN CORRADINI: Say that again. I'm sorry. Could you repeat that?

MR. CHEUNG: The PANDA test in Italy is full scale.

MEMBER BANERJEE: And the PANDA test -- is high fluoresce that we are getting?

MR. CHEUNG: The PANDA test in Switzerland is a system testing, full height.

MEMBER BANERJEE: You got two separate tests. Right? One is the PANDA, was the largest test?

MR. CHEUNG: That one is done in Italy.

MEMBER BANERJEE: Yes. So in PANDA you also measured the heat transfer coefficients in the

PPC?

MR. CHEUNG: Yes.

MEMBER BANERJEE: But it was not a systems test. It was just to test the PPC. Right?

MR. CHEUNG: This is -- We call it component test.

MEMBER BANERJEE: Yes. Okay. So it's a sort of a separate effects test?

MR. CHEUNG: Yes.

MEMBER BANERJEE: And the PANDA was like a system test?

MR. CHEUNG: Yes.

MEMBER BANERJEE: The PANDA test did not look at the early state -- Right? So they only looked at the situation one hour later or whatever?

MR. CHEUNG: The system in action after one hour.

MEMBER BANERJEE: So I'm really asking: In this very complicated geometry where you've got, you know, the PCC and the suppression pool and all this and you are going from most of the heat transfer being done in the suppression pool to most of the heat transfer being done in the PCC. In this transition period, what sort of experimental database and validation do you have for your analysis tools?

MR. CHEUNG: We have a coefficient test report and then to lay out all this time period, in a given time period, given testing, to qualify the computer code.

MR. MARQUINO: Let me expand on that. In the middle of TRACG for containment analysis of ESBWR and ECCS analysis of the ESBWR, we started with a TAPD report, test and analysis program description. That laid out the phenomena and how we were going to qualify our code to the phenomena and what tests we considered had to be conducted.

Then we conducted those tests, and we qualified the code to those tests. We submitted a number of TRACG qualification reports to the staff, and they have been reviewed. The specific report number for the TAPD report is 33079.

CHAIRMAN CORRADINI: Yes, I've got it here.

MR. MARQUINO: And then if you go to the 33083, which is a TRACG application methodology for ESBWR, that references different qualification reports for the code.

So you are asking valid questions here. We have in the 33083 report a qualification matrix where we lay out the phenomena and then the tests that included those phenomena, and the qualification of the code in another matrix.

So we have documented the capability of the code and the qualification of the code.

MEMBER BANERJEE: I guess my question is much simpler. I mean, were you -- Do you have any integral database for integral rather than separate effects for the phase which is before PCC control of condensation?

MR. MARQUINO: Let me --

MEMBER BANERJEE: Even on a small scale.

MR. MARQUINO: Let me answer that directly.

MR. WALLIS: May I ask, Sanjoy, are you asking about PANDA or are you asking about the modeling of how the gas gets from the GDCS DW annulus and all those different regions to the PCC? Are you including that in your integral test question?

MEMBER BANERJEE: It is all that. Right?

MR. WALLIS: I think we can talk about PANDA forever, but just is the PCC, and the key question for me is how the GDCS is able to store so much gas for so long and then suddenly get rid of it. Things like that are my questions.

Doesn't make sense. I mean, it fills up

in 15 hours. It gets more stuff in it, and then it suddenly empties. I mean, all these things don't make sense to me, and how the non-condensables get around the various regions.

MR. MARQUINO: Let me try and --

MR. WALLIS: There is no test for that, is there?

MEMBER BANERJEE: Well, we can divide this into phases. Let's start with the early phase. Then we will go on to the longer term. I guess everybody's concern is about the non-condensables and where they are going. This is really the issue, and we are asking that.

MEMBER ABDEL-KHALIK: Can I just ask about one number in this table?

MR. CHEUNG: Yes.

MEMBER ABDEL-KHALIK: 529, the second column, at 15 hours.

MR. CHEUNG: Yes.

MEMBER ABDEL-KHALIK: So I'm trying to compare the conditions, the GDCS gas phase in the drywell. The drywell is mostly steam. Right?

MR. CHEUNG: The drywell, mostly steam.

MEMBER ABDEL-KHALIK: At that point, and the GDCS has a lot more non-condensable gas.

MR. WALLIS: the DCD says that the partial pressure is 100 kilopascals. That is an atmosphere, but it's half non-condensables in there. Doesn't make sense.

MEMBER ABDEL-KHALIK: And yet these two spaces are pretty much connected.

MR. WALLIS: Then it suddenly vents itself for 30 hours.

MR. CHEUNG: I have curve to explain that.

CHAIRMAN CORRADINI: Well, can you try it in words?

MR. CHEUNG: Okay. Now through the blowdown period -- or after the blowdown period, the GDCS injection stop. The GDCS pool drains. Then you increase the volume, and at the same time there is some amount of the non-condensable gas in the drywell, because --

MR. WALLIS: Not much left.

MR. CHEUNG: Not much left, but in the blowdown period they are trying to push away all the way up, find any way to move it.

MR. WALLIS: Doesn't it force pretty much all the non-condensables before two hours?

MR. CHEUNG: And this accumulation -- I have a curve to show that this accumulation of non-condensable gas in the GSCS drain down volume occurring in the very first period, time period.

MR. WALLIS: But it hasn't drained yet. There is no volume for it to go to.

MR. CHEUNG: It drained at a couple hundred seconds.

MR. WALLIS: The GDCS pool drains in a couple hundred seconds?

MR. CHEUNG: Start draining in a couple hundred seconds.

MR. WALLIS: So it sucks in a lot of non-condensables.

MR. CHEUNG: Yes. Let's move on to curve number 12 and show you --

MR. WALLIS: Then they suddenly get purged between 15 and 30? The first 15 hours, they build up.

MR. CHEUNG: Yes.

MR. WALLIS: The next 15 hours they miraculously disappear.

MR. CHEUNG: Not they are building up in the first couple of -- 15 hours. Build up in the first one hour and stay there, and at 18 hours there is some phenomenon happening, and I am going to explain it.

MEMBER BANERJEE: I still am stuck on the first hour.

CHAIRMAN CORRADINI: Yes. I think -- So just to help us organize our thoughts, I think Sanjoy is asking a question which you can defer to later, but I think we want to understand, which is: You are saying the PANDA tests were full height integral and gave physical insight into code and phenomena synchronization, normalization, whatever, from one hour forward.

For the first hour, you have -- essentially, your are dominated by losses to the suppression pool, but you have the parallel path of PCC. So what Sanjoy is asking is: What testing or calculations or combination of logic gives you good confidence that that hour is properly characterized? I think that is what --

MEMBER BANERJEE: Exactly. Because where I am coming from eventually is I want to trace the history of the non-condensables from time zero through each of these phases.

So the first hour I want to know how well you predict where the non-condensables are, how much confidence you have in that. Then we will move on to the next phase and the next phase, because the whole story eventually is all --

MR. WALLIS: And this will take the whole day to explain.

CHAIRMAN CORRADINI: Well, we don't have the whole day.

MR. WALLIS: No, but at least we've got the questions.

MEMBER BANERJEE: I think the story about the non-condensables and how you predict where they are going and what confidence you have in that is the crux of the matter here.

MR. WALLIS: And your cartoon shows the GDCS half-full.

MR. CHEUNG: Yes.

MR. WALLIS: Doesn't it empty?

MR. CHEUNG: No, not for main steam line break.

MR. WALLIS: For three days, it stays half-full?

MR. CHEUNG: Yes. At equilibrium elevation between the pool and DP elevation.

MR. WALLIS: Oh, it's halfway down.

MR. CHEUNG: Halfway down.

MR. WALLIS: So there is a very big cold water surface to condense vapor in the wetwell, if there is condensation through the ceiling, and if there isn't -- If there isn't conduction through the ceiling, then the ceiling is already cold --

MR. CHEUNG: We are not taking that credit. You are right. We are not taking that credit.

MR. WALLIS: So, well, I mean I can't understand why the ceiling, which is the biggest and the coldest area and obviously plays the biggest role in controlling the wetwell pressure, is ignored.

MR. CHEUNG: Yes.

MR. MARQUINO: This is Wayne Marquino. I would like to take 60 seconds to try and answer Dr. Banerjee's question.

At the onset of the ESBWR program we had completed a large number of full pressure blowdown tests into various types of pressure suppression containments, Mark I, Mark II, Mark III, ABWR.

The vent configuration in ESBWR is very similar to the ABWR configuration. So we did not conduct a full pressure blowdown test for ESBWR. We are informed by the ABWR data, and we are applying it.

MEMBER BANERJEE: When you say vent configuration, it's like for the PCC line?

MR. MARQUINO: No. No, the main vents between the drywell and the wetwell and the horizontal vents leading off the main vents.

CHAIRMAN CORRADINI: So can I just modify his question, because I think it will help.

I think another way to ask Sanjoy's question is: Now you've added a parallel flow path. How much energy are you pulling from that that you are going to have to either validate or ignore?

I mean, I'm waiting for you to tell me I don't care about the PCC, but you haven't said it yet -- in that first hour.

MEMBER BANERJEE: You may not care in the beginning, but toward the end you start --

CHAIRMAN CORRADINI: I think that's his point. He is looking for the energy split and the flow split.

MR. MARQUINO: Okay.

CHAIRMAN CORRADINI: And your confidence that you know what those are.

MR. MARQUINO: Let me try. So at the onset of the SBWR, we understood we have to test these passive cooling features, passive gravity drain pooling. The tests were done starting from about 150 psi in the blowdown.

So that allowed us to save some costs in the test facilities. They were not designed to full reactor pressure but 150 psi. So if you look at the GIS gravity drain tests, the GIRAFFE gravity drain tests, the PANDA containment tests, they are about 150 -- They start at 150 psi in the blowdown.

Now your question is: So how do we know what happened in the first part of the blowdown? In that part, we have a differential pressure between the drywell and wetwell, and we have qualified our codes very well to calculate that differential pressure.

So the PCC has a forcing function applied to it, and we have tube data and PANTHER's data on the PCC with various differential pressures and flows that we qualify the code to.

So although we don't have an integral test for that portion of the blowdown, we do know what is going on in the PCC during that portion..

MEMBER BANERJEE: So what you are really saying is that you have some separate effects tests on the PCC which tell you what would happen there. You have some tests about what happens in terms of flow into the suppression pool and the heat transfer there.

The issue really then is you've probably -- and I don't know, but you probably take the drywell region as being well mixed and then, just calculating the various pressure losses, you split the flow between the PCC and the suppression pool. Is that correct -- or into the suppression pool?

MR. MARQUINO: Yes.

MEMBER BANERJEE: And then this is approximation what you are doing?

MR. MARQUINO: Yes.

MEMBER SIEBER: You have ignored all the other effects, because they are all conservative?

MR. MARQUINO: Yes. Dr. Cheung is talking about some of the conservatives that we have included.

MEMBER BANERJEE: But you assume everything is well mixed. Right? So there is no -- In this period, there is no stratification occurring in the drywell or anything like that?

MR. MARQUINO: It is well mixed. You can see in Chapter 6 we have a nodalization diagram. So we have some nodes, and it is possible to have different concentrations in the different nodes. But that is not a major player in the blowdown portion, because basically, the -- We are talking like -- what was it, a half an hour for -- So out of 72 hours, we have this half-hour period, and there is no non-condensable gas accumulation in the PCC in that period for sure, because it is completely flowing through the vent.

MR. ALAMGIR: This is M.D. Alamgir from GEH. In the PCC, the range of non-condensable fractions tested, in my opinion, cover what happens in the ESBWR containment during the first hours leading to the PCCS. That's my point number one. So it is local, and then that confidence gives us to go global in analysis. Local qualification of the USB-MIT test and the correlations that come out of it.

MR. WALLIS: Well, let's go back. I mean, I think you did a good job on the PCC. You did full scale tests, height tests and so on. You probably understand it.

It is only one of about six or seven different systems here which are interacting, and you don't have, it seems to me, experiments for the mixing between the GDCS gas space and the drywell. You don't have any experiments for what really happens in the wetwell gas space where you have steam leaking in and you have walls at different temperatures and you have a cold floor and so on, and the mixing between how the stuff gets in and out of the drywell head and the drywell annulus is all just theoretical in some way.

So what is the basis for -- Those are very important phenomena governing what happens.

MR. ALAMGIR: Professor Wallis, you have

very good comments there. I do want to explain that the stratification is also diffused to some extent by the fact that there is condensation on the vertical walls. There is some minimum diffusion. So it is not really the light steam will be fully stratified --

MR. WALLIS: Do you somewhere explain that? I couldn't understand your model for the wetwell. Your model is the steam is all on the top and the gases all underneath?

MR. ALAMGIR: It's well mixed.

MR. WALLIS: It's well mixed? The wetwell?

MR. CHEUNG: No. Wetwell is not well mixed. The drywell.

MR. WALLIS: Completely stratified wetwell?

MR. CHEUNG: Pretty much.

MR. WALLIS: Pretty much. Now come on.

MR. CHEUNG: Yes.

MR. WALLIS: Is it or not?

MR. CHEUNG: Yes.

MR. WALLIS: It's completely stratified?

MR. CHEUNG: We force it to be stratified. We have --

MR. WALLIS: And then you are going to

tell us how you model the heat and mass transfer to the walls? Do you know how to calculate what happens in there? I mean, this is not a simple problem, is it? The walls are different temperatures, undergoing transients, and the steam coming in at one place and going somewhere else. It's not a trivial problem.

So to make sure that you've done it conservatively, we have to look at it carefully. Then it may be -- I think your conservatism is probably way beyond what is necessary.

MR. CHEUNG: Yes. We agree with that.

MR. WALLIS: I think it probably is, but I haven't seen what it is yet.

MR. CHEUNG: We have curves. Later on, we show that conservative --

MR. WALLIS; It's unreasonably conservative, isn't it?

MR. CHEUNG: Yes. Because we cannot arrange that, we -- a very good job in mixing --

MR. WALLIS: Well, it may be so conservative that it misses some other phenomenon that is important, because it misrepresents the transient. But anyway, let's go on.

CHAIRMAN CORRADINI: Let me -- If I might just help us along. So I know we are behind, but I want to make sure -- You are going to move on. So are you done with this slide?

MR. CHEUNG: No, this slide I am going to show that -- The table is going to show up in a couple of other slides. This one, I am going to show that on the righthand side, that the GDCS pool going to drain down to a equilibrium level here that equalize to the DPV elevation.

MR. WALLIS: Are you going to tell us what this phenomenon is that suddenly gets the gas out of the GDCS?

MR. CHEUNG: Yes.

MR. WALLIS: Okay.

MR. CHEUNG: Now the GDCS pool still have about 1,000 cubic meter of water remaining in it, cold water, and the PCC drain water is hot, to mix with the pool water and heat up the pool water slowly and slowly, and then the pool water going into the RPV downcomer and mix with water in the downcomer. Because the temperature of this pool water keep going up at, at about 18 hour or so the water level in the downcomer slowly change and get into the point that overspills from the DPV in the drywell annulus and --

MEMBER BANERJEE: Can you show us what you mean?

CHAIRMAN CORRADINI: I think you are trying to say the righthand blue and the blue inside the vessel equalize, and then you get to the point of the open pipe, and it spills out.

MR. CHEUNG: Yes, out of the RPV. Once it overspills in the drywell --

MR. BANERJEE: I'm losing it.

CHAIRMAN CORRADINI: It is spilling out of the vessel. The GDCS drains, drains, drains, until the RPV fills, and then it gets to the open pipe and spills out.

MR. WALLIS: When it comes out of the DPV, where does it go? Does it just drain down the annulus space?

MR. CHEUNG: It drains down the annulus space.

MR. WALLIS: Does it fall into the wetwell downcomer?

MR. CHEUNG: No. Accumulating in the bottom of the drywell.

MR. WALLIS: You see, this cartoon is misleading. Some of the other cartoons show the DPV above the wetwell.

MR. CHEUNG: When that drain starts, the cold water from the downcomer condenses steam in the drywell, create a sudden drop in the drywell pressure, and the drywell pressure drops. The pressure in the drywell head and the GDCS pool air space still higher. Then force start initiate the process of pushing whatever remaining gas mixture from this too high a volume into the drywell.

Once this gets into the drywell and --

MR. WALLIS: I don't understand that at all, because the volume is still constant in the gas space in the GDCS. How can it be pushed out? The only way it can be pushed --

MR. CHEUNG: Because the drywell pressure is low due to --

MR. WALLIS: No. It doesn't make any difference. The water level -- It can expand --

MR. CHEUNG: Suck up by the drywell low pressure.

MR. WALLIS: So the water level in the GDCS rises to the ceiling and pushes out the gas?

MR. CHEUNG: No, not the water level push it out, but --

MR. WALLIS: Well, how can the gas get out? It can expand, and some of it can come out.

MR. CHEUNG: Yes.

MR. WALLIS: But the rest of it stays

there.

MR. CHEUNG: And because the water from the GDCS drain water is hot --

MR. WALLIS: Yes. It's steam.

MR. CHEUNG: And steam trying to slowly push it up.

MR. WALLIS: So it steams in there.

MR. CHEUNG: The water temperature or water partial steam pressure in the GDCS pool lowering going up.

MR. WALLIS: Steam is lighter than nitrogen, isn't it?

MEMBER BANERJEE: I guess that's the issue.

MR. WALLIS: Steam is lighter than nitrogen, and to be conservative, as in the wetwell, you should assume it goes to the top without mixing.

MEMBER BANERJEE: And, basically, you vent the steam out, but you may still leave the non-condensables in the GDCS.

MR. CHEUNG: I agree with you. In reality, the non-condensable gas will hide in those, but we cannot demonstrate how accurately we can calculate it. We force it out, but --

MR. WALLIS: Well, how do you get it down to 1.26 kilogram at 30? That's a real mystery.

MEMBER BANERJEE: Basically, it's a piston. The steam is pushing it out.

MR. WALLIS: But that's a nonconservative assumption.

MEMBER BANERJEE: Well, I don't know if it is conservative or not. It is probably an incorrect assumption.

MR. CHEUNG: No, yet the -- gas stay behind, not going in the wetwell. The end pressure going to be lower. That, I know.

MR. WALLIS: Do you know -- Do you understand how steam evolving from a pool pushes gas out above it without -- because it is lighter. It is hotter, and it's got a lower molecular weight. So the steam will tend to come up in plumes or along the walls or something.

MR. CHEUNG: Yes.

MEMBER SHACK: It is a conservative calculation, not trying to be realistic.

MR. WALLIS: Well, I'm not sure what is conservative, because what is conservative in one stage may be unconservative in another.

MR. CHEUNG: The key measure here is the drywell pressure, which trying to force the way into that maximum driver pressure going to be.

MR. WALLIS: Well, the key to the whole thing is the wetwell gas space pressure.

MR. CHEUNG: Yes.

MR. WALLIS: The drywell pressure really just follows it, with a little difference.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: So I am going to do a time check, since we are already 20 minutes behind.

MR. WALLIS: That's all?

CHAIRMAN CORRADINI: Yes. And so I am going to turn to the committee and ask that we give Dr. Cheung the time to go through his presentation, because we want to hear the audit calculations from Melcor, or else I will also be chastised about not allowing that to occur.

So I would ask that we let you finish, and we will clarify but allow you to proceed. Okay?

MR. CHEUNG: Okay.

MR. WALLIS: So we are not going to get in a presentation of what happens in the wetwell gas space?

MR. CHEUNG: We are going to touch base on that.

MR. WALLIS: Which is the key to an awful lot of what happens.

MR. CHEUNG: Next slide, please.

So about 18 hours and the water is in the downcomer overspill, and start decreasing the drywell pressure and then start the process of sucking up the non-condensable gas from the higher wall and back into the drywell, and once it gets in the drywell and then all the non-condensable gas will find a way and move it to the PCC and get into the wetwell.

Now these two pictures show at 30 hour and 60 hour, and notice that the PCC pool water level drops, and because the evaporation; and also notice that the non-condensable gas column, as shown in this cartoon, change to just what is needed to condense the steam generator in the drywell or by the decay heat. You can see that the effective heat transfer area change over time.

MR. WALLIS: Would you show in this figure next time you present it the level of the steam in the wetwell gas space, because presumably your model says steam is here, and gas is underneath it, and as the steam leaks in through the vacuum breaker, that steam gets bigger. Would you show that next time you present this?

MR. CHEUNG: Yes.

MR. WALLIS: There might well be a next time, it seems to me.

MR. CHEUNG: Okay. Sure.

MR. WALLIS: That's a key thing. Right? How much steam is in that wetwell, and where is it, and what is its temperature and pressure.

MR. CHEUNG: We have the temperature, but we will show it in a back-up. Okay.

Now the key thing is you can see that the effective heat transfer area or the PCC capacity is self-regulated and you can see that, from time to time, that the actual -- the PCC tube will transfer energy to the pool, which is water. It is reducing such that to accommodate what is being generated in the drywell.

MR. WALLIS: Well, that's the old story. We understand that one.

MR. CHEUNG: Okay. Next page. Now this going to end of the 72-hour, again showing the interaction between the correction of non-condensable gas in the bottom. The table, showing it again, you can see that we force most of the non-condensable gas in the drywell into the wetwell, and also whatever that rate are that get generated can also get into the wetwell, and at the end of it the wetwell collect about 15,000 kilograms.

MR. WALLIS: Okay. So let's see. Between 30 and 72, there is almost no addition of gas to the wetwell. It's almost constant --

MR. CHEUNG: No. The radiolytic gas, about 300.

MR. WALLIS: It's almost constant, though.

MR. CHEUNG: Almost constant. It's 300.

MR. WALLIS: Almost constant. It goes up by one or two percent. Right?

MR. CHEUNG: Go up by two percent, to be exact.

MR. WALLIS: So the temperature is what is raising the pressure, is it? Of steam.

MR. CHEUNG: Let qualify that. The non-condensable gas by the radiolytic gas would generate from 30 hours to 72 hours is two percent.

MR. WALLIS: I'm saying the amount of gas in the wetwell space, the 14736, rises to 15,000, which is a very small, relatively small, change.

MR. CHEUNG: That's two percent.

MR. WALLIS: Right. That can't account for the rise in pressure. Something else causes the pressure to --

MR. CHEUNG: The other thing is the

leakage. That increases the wetwell temperature by six percent. So it is a total of about eight percent. That's the wetwell pressure increase from 30 hours to 72 hours.

MR. WALLIS: So what heats up the wetwell gas is only the steam coming in?

MR. CHEUNG: The steam through the leakage, the energy through the leakage.

MR. WALLIS: The steam -- No. The steam coming in through the leak is what heats up the gas.

MR. CHEUNG: Yes.

MR. WALLIS: All right. That's the only thing heating it up?

MR. CHEUNG: Yes.

MR. WALLIS: And the walls are not cooling it down?

MR. CHEUNG: The wall cooling it down, but it is limited, because you look at it. You see almost 2 meter thick of concrete, and take only two hours. So that the concrete --

MR. WALLIS: The Melcor report says that the wall is very important, I thought. But anyway --

CHAIRMAN CORRADINI: We'll get to that, if we allow him.

What is the vacuum breaker setpoint?

MR. CHEUNG: I don't have the number. It's about half a psi or so, when the drywell pressure lower than the wetwell pressure by half --

CHAIRMAN CORRADINI: Can we get that number exactly?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Then you are going to move on. So I will just suggest something here, because I think what your intent of this was, was helpful. But I think it's got to be coordinated with what you were trying to explain to us in the qualitative part.

You made a big thing about the qualitative part about time phasing, zero to one hour, one hour to five hours, five hours -- whatever. All these aren't matching up. So that is what's causing some of the questions.

I would think it would be very educational for me to understand how it changed from zero to one hour in the non-condensable, because I think the non-condensable is decreasing from one hour forward, and the 15 hour just happens to be a slice in time.

So next time you do it, and you are going to explain phasing qualitatively and phasing quantitatively, all the graphs and all the cartoons ought to be at the same points in time. Otherwise, it will cause some confusion. That's just a suggestion.

MR. WALLIS: And show the continuous curves from the DCD about what the gas is doing.

CHAIRMAN CORRADINI: But I think I understand your point of how you tried to do it. I just wanted to compliment you on I understood what you were after, but the lack of the one hour caused us to be a bit confused.

MR. CHEUNG: Yes. We have the -- The next couple of slides show the mass distribution.

MR. WALLIS: I would say we are not confused. We are not informed.

MR. CHEUNG: Next slide. This shows the drywell pressure and the wetwell pressure, and you can see that from 30 hours to 72 hours is continuing increase.

MR. WALLIS: So the key thing you should focus on next time you come here is why the temperature does what it does and how you calculate that.

MR. CHEUNG: Okay.

MR. WALLIS: Why the pressure does, and what the temperature is doing all this time, and the temperature you should show on the same graph. And that's a very key thing, because the temperature rise is what is driving the biggest force driving the pressure rise.

MR. CHEUNG: Yes.

MR. WALLIS: Then the question is how does the temperature rise so much? Okay.

MR. CHEUNG: Next slide, please.

Now this shows the PCC condensation power versus the decay heat, and you can see that the first two hours of that, there is a big dip in the PCC power. Doesn't mean that the PCC is not doing anything, but because of the GDCS water going into the -- draining into the RPV and pick up all the decay heat. So this big dip is due to the GDCS injection, and after two hours or so, then the PCC start picking up, and the difference between the direct curve and the back curve in the first couple of hours is the deficiency or the water that is left over is going into the suppression pool through the PCC vent line, and after a couple of hours or so, the PCC actually pick up all the decay heat or all the steam generated by decay heat.

Now after a couple of hours, so the difference between these two curves is due to the 1,000 cubic meter of cold water in the GDCS pool is still cold and going into the RPV and pick up some of this energy.

CHAIRMAN CORRADINI: So now this -- I think it is important at this point to link back to your question. In the first hour, the PCCS is just going along for the ride, and that goes, I think -- at least, that's my interpretation, is that you are concerned about the parallel flow paths, which are really crucial, but I think from an energy sucking standpoint it is doing nothing -- well, almost nothing, compared to what --

MEMBER BANERJEE: Well, sort of -- Why are we getting this huge dip? This is what I don't understand.

MR. CHEUNG: Because the GDCS cold water going in the RPV, and the decay heat had to heat up the cold water until generating steam.

CHAIRMAN CORRADINI: And that's what causes in curves 2 through 3 to go below. Right? We start at 6, 5, then we fall below because of the cooldown effect, and now we come back up to this kind of quasi-steady.

MR. WALLIS: Well, we didn't get back to that question about how that green curve could ever be below the --

CHAIRMAN CORRADINI: And I am not going to let you right now.

MR. WALLIS: Okay, but we don't know how the non-condensables --

CHAIRMAN CORRADINI: It was my one shot at you today. I only get one, but that was my one.

MR. WALLIS: But that's a question which is not answered.

CHAIRMAN CORRADINI: But I think the crucial thing is in that first hour you are essentially dumping everything, and it is very cold, and now I come back up and I start now cruising along at this quasi-steady behavior.

MR. WALLIS: You can't do that, if you've got non-condensables in there.

CHAIRMAN CORRADINI: We are talking in the vessel. In the vessel. That's what their point was. Their point was in that first hour you are dumping the GDCS. You are cooling down, and now you have to reestablish a quasi-steady state. And that is why you are not pulling power out of the PCC.

MEMBER BANERJEE: Dumping it into the drywell.

MR. WALLIS: Okay. That's very helpful. So that would be good to show where the heat goes first.

MEMBER BANERJEE: Yes. I think that there is -- What you really -- I wasn't aware that this stuff would spill out into the drywell in some way.

MR. CHEUNG: At about 18 hour. So that you can see the overspill. The cold water from the downcomer in through the DPV into the drywell annulus. The condensed steam is not going through the PCC but rather by condensed by this overspill of cold water.

MEMBER BANERJEE: Why do you get these little spikes?

MR. CHEUNG: Because this is a parallel path. You can see that the GDCS pool is one. There is a U-tube going to the downcomer and then when the water is going out and then condensed to steam, and then the U-tube effect, and the amount of the water going condensed in drywell annulus as steam is -- This is the U-tube process. It is not -- It takes long time. It is not changing in over a couple of seconds.

MEMBER BANERJEE: It would be helpful to have some markings on this red showing what events are these spikes showing. Otherwise, they just look strange.

MR. CHEUNG: Okay.

MEMBER ABDEL-KHALIK: When you say that

the PCCS capacity is 60 megawatts, what are the conditions corresponding to that capacity ?

MR. CHEUNG: i believe it is 300 -- 350 kilopascal at roughly about 45 psia at that test condition. The steam at that test -- at that pressure condition, the PCC will condense 100 percent steam at 60 megawatt.

MEMBER ABDEL-KHALIK: Okay. And that pressure is never reached during this transient?

MR. CHEUNG: No, during this transient the pressure is somewhat over the design pressure or the rated condition.

MEMBER ABDEL-KHALIK: And the reason why the PCCS heat removal capacity is less than its stated 60 megawatts is what? What is limiting the heat removal capability here?

MR. CHEUNG: There are a couple of slides before that. The PCC is self-regulated. After a couple of hours or so, the PCC had over-capacity. The PCC is trying to condense -- or trying to collect non-condensables in the bottom of it to suck off the surplus capacity.

CHAIRMAN CORRADINI: Can I try? I think what he is wanting to tell you is I have parallel flow paths. So I can't get to the flow through the PCC to demonstrate at 60 megawatts. It's dumping through the vent line. Right?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay.

MEMBER BANERJEE: Well, also there is another effect, that the 60 megawatts must be with all steam. So if you block a part of it with non-condensables --

CHAIRMAN CORRADINI: You degrade it.

MEMBER BANERJEE: -- you degrade it.

MR. WALLIS: Well, I disagree with you, Mr. Chair. If there is enough pressure drop to open the vents, that pressure drop is still applied to the PCCS and drives steam into it. Must do. I mean, it drives even more steam than when the vent is closed.

CHAIRMAN CORRADINI: But it's a combination of the 60 megawatts -- unless I misheard -- is pure steam.

MR. WALLIS: No, the pressure drop. You've got a pressure drop, and you've got a pipe, and that determines the flow rate into the PCCS. It has to go somewhere. Has to be condensed or bubble out the bottom.

CHAIRMAN CORRADINI: So just to be clear: So the 60 megawatts is pure steam or --

MR. CHEUNG: Pure steam.

CHAIRMAN CORRADINI: Okay.

MR. WALLIS: No, but you see what I mean.

CHAIRMAN CORRADINI: I understand.

MEMBER BANERJEE: I'm still having problems with this. Maybe I'm not getting it, because it needs to be sketched for me. But this big dip right in the first hour -- You have steam flow through this thing. Right? So why doesn't it remove --

MR. CHEUNG: It's the electrical power is going to use to heat up the incoming cold water, instead of generating steam. No steam going into the drywell and, therefore, the PCC is not seeing any drywell --

MEMBER BANERJEE: So in this there is no flow. The pressures are not such that you are getting any flow through here. Once you get flow, you have heat transfer. Right?

MR. CHEUNG: Yes.

MEMBER BANERJEE: So the only way you cannot have heat transfer is not to have any flow, which means there can't be any pressure drop. So there is no pressure drop. So there is no pressure drop across this year.

CHAIRMAN CORRADINI: There is no steam.

MR. WALLIS: There is no steam.

CHAIRMAN CORRADINI: They have dumped the water.

MR. WALLIS: It has cooled everything down.

CHAIRMAN CORRADINI: Education is a very painful thing.

MR. WALLIS: No, it's a very good thing. Those of us who believe in it think it's great.

CHAIRMAN CORRADINI: But it's painful.

MR. WALLIS: It's painful for the instructor. I know that.

CHAIRMAN CORRADINI: Okay, next slide, 12.

MR. CHEUNG: Now this shows the distribution of non-condensable gas in different regions, and you can see that the red curve is the drywell non-condensable gas, and during the blowdown period it just all of a sudden --

MR. WALLIS: This is a very interesting curve. If you look at the DCD, this is expressed in terms of partial pressure, which gives a different impression when you see the partial pressure in the GDCS space is one atmosphere. That tells you a lot about how much gas is there, and this number here doesn't quite give that -- or tell you that.

MR. CHEUNG: You have to calculate the pressure together with the volume.

MR. WALLIS: Yes, but that tells you how much of it is gas, which isn't evident from this figure.

CHAIRMAN CORRADINI: And you can see that the green curve --

MR. WALLIS: Then at 18 hours something magical happens.

MR. CHEUNG: At 18 hours, that is because of overspill of the cold water from the downcomer.

MR. WALLIS: I don't understand how that works. So you have to tell me that someday, if we ever get there.

MR. CHEUNG: And the thing is we've tried to very conservatively move everything, every single jot or molecule of non-condensable gas, from the drywell into the wetwell, such that to maximize the wetwell pressure and, therefore, the drywell pressure will follow it.

MR. WALLIS: Eventually, it all gets there. Right.

MR. CHEUNG: Yes.

MR. WALLIS: All right. But whether it is conservative to assume it all gets there in the first hour or doesn't all get there until after 18 hours, we don't really know until we look at all the details. I'm not sure what is conservative and what isn't.

MR. CHEUNG: Well, the endpoint is the wetwell pressure at the end depends only on a few things, the total amount of non-condensable gas.

MR. WALLIS: Yes.

MR. CHEUNG: That we have, and then the temperature in the wetwell, we force it to be high, because we do not allow the mixing. Then the suppression pool surface temperature will supply about 10 percent of the partial steam pressure, and we force it after a couple of hours, so the energy going into the suppression pool through the PCC vent line stay above the layer of water --

MR. WALLIS: So everything depends upon getting the bypass leakage right.

MR. CHEUNG: Yes.

MR. WALLIS: Okay.

CHAIRMAN CORRADINI: Which we are going to get to soon.

MEMBER BANERJEE: I mean, in a way, putting all the non-condensables in the wetwell is conservative, I guess, from the viewpoint of pressure.

CHAIRMAN CORRADINI: I would think so.

MEMBER BANERJEE: But the real issue here is removing the heat.

MR. WALLIS: Right.

MEMBER BANERJEE: And removing the heat requires that your PCC system works. So if it somehow gets blocked with non-condensables, then you are really in trouble.

MR. WALLIS: So conservative for one thing is not conservative for the other.

MEMBER BANERJEE: Right. But conservative -- We could block the PCCS with non-condensables --

MR. CHEUNG: But non-condensable column in the PCC tube is self-regulated. It takes only a small amount of non-condensable gas to self-regulate. Condense no more steam or no less steam than is --

MEMBER BANERJEE: I guess the behavior of the PCC system is the crucial issue here. If it is clearing itself and keeping removing the heat, we are all happy.

MR. WALLIS: The non-condensable vent line has valves in it, I see. Are these operator controlled valves?

MR. CHEUNG: No. There is no valve.

MR. WALLIS: There are valves shown in the figure, non-condensable vent line.

MR. CHEUNG: That's for testing.

MR. WALLIS: Those are for testing?

MR. CHEUNG: Yes.

MR. WALLIS: What? On page 13, I see valves. It would seem to me that closing one of those valves would be in the PRA somehow. I mean, if you close the vent line, do you prevent the PCCS working?

MR. CHEUNG: That's for the testing purpose.

MR. WALLIS: Testing purpose? So they can't be closed during operation?

MEMBER SHACK: This is a design basis accident. They are not closed. In the PRA, there's a chance.

MR. WALLIS: Well, the only thing that really matters to the public is an accident that happens, not a design basis accident.

MR. CHEUNG: Okay. This picture shows --

CHAIRMAN CORRADINI: I'm sorry. Let me just take again a time check. So are we moving on to the post-72 hour discussion?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay.

MR. CHEUNG: This is the PCC vent fan, and this sketch shows that the PCC vent fan suck the gas mixture from the bottom of the PCC tube or the vent line, and then discharge it into the GDCS pool and then eventually bubble up to the GDCS gas space -- or GDCS pool air space.

MR. WALLIS: So if there are no non-condensables, what does it pump?

MR. CHEUNG: No. This condensable accumulate in the bottom of the tube. We pump that bottom of the tube to destroy that column.

MR. WALLIS: If the vent fan is too strong, it will pump enough pressure drop that it will be pumping steam, if there is very little non-condensable. It will exceed the capacity of the PCCS, and it will pump steam. Right?

MR. CHEUNG: It is very big fans, yes.

MR. WALLIS: So we need to know how much it pumps and what the pressure drop is and all that kind of thing, and what happens when there are no non-condensables.

MR. CHEUNG: That won't happen.

MR. WALLIS: What do you mean, it won't happen?

MR. CHEUNG: Because I can show you in a couple of slides that it won't happen.

MR. WALLIS: Well, it depends on how well you can calculate where the non-condensables are.

MR. CHEUNG: because once the -- Let me go back this way. Once the vent fan turn on, the column of non-condensables destroyed, and then the PCC heat capacity increase.

MR. WALLIS: That's right.

MR. CHEUNG: And then it's increased. That means it condense the steam.

MR. WALLIS: That's right, and that's why the pressure comes down in the drywell.

MR. CHEUNG: The drywell pressure drop comes down.

MR. WALLIS: So what is that steam fluorides? That steam fluoride correspond to 70 megawatts or 50 or 40 or what?

MR. CHEUNG: Whatever the steam in the drywell condense, and then drywell pressure drop, breaker open. Non-condensable gas from the wetwell back into the drywell, and then non-condensable gas, once it get into the drywell and eventually go back to the PCC tube.

MR. WALLIS: You have a very good model for how it mixes in the drywell. Right?

MR. CHEUNG: Yes.

MR. WALLIS: Yes? Okay.

MR. CHEUNG: Once it go back to the PCC tube and then the self-regulate, now I have a uniform -- not say uniform. I do not have a column of non-condensable gas, but rather I have an incoming mass, say, at 15 -- or .15, and then the mass increasing as it go on to the bottom of the tube, maybe increase from 1.115 to .25.

MR. WALLIS: When the vent valve opens, when the vacuum breaker opens, you have a column of non-condensable gas coming out which, I presume, mixes with all the steam somehow?

MR. CHEUNG: Before it opens.

MR. WALLIS: Things are pretty quiet, aren't they, in the drywell now? Things are very quiet? There's a quiet room, right ?

CHAIRMAN CORRADINI: In 72 hours.

MR. WALLIS: And you are oozing out something through the floor, which is non-condensables. Right? And you are going to tell me that mixes with everything in there?

MR. CHEUNG: If not mixed --

MR. WALLIS: It's a plume of some sort? Is it lighter or heavier? Does it flow along the floor? It's heavier. It's nitrogen. It's heavier than steam. And it's colder as it came from the wetwell. It just flows along the floor, doesn't it?

MR. CHEUNG: It flows on the floor, though, even better, because then the PCC is going to condense more steam.

MR. WALLIS: You are telling me it doesn't.

CHAIRMAN CORRADINI: I don't think we are allowing him even to answer the question --

MR. WALLIS: Okay. I'm sorry.

CHAIRMAN CORRADINI: -- before he gets to the next question. That's not fair to him. So let me ask this. You are now phasing into the post-72-hour period where you are going to show your analysis. Is that correct?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: And then you are going to go into your bypass uncertainty or bypass sensitivity.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay. Let's take a break, I would propose, for five or 10 minutes, and I want to caucus with GE and the staff, because I want to hear before -- soon the Melcor audit calculations to compare to this. So can we take a break for 10 minutes, please. We will be back at 10:35.

(Whereupon, the foregoing matter went off the record at 10:26 and went back on the record at 10:40.

CHAIRMAN CORRADINI: Chester, you're up. Consultants or no consultants, you're up. And just to tell the Committee, I suggest to Chester that we go to the bypass leakage analysis, and if we have questions about post-72 hour, we bring it up, but first we probably want to see bypass leakage first. Okay?

So we will kick off. Dr. Cheung, you're up. Twenty-one, Chester?

MR. CHEUNG: Okay. Now bypass leakage is one of these things that affect the wetwell temperature, such that the wetwell temperature will affect the wetwell pressure, and then bring down the drywell pressure.

We have performed parametric case on a bounding calculation from zero, one, two, 2.25, and 2.5 square centimeter, and on the blue line shows the design pressure. And when we increased the bypass leakage from zero all the way to 2.25 and then see that the drywell pressure almost touching the design pressure, and another point I am going to bring is that these set of curve -- they behave nicely and are not -- They behave as expected, increase the pressure as they increased the bypass leakage.

Next slide, please.

MEMBER ABDEL-KHALIK: I guess the question, if I remember correctly, is: How realistic is a limit of one square centimeter on the bypass leakage area?

MR. CHEUNG: Let me comment on that. The leakage is coming from the diaphragm floor. That leakage coming from the diaphragm floor is way below .5. Now the other possible leakage is through the vacuum breaker, and currently we have isolation well on vacuum breaker. So the vacuum breaker leakage is almost -- once it is a detected leak with isolation wall isolate. So the remaining possible way of leakage is through the diaphragm floor, the penetration, which is very small.

On top of it, at the current technology we can test the leakage or leakage area. We have 95 percent confidence at .5 square centimeters.

MEMBER ABDEL-KHALIK: Why do you set the acceptance level at 2 and the design calculations at one?

MR. CHEUNG: Currently we turn it the other way, that acceptance testing acceptance of 1 and licensing at 2. That means that gives you a 50 percent margin.

MEMBER SHACK: DCD goes the other way, doesn't it, or did I read it wrong?

MR. CHEUNG: We are going to try to bring it -- change it.

MR. MARQUINO: This is Wayne Marquino. We are going to make a revision in 5, and we will show the bounding result at 2 square centimeters bypass leakage.

MR. WALLIS: This is 2 square centimeters for all the vacuum breakers taken together?

MR. MARQUINO: Yes.

MR. WALLIS: Because if one presumably stuck, the leakage would be many square centimeters, wouldn't it?

MR. CHEUNG: We have isolation model to limit it.

MR. WALLIS: One square centimeter is a very small thing.

MEMBER BANERJEE: How many microns raising will give you one centimeter?

CHAIRMAN CORRADINI: Well, just to remind the Committee, we have their report where -- I've forgotten, but I remember you've given to all of us, which has the testing and the design, and we discussed the fact of this last time, if I remember.

MEMBER SHACK: He's going to have a tech spec that they are going to test to meet this.

MR. MARQUINO: That's right.

MEMBER STETKAR: What closes the isolation valves on the vacuum breakers -- signals?

MR. CHEUNG: The signal -- The temperature measurement around the vacuum breaker in the drywell temperature, the wetwell temperature and the cavity which is inside the vacuum breaker -- the temperature. So we measure all these temperatures and then determine if there is a leak, and then we isolate it.

MEMBER STETKAR: Manually close?

MR. CHEUNG: No. Close by signal.

MEMBER STETKAR: Signal? Okay.

MEMBER BANERJEE: If you have some grit or some particles getting in there during operations, how much would that -- Remind me how much it would have to rise in order to get one centimeter squared? Is it 10 microns? So a 10 micron particle could do that?

MR. WALLIS: Well, there is a seal, presumably.

CHAIRMAN CORRADINI: So I guess I want to ask GE to remind us, or we can pull out the PDF file, what is the -- It seats at some diameter with some lip. Right? And it's a soft seal. So can you just remind us briefly.

MR. MARQUINO: The vacuum breaker has both a hard seat and a soft seat on it. Is that what your question was?

CHAIRMAN CORRADINI: Yes.

MEMBER BANERJEE: In other words, can it tolerate some dirt getting in there and still close?

MR. MARQUINO: Yes, it can tolerate dirt during the test, they inject it, and it was forced to ingest sandblasting grit, and the leakage was tested.

MEMBER BANERJEE: And what was the leakage? Very low?

MR. MARQUINO: In that post test degraded condition, it was less than one square centimeter.

MR. CHEUNG: No, less than point-some square meter, .1 or .2.

MEMBER BANERJEE: Square centimeters?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: We have the report. I can -- Okay, fine.

MEMBER BANERJEE: So under most circumstances that one can imagine in this mass that will be there with all sorts of things floating around, you feel that this vacuum breaker will close, even though there could be particles and debris and everything in the air?

s MR. MARQUINO: Yes. There is a screen on the vacuum breaker, and the vacuum breaker is initially seated during the blowdown phase. So --

CHAIRMAN CORRADINI: Because of just those dynamics. But during the blowdown phase -- I guess I wanted to ask that. So we have the testing that we can look at, but from the standpoint of its operation, will it open during the early hours? I was trying to think of this, because of the delta Ps or will it always be seated from the moment I have the main steam line break and remain seated?

MR. CHEUNG: Remain seated until the GDCS injection.

CHAIRMAN CORRADINI: Until the GDCS injection ?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: So in that frame of less than a couple hours, it will then open up? It will open?

MR. CHEUNG: It will open. Yes.

CHAIRMAN CORRADINI: Okay. All right.

MR. WALLIS: So none of these spikes and things that we see in the traces are due to the vacuum breakers opening early on? They remain seated until it is eventually called upon after three days to open?

CHAIRMAN CORRADINI: The opposite, Graham. It will open. Ten minutes to one hour is when it would open, because we are in that curve --

MR. WALLIS: So it does open at the beginning?

MR. CHEUNG: No. Only when the GDCS inject.

MR. WALLIS: So it does open early on.

MEMBER SHACK: Depends on what you mean by "the beginning."

MR. WALLIS: An hour or two. It does open at the beginning. Right? It does some up and down early on in the transient.

MR. CHEUNG: Not during the blowdown.

MR. WALLIS: No, but it does some early on in the transient.

MR. CHEUNG: Yes.

MR. WALLIS: Before a day is up, it has opened.

MR. CHEUNG: Before couple of hours, yes, it's going to open in a couple of hours. Yes.

MR. WALLIS: So it does open. So it has a chance to open and not quite close several times before it really is called upon to open.

MR. CHEUNG: The design is such that our guaranty -- the warranty is not --

MR. WALLIS: But it is exercised a few times early on in the transient.

MR. CHEUNG: Yes.

MR. WALLIS: So there is a chance that something could happen. Right? It has to be evaluated somehow.

MR. CHEUNG: There is a chance, but there is also an isolation wall on top of it.

MEMBER ABDEL-KHALIK: Let's go back to the question that was asked earlier by Mr. Stetkar as to what signals are used by the operator to know that these valves are in an erroneous position and, therefore, must be isolated manually.

Does the operator really know at every moment --

MR. CHEUNG: The isolation valve is not operated by --

MEMBER ABDEL-KHALIK: The isolation valves are operated how?

MR. CHEUNG: By signal, automated by signals.

CHAIRMAN CORRADINI: Professor Abdel-

Khalik and John -- John and Said are asking you what is the logic that would tell the operator to hit the button and --

MEMBER STETKAR: Operator.

CHAIRMAN CORRADINI: Oh, I'm sorry. Excuse me.

MEMBER STETKAR: Operator doesn't hit the button. The signal is automatically configured. The question may still be relevant, but the operator is not required.

CHAIRMAN CORRADINI: And the signals are what?

MR. CHEUNG: The temperature around the vacuum breaker and inside the vacuum breaker.

MEMBER ABDEL-KHALIK: And under all conditions, measuring those two temperatures one can come up with a logic that --

MR. CHEUNG: Yes.

MEMBER ABDEL-KHALIK: -- would tell him whether or not these valves should be open or closed?

MR. CHEUNG: Yes, and on top of it there is a proximity probe that sees, if the vacuum breaker is not seating well, then also close it.

MEMBER BLEY: And there must be some time delay or something.

MR. CHEUNG: Some time delays.

MEMBER BANERJEE: So what are these temperatures that are measured in the flows? If a flow establishes through the vacuum breaker, what happens to these temperatures?

MR. CHEUNG: No, if the vacuum breaker is a very small leak, is not huge, then we measure the drywell temperature. We measure the cavity temperature inside the vacuum breaker. We measure the wetwell temperature. So compare the delta P between the cavity and the drywell and cavity and the wetwell. If there is a leak at this temperature ratio, so it is sort of indication that that's a leak. If there is no leak, then the ratio is the other way around.

So we have established a logic.

MR. MARQUINO: So if you have a -- You should have a flow from the wetwell to the drywell through the vacuum breaker. The wetwell is a lower temperature than the drywell.

if you have an indication that the temperature in the vacuum breaker is high, that indicates that you are getting flow from the drywell into the vacuum breaker. It is not sealing as it should, and that would initiate closure of the backup valve.

MR. WALLIS: I think your assumption is that steam comes into the wetwell from the drywell, very small pressure drop, leaking in. So it doesn't change its temperature much, and there is no heat transit. So it's still about 260 degrees Fahrenheit.

If that steam leaks out, it won't tell you anything, because it's about the same conditions as what is in the drywell. So are you are going to suddenly invert it and put the gas through the vacuum breaker? I don't understand your model for what happens in the wetwell.

I think you said the steam is at the top, and it hasn't been cooled down.

MR. MARQUINO: Well, I think you are talking about our TRACG analysis versus the logic for isolating the vacuum breaker.

MR. WALLIS: But when it comes to the vacuum breaker, you assume that the gas coming out of the wetwell is cold. When it comes to calculating the pressure in the wetwell, you assume the steam is on top, and it's hot.

MR. CHEUNG: That's conservative.

MR. WALLIS: So you are warping reality in both cases, and I'm just wondering if that is the right way to approach an accident, because you never quite know when you make what you think is a conservative assumption that you might be making something else happen which is unreal, which is bad.

MR. MARQUINO: In terms of isolating the vacuum breaker, the concern is getting a high temperature gas flowing in and steam from the drywell. So we --

MR. WALLIS: I'm just wondering if temperature is the right indicator. That's all.

MR. MARQUINO: Well, we chose temperature, because it will be more sensitive than any kind of differential or --

MR. WALLIS: Well, how do you know the temperature of the gas layer at the top of the wetwell, because steam has been leaking into there all the time.

MR. MARQUINO: We will be measuring it.

MR. WALLIS: You will be measuring the temperature at the top of the wetwell.

MR. CHEUNG: That's separate. In the model, we assume there is a leak.

MR. WALLIS: Ah. So when you actually build one of these things -- Well, I guess -- so we won't know whether any of these assumptions make any sense until there is an event.

MR. CHEUNG: And even with the conservative model, there is still a large significant delta P between the drywell and the wetwell.

MR. WALLIS: Well, calculating the temperature in the wetwell and the pressure, we assume the steam is on the top, and it doesn't cool down very well. When it comes to figuring out the temperature, when it goes through the vacuum breaker so we can figure out whether to close off the valve or not, we assume something else about the temperature in the wetwell.

MR. CHEUNG: Even in that calculation, the temperature in the wetwell, top of the wetwell, is still significantly below the drywell. So we can establish the --

MR. WALLIS: Is it 100 degrees lower or what?

MR. CHEUNG: It's 80 degrees Celsius lower sometimes.

MEMBER BANERJEE: Does it matter to you -- You are measuring the temperatures. Right? Just outside, and then within the chamber? What you are really seeking is to see whether if there is a flow, then you would get the cavity temperature becoming equal to the --

MR. CHEUNG: Close to the drywell.

MEMBER BANERJEE: Close to the drywell temperature. So it's a direct measurement.

MR. WALLIS: But what has been coming in through the leakage is close to the drywell temperature, which reminds me of TMI where they had a leak, because the temperature was up all the time and they didn't fix anything. When there was an accident, the fact that the temperature went up didn't tell them anything, because it didn't really go up, because it had been leaking already.

So the temperature is not a good indication, if there is a leak the other direction.

MEMBER BANERJEE: Well, if there was always a leak.

MR. WALLIS: So if your one square centimeter is aimed at your thermometer, it's going to heat up, isn't it?

MR. MARQUINO: We have proximity probes on the vacuum breakers which are very sensitive, and we have drywell pressure -- drywell-wetwell differential pressure measurements.

MEMBER STETKAR: Those I've found. I haven't found any mention in Chapter 7 of the DCD that talks about signals and actuations. The temperatures were the first -- Today was the first time I had ever heard of that.

MR. MARQUINO: That is new, and it is in an RAI response. Yes.

MEMBER STETKAR: So it would be interesting to see what those temperatures really are.

MR. MARQUINO: Maybe we should wait until you have had time to read the RAI response.

MEMBER ABDEL-KHALIK: But let me just ask you a simple question. Let's just say that you are just right on the borderline, and you have one centimeter squared of leakage area. How big are these vacuum valves -- vacuum ports -- Manhole cover, right?

One square centimeter is a tiny tilt in that valve. Right? And if you are going to try to detect a leak through one square centimeter leak area from something that big, how well do you have to instrument this thing to measure the variations of temperature along the entire perimeter of this valve?

MR. CHEUNG: Again, we have a design --

MEMBER ABDEL-KHALIK: Is it at all reasonable to use temperature measurements? I don't know how many temperature probes you would have to have to be able to detect a one square centimeter leakage area in something that big by measuring temperature variations.

MR. CHEUNG: Currently, we have four set -- or four probes at different angles and different locations for the drywell temperature, cavity temperature, and the wetwell temperature. It's been designed and tested and even threw sand, blasting sand, into it, and it still satisfied the design requirement of less than one square centimeter, and actually, the leakage is less than .1 or somewhere around .1, .2 square centimeter.

MEMBER ABDEL-KHALIK: That is not the point. The point is whether or not you would be able to detect a one square centimeter leakage area by temperature measurement.

MR. MARQUINO: The concern is that we have a high temperature flow going -- leaking through the vacuum breaker and entering the wetwell. So by these differential temperature measurements, we are detecting the symptom that we have a high temperature in the wetwell side of the vacuum breaker, and that's what we have chosen to trigger the isolation.

MEMBER MAYNARD: I'm just a little bit confused. Let me go back over it. My understanding: Basically, the vacuum breaker is a check valve, and it doesn't really require electricity or anything to move it. It's basically done on differential pressure.

It's the isolation valve that requires some type of signal. When it detects that the valve is supposed to be closed and didn't close, well, that's when the isolation valve is then closed by -- I think it's a DC solenoid valve or something.

So you're saying you're using a combination of temperature and the proximity probes to trigger that isolation valve?

MR. MARQUINO: No, only the temperature.

CHAIRMAN CORRADINI: I didn't mean to interrupt you. So let me just ask a couple of questions, not about detecting anything, but I want to understand timing again.

These are new vacuum breakers. They are not on the ABWR. Okay. So there is no past history of performance in the field.

Why do you even care about the vacuum breakers after 10 or 15 hours into the accident? Why don't you just isolate them and be done with it? What the hell. Why even have them even there? You've told me that I'm going to have a positive pressure. Why don't I just simply isolate them to 12 or 24 hours into the accident and be done with it?

MR. CHEUNG: After a couple of days --

CHAIRMAN CORRADINI: Well, they just told me they have an electrical system. They got batteries. They hit the button or it closes on temperature, and you isolate.

MR. MARQUINO: Two reasons. The one is the basic function of the vacuum breaker is, if there is a rapid drop in the drywell pressure, the vacuum breaker opens, lose non-condensable gas in the drywell . it prevents the drywell from going sub-atmospheric or having too large a differential or too large a liner differential.

CHAIRMAN CORRADINI: But what I guess I'm asking is: So since this is a stylized accident and there are possibilities a day or two days into the accident that you actually would have a negative pressure, you had to equalize?

MR. CHEUNG: When we turn on the active system, like FAPCCS or like a vent fan --

CHAIRMAN CORRADINI: We are just trying to understand -- I'm just trying to understand actuation of isolation, you said, is automatic. I, somehow in my head, thought it was manual. But actuation of isolation is automatic, and it is based on some sort of measurement.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: So take for the moment the measurement is perfect. I'm trying to understand the automatic isolation versus manual isolation, if you have battery power to isolate.

Under some scenarios, do you even need it? I mean, by this scenario you don't need it. It's sitting there above pressure, and you don't want them to leak.

MR. MARQUINO: Well, we don't want them to leak, and we don't expect them to leak.

CHAIRMAN CORRADINI: Nor do you even need their function task, according to the stylized accident.

MR. MARQUINO: I think we do need their function. All pressure suppression containments have drywell-wetwell vacuum breakers for the reason I just stated, to allow non-condensable gas to move back into the drywell after a blowdown, if you have a cold water injection into the drywell.

Granted, that is more of an issue in the forced EECS plants where they do inject a lot of cold water into the vessel and drywell post LOCA.

The other reason we like the vacuum

breaker is when we recover the FAPCCS systems in this postulated accident and we can pump cold water into the vessel. We can cool down the drywell, and then when the vacuum breaker opens, the non-condensable gas moves and we decompress the wetwell, and we drop the containment pressure.

CHAIRMAN CORRADINI: Let's move on. This graph shows the sensitivity of the --

MR. WALLIS: I have a question. I'm sorry.

MR. CHEUNG: Okay.

MR. WALLIS: Are you going to discuss pages 13 and 14, because I have questions about those.

CHAIRMAN CORRADINI: We have to make a choice. I want to -- I've made the decision that I want to hear from the staff and their audit calculations.

MR. WALLIS: So we are not able to talk about the vent fan?

CHAIRMAN CORRADINI: No. We had too much fun with the first few graphs.

MR. WALLIS: I don't think it's fun. I think it's professional activity.

CHAIRMAN CORRADINI: I know, but I meant we spent enough time on the first few graphs, that we have to get to the audit calculations.

MR. WALLIS: Well, I just want to indicate that I have some questions which, I guess, we have to make another time for, on pages 13 and 14.

CHAIRMAN CORRADINI: This is the post-72 hours? Yes. If we have time later today, we can, but I want to hear the staff.

MR. WALLIS: I agree.

MR. CHEUNG: On the vertical side of this chart is the margin, the containment pressure margin. That is relative to 45 psig. On the horizontal side is bypass leakage flow area. The blue line is the bounding calculation, and the red line is nominal calculation.

Bounding -- that is, we use the bounding initial condition, bounding plain condition like one or two percent power, and initially we want to stop as much nitrogen gas in the drywell as much as we could in the initial condition, and so on. And also in the blue curve we assume that the gas that the hot energy leak from the drywell into the wetwell through the leakage stay at the top of the wetwell. We also assume that the energy going into the suppression pool via the vent line stay at the top of the layer of the water.

The blue curve -- So that at about 2.25 square centimeter then, the margin becomes approaching the seal, and 2.5 become negative margin.

The red line -- so the nominal calculation, which is typical operating conditions and also the nominal model parameter -- Well, with the restriction on mixing, on the wetwell, top layer and the suppression pool top layer, and the nominal calculation show that the margin decreased with the increasing leakage flow area, bypass leakage flow area, but the point at the seal, margin is about 4 square centimeter.

Now at 1 square centimeter, you can see that there's two big triangles there. This is a parametric case. The lower one is the one we are allowing some mixing in the wetwell gas. You can see that. Once we allow that, the margin increase about three or four percent.

The top triangle, light blue, is the one that we allowed the top layer of suppression pool water to be mixed, some of it, with the rest of the pool. You can see that with that model turnoff -- the certification model turnoff, the margin increase about seven percent.

Now the combine of these two model

turnoff, we are expecting or we have some rough calculation, we are expecting nine percent margin increase.

Now this is a very conservative model. We turn it off. We can see that there is a margin there 8 or 9 percent, and if we slide off all the way to 2 square centimeter, we expect similar margin improvement without that conservative assumption, and on top of it --

MR. WALLIS: I don't know. It is only conservative if you can really talk about a few microns being realistic. The difference between -- If it is fully open, you've got, what, a few centimeters of gap or something; orders of magnitude difference if one of these things sticks open.

MR. CHEUNG: For this discussion, we are assuming less stick. The vacuum breaker is the testing well, and we can go to the test report, and we have the isolation wall to prevent, if anything happened in the vacuum breaker, we isolate it.

MR. WALLIS: Let's say if the vacuum breaker sticks fully open, one vacuum breaker sticks fully open. How long does it take to discharge what is in the wetwell? I mean, that's the kind of thing that is got to be calculated somewhere. If it sticks fully open, what happens? Is that in the PRA?

MR. CHEUNG: Sticking open, that takes a couple hours for the pressure to increase all the way to the design --

MR. WALLIS: You've got that calculation somewhere?

MEMBER ABDEL-KHALIK: And the other extreme, of course -- I don't know if you have demonstrated clearly and have actually designed both the sensors and the logic that would allow you to detect a one square centimeter leakage area and show that you can actually isolate these bounds.

MR. CHEUNG: The logic and the highway design are being in process for the isolation wall.

MEMBER ARMIJO: Does GE have any operating experience they could refer to that demonstrates that vacuum breakers of this size instrumented with temperature sensors -- that it is capable of detecting small leakages, let's say one square centimeter or less, in a reasonable time? Is there any operating experience that you can point to, in addition to whatever testing you have done?

Do you understand my question?

MR. CHEUNG: Yes, I understand your question. Wayne, you want to comment on that?

MR. MARQUINO: We -- As I said, we have a new vacuum breaker for ESBWR, and we don't have specific operating experience of instrumenting the vacuum breaker for this back-up isolation function.

MEMBER ARMIJO: Let's say for the ABWR. Did you have any temperature sensors on the vacuum breakers in those systems or any others?

MR. MARQUINO: No. Those vacuum breakers have position indication on them, and it wouldn't be applicable to this temperature isolation feature.

MEMBER ARMIJO: My last question, and that's with regard to the position indicator. My personal opinion is that they would probably be more sensitive than the temperature sensors, but that's just my bias. Do you have data on the sensitivity of these position indicators on leakage of other vacuum breakers that are actually in operation?

MR. MARQUINO: I believe there is information in the test report on the position indication for the ESBWR vacuum breaker, and it is very sensitive. I think it can detect down to less than one square centimeter, and there was some discussion about like how much offset, how many millimeters of offset would correspond to that to the leakage.

The soft seat provides the ability to pick up some offset in the valve seat, but we have chosen to go with this temperature differential isolation, because it removes the question of are there ways to get leakage besides the valve being open or slightly open. So that if you had some degradation of the seat, this detection would still work. Whereas, if you are just looking at the fixed position of the seat, you could postulate things that wouldn't be picked up.

MEMBER BANERJEE: Why did you -- Excuse me. Why did you go to a new set of vacuum breakers compared to the previous ones?

MR. MARQUINO: We wanted these to be more leak-tight than the available --

MEMBER SHACK: It's only got two square centimeters.

MEMBER BANERJEE: And the other vacuum breakers leaked? They did?

MR. MARQUINO: Well, in the operating plants, they have problems with the vacuum breakers not showing full closed indication. So that was another reason that we wanted to go to the new design for the passive plant.

MEMBER BANERJEE: So this becomes a more

crucial component than in the other plants?

MR. MARQUINO: That's right. It's important that these vacuum breakers are leak-tight and work.

MEMBER BANERJEE: So what is the physical reason why these become more important?

MR. MARQUINO: Because of the drywell-wetwell leakage, which causes energy to bypass the PCC, so that we don't have full decay heat removal mechanism.

MEMBER BANERJEE: So if one vacuum breaker was stuck open and was not isolated, what would it do to the PCCs then?

MR. MARQUINO: Well, you can -- We are providing some curves with -- We don't have the full vacuum breaker area shown on that.

MEMBER SHACK: Fourteen centimeters squared to get to the failure pressure of the containment. Right?

MR. MARQUINO: Right, and that is in the full area of a vacuum breaker.

MEMBER SHACK: A vacuum breaker would normally be closed during operation.

MR. MARQUINO: Right.

MEMBER BANERJEE: So coming back to this

question: Let's say whatever that number is, 14 square centimeters or whatever. At that point, your PCC system would not be able to remove the decay heat?

MR. MARQUINO: Yes. Now before we scare anybody, remember that these are like manhole covers that are held closed by gravity. So they tend to be seated. In order to open them, you have to have a differential pressure.

So the chance of the vacuum breaker staying open is very, very unlikely. I think what we are talking about is, even though it has some ability to ingest grit and not leak, we are providing the capability that, if it is leaking, we are able to isolate it.

MEMBER BANERJEE: How many vacuum breakers are there?

MR. MARQUINO: Three.

CHAIRMAN CORRADINI: Other questions?

MR. CHEUNG: Okay, let's move on. The next slide.

MEMBER BLEY: Just a quick question. I'm sorry. How many need to work?

MR. CHEUNG: One.

MEMBER BLEY: Just one.

MR. CHEUNG: On the righthand side of the curve showing the leakage area and a margin, and in the bottom is zero, and one square centimeter is in the bottom of the curve. From zero to one, that's been identified as operation or plant operation margin.

MR. WALLIS: I think you said that one of them fully open was 14 centimeters square?

MR. CHEUNG: No. That's what needed to fail the --

MR. WALLIS: Well, how much is one of them fully open?

MR. CHEUNG: Two square feet.

MR. WALLIS: Two square feet?

MR. CHEUNG: When it is fully open.

MR. WALLIS: What is that in square centimeters?

MR. CHEUNG: About .3.

MR. WALLIS: 2,000 square.

MR. CHEUNG: About .3 square meter.

MR. WALLIS: So you don't want it fully open?

MR. CHEUNG: It is not happening by design.

MR. WALLIS: Well, sometimes these things, if they are going to stick, stick in the fully open position. They can bang up there, and they stick.

CHAIRMAN CORRADINI: But their argument there is then any sort of proximity or temperature is going to isolate. I think that is their argument.

MEMBER BANERJEE; Is what?

CHAIRMAN CORRADINI: Anything that severe will be caught and isolated downstream. Isolation valve would close. You would have to have three sticking like that.

MR. CHEUNG: Let's go on to describe that one centimeter -- We chose it as a test of acceptable limit. Then the plant operator can have a margin between zero and one, and the current technology we can test it with 95 -- 95 percent confidence that certify the acceptable limit of one square centimeter.

MR. WALLIS: So that's good enough? I mean, if it only works 95 percent of the time?

MR. CHEUNG: Even over that, that we still below -- somewhere around one, but 95 percent of the time is less than .1 square centimeter.

MR. WALLIS: Is that good enough? Why 95? I mean, if it doesn't work five percent of the time, is that acceptable?

MR. CHEUNG: It is not -- The test showing that, if it is not acceptable, then the plant operator had to do something to make it acceptable.

MEMBER ABDEL-KHALIK: And what would that be?

MEMBER SHACK: Well, five percent of the time he may exceed the one percent. Some fraction of that he may see the design pressure. Some even smaller fraction of that, he is going to fail the containment. So it's not as though at 95 percent of the time it is going to work and five percent of the time it is going to fail.

MR. WALLIS: So he has to test these things periodically, and he can detect these very small leakage rates?

MR. MARQUINO: This is Wayne Marquino. So there will be periodic interval containment leakage tests that measure the drywell, wetwell leakage and we'll be conducting those tests with instrument accuracy sufficient to provide 95-95 measurement of the one square centimeter acceptance criteria.

So this is a statistical accuracy basis on the test. It is not that five percent of the time the vacuum breaker is going to be open and we don't know about it. It is five percent of the time the leakage might be a little higher than one square centimeter.

MR. WALLIS: So the person who owns this

plant is going to be a little careful, isn't he? He may find that he buys this thing, and after two years he gets a lot of trouble with vacuum breaker tests.

MR. MARQUINO: We have some representatives from Entergy here today, and they are aware of this concern, and they are helping us get through the licensing with a leakage area that they are confident can be met when the plant is ready to load fuel and we have the initial tests, and also continues through the 60 year life of the plant.

MEMBER BANERJEE; How easy is it to repair?

MR. MARQUINO: They are accessible. They are on the drywell floor.

MEMBER MAYNARD: Well, like any other component, if you end up being a maintenance or testing nightmare, you end up redesigning it at some point.

My question would be more along the lines of the frequency of the testing here. If it is only done as part of the overall integrated leak rate testing, that is not a real frequent test.

MR. MARQUINO: Yes. We are going to test -- The individual vacuum breakers will be tested on a higher frequency than the integrated drywell-wetwell test.

CHAIRMAN CORRADINI: You will do that -- I thought you explained that last time we were going to put like a little cover over it and then pressurize and look at them individually. Is that not correct?

MR. MARQUINO: Yes.

CHAIRMAN CORRADINI: So are we at the end?

MEMBER ABDEL-KHALIK: So would some of these tests be done during operation or are they always done during refueling outages?

MR. MARQUINO: During outages.

MEMBER ABDEL-KHALIK: So there is really no consequence to this, if you find out that a valve fails the leak test?

MEMBER MAYNARD: There are consequences. You find something that has been inoperable, there are consequences.

CHAIRMAN CORRADINI: Like the ox-feed one, there is consequences.

MR. WALLIS: So is it tested at the temperatures that you would get in a LOCA or is it tested at the temperatures you get in normal operation? Presumably, you put a cap on it, and you put in steam at several atmospheres.

MR. MARQUINO: It will be tested at the

normal refueling temperatures.

MR. WALLIS: It won't be tested at the LOCA temperatures?

MR. MARQUINO: No, only --

MR. WALLIS: It still might behave differently?

MR. MARQUINO: That's why we do equipment qualifications, so that we can consider the LOCA environment as well.

MR. KRESS: I can't imagine you would use steam. Wouldn't you use a gas to do that leak testing?

CHAIRMAN CORRADINI: Just to ask a question, wouldn't you want to use it with a non-condensable gas? Isn't that more of a difficult test at cold conditions than steam condensing into cold gas?

MR. WALLIS: I don't know how the seal performs at elevated temperature.

CHAIRMAN CORRADINI: I guess I was thinking this was a harder test to pass, similar to the containment leak rate test.

MR. WALLIS: No. We are asking about integrity of the seal. Heat it up to the maximum temperature obtained in a LOCA after three days, it may behave differently from the way it behaves under normal temperature conditions. I would think you want to test it under the most severe conditions expected in the operation during a LOCA.

MEMBER MAYNARD: And typically, you are going to set acceptance criteria that give you quite a bit of margin there. I don't know if there is some initial qualification. Most of these components have to be qualified initially for the environment, the worst case environment.

MR. WALLIS: You don't the seal to melt when it gets hot.

MEMBER MAYNARD: Right. So they are going to have some type of equipment qualification testing and certification for the materials that are being purchased.

MR. WALLIS: But then if you are going to test it heating it up and cooling it down, there's a question of fatigue failure of this whatever it is, rubber type compound that is a seal, soft seal.

MEMBER MAYNARD: I would imagine a test on this would probably either be pressurizing one side and a vacuum on the other and then measuring the decay rate or the leakage that way.

MEMBER BANERJEE: Are you allowed to tell us in an open session what the seal material is? Can you tell us in a closed session?

CHAIRMAN CORRADINI: Afternoon.

MR. WALLIS: See, most soft seals in use after a while get sticky and perish, and they change their chemical surface. So you have to worry a lot about the aging of this seal material, presumably.

MEMBER MAYNARD: And I am sure they are going to fall under the equipment qualification requirements, which does address life and cycles and worst case harsh environments, and I'm sure that is being applied to the design.

CHAIRMAN CORRADINI: So are you at the end, with the proviso that we cut out a center section to try to allow staff to come in with their audit calculation.

MR. CHEUNG: Okay. Now let me summarize it. At the very beginning, I tried to demonstrate that the PCC operation is self-regulated, and such that the accumulating non-condensable gas in the bottom of the tube self-regulated.

We have not had a chance to discuss the vent fan, but I can tell you that, once the vent fan turn on, the vent fan destroy that non-condensable gas column, and then the vent fan going to redistribute the mass, the non-condensable gas mass, from the wetwell back into the drywell, and the drywell pressure increases because of this mass distribution and not because you enhance the heat transfer in the tube due to the vent fan.

We established -- The first time we discussed this with you, we established the licensing basis with 2 square centimeter. This licensing basis is supported by calculation and a lot of calculations so that it is conservative modeling and plant conditions.

We established a test acceptance limit for the bypass leakage at 1 square centimeter, and realistically the leakage flow area is through the diaphragm floor, which is much less than 1 square centimeter, and there is still 50 percent margin to the licensing basis.

On top of it, there is a large margin, safety margin, to the containment ultimate capacity, and even before the containment fails, there is another structural margin on the previous slide we saw.

MEMBER BANERJEE: Can I ask you a question about the vent fan?

MR. CHEUNG: How much time do we have?

CHAIRMAN CORRADINI: Two minutes.

MEMBER BANERJEE: What are the velocities in the tubes of the PCC when there is a vent -- when you operate the vent fan?

MR. CHEUNG: I do not have that number in my mind, but the vent fan -- what it does is, when --

MEMBER BANERJEE: What is the -- The reason I am asking this is, if you have a mixture of steam and non-condensables, you will get some condensation, and I am wondering whether the velocities are high enough to entrain the water and bring it into the vent fans.

MR. CHEUNG: We will find out the velocity.

MEMBER BANERJEE: Or will the water separate or will it be entrained? That's really what I want to know.

MR. CHEUNG: The water -- We will separate it in a lower drum, on the lower header.

MEMBER BANERJEE: But it's a matter of velocity whether it separates or not.

MR. CHEUNG: Yes. And I can tell you the consequence is not important, because it will be going back to the other side of the GDCS pool, still going back to the GDCS pool and with the water and with the gas and everything else.

MEMBER BANERJEE: But not if you have a fan which is pumping a multi-phase mixture --

CHAIRMAN CORRADINI: He is worried about the equipment operability, I think.

MR. CHEUNG: Yes. The equipment going to be quantified or qualified for that operation.

MEMBER BANERJEE: With water going through it?

MR. CHEUNG: Has to be, in case of the water coming in. And during the vent fan operation, actually, the PCC vent is all -- all full of water. There is no flow going to the PCC vent.

MR. WALLIS: Could I have 10 seconds? You have a summary. I have a summary. My summary is most of my technical questions remain, and I've found some new ones.

MS. CUBBAGE: Ready for the staff now?

CHAIRMAN CORRADINI: I'm ready for the staff.

MS. CUBBAGE: All right. In the interest of time, we are going to skip -- The NRO had a few introductory slides. We are going to go straight to the Office of Research. Allen Notafrancesco will be beginning and bringing up some of his colleagues and contractors.

CHAIRMAN CORRADINI: To remind the Committee, we had a CD with the audit calculations, and also, I think, the boron dilution calculations were on it, on the CD that was sent to us.

MR. WALLIS: I'm not sure I had the CD, but I may have lost something along the way, but I'm not sure I saw this.

MS. BANERJEE: I don't remember a CD.

MEMBER SHACK: There's so many of them.

MR. WALLIS: Yes, I saw the Melcor. That's what you mean. I thought you were referring to something else.

CHAIRMAN CORRADINI: No, no, no. I meant the CD that has --

MR. WALLIS: That's clear enough.

MR. NOTAFRANCESCO: Okay, I'll start. I am Al Notafrancesco, Office of Research.

The RES research had a mandate to provide NRO with audit calculations: Technical monitor. We sponsored this effort with Sandia National Laboratory. Jack Tills is a subcontractor to Sandia, and he will get up next.

We also did some scoping calculations in the past six months, and Hossein Esmaili will discuss that in a few minutes.

The code we selected for this application was the MELCOR Code for several reasons. It is robust in running long term. It uses state of the art computational approach.

MR. WALLIS: I think it has one node for the containment volume. The drywell has one node.

MR. NOTAFRANCESCO: It has more than one node, but we will get to it. I'm giving you the overview.

MR. WALLIS: I thought it had one node for the drywell.

MR. NOTAFRANCESCO: Most of the drywell is one node except the GDCS pools. We'll get to that.

MR. WALLIS; Yes. Yes, thank you.

MR. NOTAFRANCESCO: The key issue I wanted to make here was that usually MELCOR is associated with severe accidents. In selecting it for design basis application, we went back and did target assessments to make sure that MELCOR is ready to look at design basis accidents.

The next slide: And as part of the technical review of the audit calculation, we did provide RAIs and we did try to understand the TRACG modeling to a certain extent.

Next slide.

MEMBER BANERJEE: Does TRACG use only one node in the drywell?

MR. NOTAFRANCESCO: No. Jack will have a --

MEMBER BANERJEE; It was a comparison of the nodalization?

MR. NOTAFRANCESCO: We have back-up slides. It's in the DCD of the TRAC, and we will show you the node from MELCOR.

Basically, we are focusing on the limiting containment pressure break, which is the main steam line break with a failure of 1 DPV. Jack will describe what he did in the first three days, and that's the report the Committee was sent about a year ago, and then any scoping calculations. But again, Jack was based on the DCD Rev. 3-Rev. 4 TRACG results. The beyond three days has not been documented, but these are scoping calculations, and Hussein will get into that.

So Jack will describe our MELCOR analysis.

MEMBER BANERJEE: Let me ask a question which is sort of general. Does TRACE have the same capability as TRACG to do these things?

MR. NOTAFRANCESCO: TRACE right now is

limited to look at reactive vessel water level. So the interest is more short term. Whether it could run out to three days to seven days is questionable at this time.

MEMBER BANERJEE: For what reason? What is the reason it can't?

MR. NOTAFRANCESCO: I can't speak for that, specifically for the code. All I know, it's not coming through in that area.

MEMBER BANERJEE: The reason I ask this question is that, if GE can have an integrated code which can handle the inside and the outside, and TRACE is supposed to be a distant spirit -- it will do the same thing -- why do we choose this sort of diversity of codes to try and do confirmatory calculations?

MR. NOTAFRANCESCO: Well, first of all, it's a good idea to have diversity and independence from TRACE and TRACG here.

MEMBER BANERJEE: But TRACE is not TRACG. It's a separate code.

MR. NOTAFRANCESCO: Well, I understand. Originally, three, four years ago, our strategy was to use TRACE-CONTAIN and then develop TRACE enough to have the CONTAIN modeling wither away and TRACE to be the unified code.

For whatever reason, that did not happen. So in the meantime, we were involved with MELCOR analysis within the guise of the severe accident assessments. Then we got to a point where we say, well, we need to get long term calculations with results, and that's what I am trying to do.

MEMBER BANERJEE: So does MELCOR have the multi-field capabilities that TRACE and TRACG have?

MR. NOTAFRANCESCO: No. And this is one -- But this is relevant to the short term, and it turns out it won't make much of a difference in these blowdown cases -- that is, not compromise our calculations at all.

MEMBER BANERJEE: So you handle formation of liquid films and things like this in some explicit way in the code?

MR. NOTAFRANCESCO: The liquid films are going to be related to the condensation on the heat transfer, for example.

MEMBER BANERJEE: So you feed it in as sort of a boundary calculation here?

MR. NOTAFRANCESCO: Well, no. We model the RPV as a simple configuration, probably much more than TRACE or TRAC. It is basically a blowdown feed, feeding the containment. Our main interest is feed containment pressure, not water level.

So if we are sloppy with the water level, as long as we are getting the integrated amount in the short term, we're fine, and we will show you.

MEMBER BANERJEE: This is a very complex situation where you are getting non-condensables going here and there, splitting and accumulating in various things. Do you feel that MELCOR can handle this type of stuff?

MR. NOTAFRANCESCO: No, and that's why we are doing what we are doing and lumping the volumes, because we are not pretending we are going to model the mixing of non-condensables. So we have taken a conservative approach about --

MEMBER BANERJEE: Perhaps you would explain what the objectives of this are. What are you trying to actually predict, and what is the bottom line in terms of --

MR. NOTAFRANCESCO: Well, our main goal here is to look at 6.2 in the DCD on peak containment pressure analysis, and we are doing counterpart calculations to the sequence to those TRACG calculations.

MEMBER BANERJEE: So you are trying to see whether the peak pressures that your code predicts are in the same ballpark as TRACG. But these peak pressures depend very much on where the non-condensables go. So if you are not confident that you can calculate where the non-condensables go, how can you be confident in the peak pressures that you predict?

MR. NOTAFRANCESCO: Well, when we are not confident where the non-condensables are in the drywell, we make sure they are expedited to the wetwell.

MR. WALLIS: So you make the same assumptions that GE does, which is why you get about the same answer.

MS. CUBBAGE: I would like to propose that Jack proceed with the presentation, because he explains what he -- how he treats the different parameters and why.

MEMBER BANERJEE: Start with the objectives, please, so we know where we are going.

MR. TILLS: My name is Jack Tills. Sandia has me on contract to provide containment support for the Office of Research.

We started doing the type of analysis that is characterized by this plant in the mid-Nineties with the small SBWR, and we began with the CONTAIN code which is a lump parameter code, and then as SBWR went away and then ESBWR came on board, we moved over to MELCOR because we realized we needed more coupling between the RPV and what was going on in the containment.

So we stayed with a code that was lump parameter and a containment code that had the pedigree of a containment code.

Now issues of non-condensable gases certainly wouldn't be solved by TRAC or TRACE in terms of validation. So what we looked at in terms of the MELCOR code was to try and provide --

MEMBER BANERJEE: Excuse me. I was just told that TRACG modeled PANDA.

MR. TILLS: That's right, and we've modeled PANDA also and got just the same results as they did. PANDA is a one-dimensional type of a facility. We purged gases out of trapped areas, just as PANDA did.

The areas that we are interested is what controls this facility, and what controls this facility is what you have already heard, which is the wetwell. The migration of non-condensables into the wetwell is an issue, but we know what is the bounding issue, is if you get all of it going into the wetwell, you get the highest pressure.

Now that's been confirmed clearly for blowdowns, and that's been our licensing procedure for blowdowns for many years, to force a vendor to use a single cell for the drywell, to force the maximum pressure during blowdown.

There is a little bit of a difference here now with this PCCS, because if you trap too much gas in the wetwell and it bleeds out later and degrades the PCC performance, you could get a long term increase in pressure as a result of not accounting for trapping.

Now that would hold if the PCCS was designed with very low capacity and you were right at the limit. But this plant is designed with a PCCS system that is over-designed, significantly over-designed, after a few out.

Therefore, you can do a hand calculation and calculate how much retained trapping you would need to degrade the PCCS before you just begin to pass steam into the suppression pool. It's a simple hand calculation.

When you do that, you find that you have to pass gas -- you know, this may be a couple of thousand to three thousand kilograms of gas which is the amount of gas that is just in the annulus in the wetwell area -- or in the annulus and in the lower drywell. You have to pass that within an hour or less in order to degrade the condenser before you pass steam.

That is why you don't see any major blips in pressures when, even in the TRAC case, they bleed out this gas. The reason you don't see it is because the condensers are keeping up, and the gas is just bleeding out into the wetwell.

So because of that, it became clear to us that using a single cell for the drywell was really a bounding calculation for this plant.

Now in the case of the TRAC calculation, TRAC code is not qualified for blowdown containment analysis, and when you look at the early -- this goes to the question of what you are looking at in this containment deal -- you look at short term, blowdown peak for a BWR, and you look at long term.

Now in the TRAC calculation, they have many, many nodes, and you've seen that in the DCD. Early on, they trap about 2,000 to 3,000 kilograms. That is all of the nitrogen in the lower DL. That depresses the short term peak down to about 250. It should be, in terms of licensing, about 330 to 350.

So that is the issue for short term. However, that is well below the margin for the design pressure.

If you look at, going back now to delay time, now you look at the PCCS performance. Our interest in doing the MELCOR calculation was to, first of all, understand the facility, and we did that by looking and qualifying MELCOR in a variety of tests similar to what GE has done.

MR. WALLIS: I have a question for you about non-condensables. In your report, you said that radiolytic gas keeps the passive cooling condensers bound up.

MR. TILLS: That's right.

MR. WALLIS: Such that the pressure drop from drywell to wetwell is maintained relatively constant. The nitrogen is swept out very quickly in the first hour. The ones that are obtained through radiolytic formation do have a significant effect on the PCC.

MR. TILLS: That's correct. But the rest of the time in the calculation with the single cell is almost nil. If you look at what the resident time and how much gas is retained in the drywell, it is very, very small. Most of it is passed on through the PCCS. That's why they accumulate.

In the early calculations when GE was doing calculations -- and this is kind of debatable -- I don't think they had radiolytic gases in there, and certainly in SBWR they weren't accounted for, and so really you had a design that was pressure controlled.

Somewhere along the line, probably a year or two ago, radiolytic gases came into vogue, and they were put in. As a result, you have a continuous accumulation, as time goes on, of these gases, and they are bled out. That causes that pressure differential that causes additional leakage.

In early calculations, the pressures came up in the long term, was pretty much flag. That is what I consider as a pressure controlled system. Now, you know, the nomenclature to call it pressure control is getting less and less, because you are getting this large increase, and the increase is primarily dominated by the presence of radiolytic gases.

If you don't have them, the vacuum breakers are continually functioning and opening throughout this 72 hour period, because there is not enough gases to accumulate for long periods of time, and so the PCCS, because it's got excess --

MR. WALLIS: I don't understand that. There's got to be some non-condensables.

MR. TILLS: There is some. There is some.

MR. WALLIS: There has to be some fencing. It has to overcome the hydrostatic pressure.

MR. TILLS: That's right.

MR. WALLIS: Which is a constant amount.

MR. TILLS: That's right.

MR. WALLIS: Not this difference that makes the drywell pressure higher than the wetwell by the amount of that hydrostatic and the submergence of the vent.

MR. TILLS: That's right, and --

MR. WALLIS: That keeps the vacuum breakers shut as well.

MR. TILLS: And if the gases, you know, either through numerical instability or any instability in boiling causes any little burp in the system, those gases go out, because there is not very much of those accumulated, and the vacuum breaker is then open, and you go through a cycle of ratcheting between vacuum breakers going on and off. That was the old way that was --

MR. WALLIS: But if they are opening and closing a lot of times, then the chance of them sticking, seems to me --

MR. TILLS: Right. Right.

MR. WALLIS: Do you see that scenario where they open and close a lot all the time?

MR. TILLS: Well, in the tests -- The tests were not run -- A few tests of the P series were run long enough that you could see some opening and closing, but they weren't on the frequency level that we see in plant calculations.

What I am just bringing up to you, though, is that there was a significant difference when radiolytic gases were added to the problem, and that problem made the situation worse, and that is where you get --

MR. WALLIS: I'd like to press advantage on this question, which intrigued me, that some intermittent operation of the PCCS where you vent some gases, then you build them up and you vent them, and each time you do that you pump the vacuum breaker. Then you've got an oscillating behavior which I don't think is presented at all in the DCD. It might have some significance.

MR. TILLS: If you look at earlier DCDs, Rev. 0, Rev. 1 --

MR. WALLIS: You have to look at them all?

MR. TILLS: No. Well, I'm just saying, if you look at those early ones, you will see a different signature, and you will see the vacuum breakers operating and both the drywell and the wetwell having very small pressure differences.

MR. WALLIS: So which is correct? Which is right?

MR. TILLS: Well, I think, if you buy into the fact that you are going to have radiolytic gases at the rate that is being projected by GE, then clearly you are going to have the accumulation, and the other thing is that we have seen that with PANDA.

In the PANDA tests, we clearly saw, if you had a small amount of gas in the drywell --

MR. WALLIS: Well, I'm sorry, but there are these passive recombiners, whatever they are called, PARs. So if you put them in, they make a difference to the whole scenario, do they?

MR. TILLS: Well, they certainly would, if they worked. They would certainly change the way you would do an analysis, if you had them in there.

Our analysis is done without PARs, and you know, that is the bounding situation. Whether or not they qualify PARs for a very low steam environment--

MR. WALLIS: They said they had no credit for PARs, but they are there, aren't they? So I'm not sure whether they are -- I am trying to say, really, what happens realistically? Are they realistically recombining, or not?

MR. TILLS: Graham, realistically, if you looked at conservatisms which you have identified as probably excessive, you would see something very much like a MARK-3 where the peak occurs very early, and you probably didn't get a long term increase in pressure, you know, above, say, the peak pressure. That's my gut feeling of what it probably look like in a best estimate reality case.

CHAIRMAN CORRADINI: So the pressure would be coming down, Jack?

MR. TILLS: Not down, but probably leveled off.

CHAIRMAN CORRADINI: At some steady --

MR. TILLS: Right, if you did not put in the conservatisms, if you had -- especially if you had PARs activated, you put in all the heat transfer coefficients.

Let me mention another thing about the TRAC where it is ultra-conservative. The heat transfer coefficients that they use in TRAC is en empirical correlation. For some of you that are familiar with Uchida, it is a fit to -- and I know you are -- a fit to the mass fraction.

Those type of correlations are notoriously known to not be able to scale with air density. That means that, if you have large variations in air density, you can get variations in --

MR. WALLIS: Or hydrogen rather than nitrogen?

MR. TILLS: No, just nitrogen. So suppose now we move -- we doubled the air density in the wetwell -- Okay? -- as a result of moving all the drywell over there. That means that these coefficients will underpredict heat transfer coefficients by a factor of two. So --

MEMBER BANERJEE: But I guess that depends on the state of turbulence of the non-condensable, doesn't it?

CHAIRMAN CORRADINI: No. It's diffusion control at the --

MEMBER BANERJEE: All is purely diffusion?

CHAIRMAN CORRADINI: Yes. Pretty much, at the surface, but I think Jack's point is that the Uchida correlation has no pressure correction or density correction.

MR. TILLS: Density correction.

MR. WALLIS: Well, it's diffusion

controlled at the surface, but how thin the boundary layer is, is determined by the turbulence outside it. You can't just do a correction by itself.

MR. TILLS: But in the case of this calculation of all this, usually in containment space, we don't take -- We apply a turbulence but not a force turbulence for condensation, which is bounding.

MEMBER BANERJEE: But there is a scale effect here, isn't there? I mean, is it a -- So you have a liquid seal. Let me try to understand this. Then you have a film of non-condensables through which something has diffused in order to condense.

The thickness of this non-condensable film will depend on what the conditions are in the flow.

CHAIRMAN CORRADINI: But the assumption that Jack -- What Jack said is important. That is, all typical containment calculations do not take into account any force convection and diminishment of the boundary layers, essentially a natural convection estimate.

MR. WALLIS: It can't be, because if you have --

CHAIRMAN CORRADINI: I don't disagree with you. I'm just telling you that's how it --

MR. WALLIS: You don't get a boundary

layer. You just build up and build up, unless there's some way to take them away.

MR. TILLS: No. You use correlation -- You use an analogy correlation to give you that limit and that control over the boundary layer. And so the more modern state of the art type of codes that are using non-condensable, you know, degradation are pretty much all using a heat mass transfer analogy concept that is a film theory developed concept.

MR. WALLIS: But in some cases there is no film unless there is a turbulence to pull it off. The film will build up forever.

MEMBER BANERJEE: I guess what you assume is the natural convection flow is giving rise to turbulence.

MR. TILLS: That's right.

CHAIRMAN CORRADINI: We are going to move on.

MR. TILLS: Go to the next slide. This is just put up for your edification. It just kind of indicates some of the target areas we looked at, and there's about seven different references here that just focus in on ESBWR type phenomena.

the next slide just shows you what you have in front of you, which is that --

MEMBER BANERJEE: You told me that PANDA was one-dimensional. Every time I see PANDA, it looks fairly three-dimensional to me. Is it one-dimensional, because that solid is noted to be one-dimensional or is it --

MR. TILLS: I mean one-dimensional in terms of what is actually occurring. In other words, a one-dimensional or a zero-dimensional code calculates very well to PANDA. Multi-codes --

MEMBER BANERJEE: Then it would also be a function of the number of adjustable coefficients you have. Right?

MR. TILLS: Well, I mean, I look at experimental data first, and the experimental data is indicating the factor, not the code. It's well mixed.

MEMBER BANERJEE: It is well mixed across.

MR. TILLS: It's well mixed. It's very well mixed, and it the important thing is that it is well mixed at the initial condition, which starts one hour after the accident.

In other words, the injection is decay heat driven steam, not blowdown. So if it is well mixed in that case, you pretty well -- here it is going to pretty well mixed during the blowdown.

MEMBER BANERJEE: In a real drywell which has a larger length scale, do you expect that to be well mixed as well?

MR. TILLS: I would expect it to be, during the blowdown.

MEMBER BANERJEE: During the blowdown, but post-blowdown?

MR. TILLS: Well, again if it was not mixed -- I mean, this is where you get to the point of transferring between best estimate, being asked to do that, and doing an audit calculation or bounding deal.

You have to make a decision of what's the capability of the code, and then also, you know, where you find bounding situations. In this case, if you retain, as I mentioned, any gas into the wetwell that could later bleed out and degrade the PCCS, you determine what that possibility would be.

Now 2000 to 3000 is really the max, all of the annulus and all the lower drywell.

MEMBER BANERJEE: Well, if you well mix the drywell, you will always retain some non-condensables in the drywell, won't you?

MR. TILLS: Very, very small. I mean very small, because the amount of steam that is coming in with decay heat is fairly significant.

MEMBER BANERJEE: But by definition, when you well mix something, it's the third tank reaction.

MR. WALLIS: Well, it's e to -5T, and T is hours.

MR. TILLS: It is small. I mean, we have looked at how much is retained with a single cell, and it is very, very small. It's negligible.

MR. WALLIS: Can I ask you about the nodalization here? In the wetwell, you have 530, 531, and 515. Presumably, you are thinking that what is up at the top is different from what is down below, and yet your vacuum breaker seems to be connected to the 515. I thought the vacuum breaker was on top.

MR. TILLS: We did both. In this case, we are pulling in more nitrogen. More nitrogen is going back into a --

MR. WALLIS: But isn't the vacuum breaker connected to 530 or something like that?

MR. TILLS: It is 530.

MR. WALLIS: It should be. So this is not drawn right?

MR. TILLS: Well, no, the leakage is connected to 530, but the actual -- We are pulling -- In this calculation we are pulling it from --

MR. WALLIS: Oh, you sort of assume it somehow inverts itself when the vacuum breaker operates?

MR. TILLS: Well, it's not really that so much as it is just, when we added the cells to do the stratification, we added them above the cell that we normally had working with the vacuum breakers, and we did it both ways, and it didn't have any significant difference in the calculation.

I think, if you look -- You know, we can look at the scenario. The vacuum breakers, you know, because in this situation are not cycling, we only have one window where they operate, and that is a window of maybe a half-hour to an hour, a little longer than an hour.

CHAIRMAN CORRADINI: Early in the accident.

MR. TILLS: Early in the accident, and then after that they shut. They don't open again because of this bounding up of the PCC. So what I'm trying to do is -- You know, I know it may sound like I am jumping ahead to what I think is the answer, but we have done sensitivities to verify what we are focusing in on.

What we want to focus in on is what is controlling the facility independent -- as much independency of GE as we can, and then come up and see whether or not we get the same phenomena that is driving it.

What we have determined is that the phenomena -- and this report was written a year ago -- is that it is dependent upon bounding up of this PCC and the leakage, the drywell leakage. Those are the dominating things. The controlling parameters to that is the rate at which radiolytic gases come in and also any parameter that affects that leakage rate, and you have already identified --

MEMBER BANERJEE: What do you mean by drywell leakage? Leakage through the vacuum breaker?

MR. TILLS: Drywell to wetwell leakage through the vacuum -- right. That's this one centimeter squared issue that you have been focusing on.

MR. WALLIS: Can I ask you something about your report? In your report -- I'm quoting from your report -- says, "The most important structure affecting containment response is the outer wetwell wall above the full surface."

MR. TILLS: That's correct.

MR. WALLIS: Seems to indicate to me that heat transfer to that wall as it is going through some transient is important in your calculation of the temperature of the gas space.

MR. TILLS: That's right. If you took out that wall -- I'm saying right now with the wall in there, with -- you know, as I mentioned, with a calculation that has a heat transfer coefficient, that's probably our best estimate of what that would be. We sitting at 370.

If you take the wall out -- okay, just take that wall out -- the pressure goes up to about 430-440.

MR. WALLIS: Well, that really bothers me, and you also say the wetwell outer wall heats up in 5,000 to 35,000 seconds. So in one hour it heats up. Well, heat to the surface in a swirl like that lasted for days, if you look at the transient heat transfer. So how does it heat up in an hour? There is something strange about that.

MR. TILLS: It's not an hour.

MEMBER BANERJEE: It's 10 hours.

MR. WALLIS: Well, it says 5000 to 36,000 seconds.

MR. TILLS: Well, that's where the major heat-up is occurring.

MR. WALLIS: How thick is it?

MR. TILLS: Okay. It is probably, I

think, about maybe a meter and a half, two meters.

MR. WALLIS: Meter and a half, and the transient is over in that short a time?

MR. TILLS: Well, that's where, you know, the amount -- If you look at the pressure increase that's going on here, this pressure is increasing, what, maybe a half an atmosphere over three days. That's very small. That's a small rate of change when you are looking at heat transfer.

I mean, this is the problem, is it's a small amount of heat transfer that is occurring in this wetwell. Hitachi did a number of experiments, and you may be familiar with it, where they put a water wall on a suppression pool, and that was to take the energy out of a suppression pool for something maybe similar like this.

In this case, this wall is very, very thick, and on the outside boundary is basically almost adiabatic. You know, it's got a small --

MR. WALLIS: It starts cold, and you got to take it off on one side.

MR. TILLS: It starts cold, but after a long period of time the boundary condition on the outside does have an effect on this leak time.

MR. WALLIS: After a very long time.

MR. WALLIS: Yes, in a long time. So --

MR. TILLS: I'm sorry. You said this makes a difference between 270 and 400-something degrees?

MR. TILLS: If you take the wall out, if you just take the wall out.

MR. WALLIS: Well, then --

MR. TILLS: That just gives you the upper bounds of what it would be.

MR. WALLIS: That's a big heat sink.

MR. TILLS: It is a big heat sink.

MEMBER BANERJEE: How do you model it, as a lump parameter with Newton's law or do you actually-
-

MR. TILLS: No, it's a solvent.

MEMBER BANERJEE: Radial solvent.

MR. TILLS: Yes.

MEMBER BANERJEE: So you've actually got that?

MR. TILLS: Right.

MR. WALLIS: And it's not condensation? It's just natural convection.

MR. TILLS: No, it's condensation on the inside, you know, and natural convection on the outside.

MR. WALLIS: So how about -- The ceiling is bigger than the outside wall, isn't it?

MR. TILLS: The ceiling -- What they did with the ceiling was they lumped the area of the ceiling into the outside wall. That's the way I understand it. In other words, they did not just eliminate the area. They just moved it over and increased the area of the outside wall. I don't know if Chester is here.

That's my understanding of how they compensated for --

MR. WALLIS: I thought they said they ignored the ceiling.

MR. TILLS: They ignored it from the standpoint of bounding conditions.

MEMBER BANERJEE: But they --

MR. CHEUNG: This is Chester Cheung.

MEMBER BANERJEE: -- heat equivalent to the ceiling?

CHAIRMAN CORRADINI: Well, let him answer.

MR. CHEUNG: Let me comment on that. We ignored the horizontal heat slab by the horizontal top of wall underneath the GDCS pool, but there is still a horizontal surface from the -- or the GDCS pool all the way to the wetwell. So that top of --

MR. WALLIS: Why would you ignore the ceiling which is there under the GDCS pool?

MR. CHEUNG: We want to make sure that -- We wanted to have conservatives, that whatever that go into the top of the ceiling on the wetwell --

MR. WALLIS: But you aren't being very conservative, because you are taking credit for something which seems to reduce the temperature from 430 to 270. So --

CHAIRMAN CORRADINI: Not 270 -- 370. He said 370, right?

MR. WALLIS: 370 -- that sounds better to me. So it does have an effect, though.

MR. CHEUNG: We modeled the outer wall of the wetwell and outer wall of the suppression pool.

MR. WALLIS: And you put non-condensables in this steam that was condensing?

MR. CHEUNG: Well, what do you mean by non-condensables?

MR. WALLIS: Well, affect the heat transfer. Governed by the transients in the concrete.

MR. CHEUNG: Actually, after a very short time, the wetwell is full of non-condensable, and whatever that condensation is going to degrade greatly.

MR. WALLIS: Then on the inner wall -- the inner wall seems to be hot here, but it's cold to start with, isn't it?

MR. CHEUNG: The inner wall is hot on the drywell side. It is slightly colder on the wetwell side.

MR. WALLIS: It's almost two major sinks. So it takes some days to come to equilibrium?

MR. CHEUNG: It takes days to come to equilibrium.

MR. WALLIS: So it's cold. It's really a cold wall.

MR. CHEUNG: Yes.

MR. WALLIS: So all these walls have a big effect on the temperature, don't they?

MR. CHEUNG: We did parametric case increasing the wall surface area 10 percent plus/minus here.

MR. WALLIS: It makes a bi g-- Well, maybe it doesn't. Okay, go ahead.

MEMBER BANERJEE: So the controlling heat transfer resistance in your case is on the solid side.

MR. TILLS: Right.

MEMBER BANERJEE: Or is it on the gas side?

MR. TILLS: It's on the gas. Sorry, it's on the solid side on the inside of the wall. Then at later period of time, the boundary condition -- When you say controlling, I wouldn't say that -- It's significantly affecting.

What I did for sensitivities on it is I looked at -- said, you know, if this wetwell is such a significant part, you know, apart from doing fans, what would be the natural thing that a designer would look at? He would look at, you know, taking heat off of that wall.

So I flooded it. I also increased the heat transfer coefficient to kind of mirror a thin wall, by taking the concrete out and looking at that.

MR. BANERJEE: I'm just trying to figure out how you did the calculation, not what parameters you varied right now.

MR. TILLS: Okay.

MEMBER BANERJEE: So you have gas on one side, and you have a solid. Now the solid you are resolving. You are not treating it as a lumped parameter. So -- a conduction equation.

MR. TILLS: Finite difference transient.

MEMBER BANERJEE: With a realistic geometry.

MR. TILLS: Yes.

MEMBER BANERJEE: Okay. And you've got a sufficient resolution to get the temperature gradient properly on the solid side.

MR. TILLS: Yes.

MEMBER BANERJEE: What are you doing on the gas side?

MR. TILLS: On the gas side is a natural turbulent convective --

MEMBER BANERJEE: This is a closed system. Right?

MR. TILLS: Well, the gas side. I'm assuming you are talking about the outside, the environment.

MEMBER BANERJEE: No, no. I'm talking about -- Sorry, I'm talking within the wetwell.

MR. TILLS: Within it, we use the standard containment type analysis of the heat mass transfer analogy.

MEMBER BANERJEE: But this is a volume of gas. Right?

MR. TILLS: Yes.

MEMBER BANERJEE: The ceiling there?

MR. TILLS: Yes.

MEMBER BANERJEE: And the liquid.

MR. TILLS: Right.

MEMBER BANERJEE: So how are you treating this gas? What is the standard way to treat that? You treat it as stagnant gas? Do you treat it as a conductive layer? Do you calculate the natural convection?

MR. TILLS: The natural convection driven.

MEMBER BANERJEE: How do you calculate the natural convection?

MR. TILLS: Using a natural convection correlation.

MEMBER BANERJEE: What correlation?

MR. TILLS: Well, in this case what we used is a --

MEMBER BANERJEE: I don't understand, because this is a finite length, and you are going to get a boundary.

CHAIRMAN CORRADINI: But in a transition of Gratschalk numbers from about 10 to the 5th to 10 to the 12th, you can have essentially the old McAdams correlation, which is essentially independent of physical length, and length divides out, both sides.

MR. WALLIS: Does this work for condensation on the ceiling?

MEMBER BANERJEE: But is this -- There is no condensation on this wall. Right?

MR. TILLS: Yes, there is condensation.

MR. WALLIS: There is?

MEMBER BANERJEE: On the side walls?

MR. TILLS: Yes.

CHAIRMAN CORRADINI: So I am going to take a time check. You are very kind to have a conversation with these gentlemen, but we are proceeding through this presentation, are we not?

MR. TILLS: That's right.

CHAIRMAN CORRADINI: Okay. So I'm going to ask this, because I had summoned some of the members to what was going to be a lunch meeting. So is it better that you are able to finish in 20 minutes or should we take a break at 12:15 and come back and have you resume?

MR. TILLS: Well, it just depends on the questions. I can go through it in 20 minutes.

CHAIRMAN CORRADINI: Well, but the questions can go infinite, can go on for infinity.

MR. TILLS: Right. If you are asking me can I go through this in 20 minutes, yes, I can.

CHAIRMAN CORRADINI: Okay. So I'm going to look at the committee, because I'm going to lose three or four of you. Would you prefer to take a break at 12:15 and come back and hear this? Okay. So can we get to some logical break point in the next few minutes, Jack, and then we'll bring you back?

MR. TILLS: Sure.

MEMBER BANERJEE: Not getting off the hook.

MR. TILLS: Let me just kind of summarize kind of the points on --

MR. WALLIS: Well, could you --

CHAIRMAN CORRADINI: At least get somewhere before -- All right? Go ahead, Jack.

MR. TILLS: Well, the RPV model was an important part in order to do the coupling and, you know, do a complete scenario. We did feedwater breaks. We did main steam line breaks.

So on the left side of that model is the RPV. This RPV looks similar to what you would typically see with MELCOR except it does not have any of the core functions that would be used for severe accidents. In other words, the rods are put in as heat surfaces, and thing is driven -- This is pot driven, but it was important to know how much quenching, what the time of the quenching would go, and also get an approximate idea of what the level would be, because that shuts off the time at which the

GDCS quits draining.

So that's on the left side. The wetwell side: The nodalization there was formulated based on looking at what also was a similar feeling from us of what things would increase the wetwell pressure, and one of them was to stagnate the lower portion of the pool, the suppression pool, after the blowdown, after the turbulent region, so that you had a heated layer above that.

So we used a very similar thing as what TRAC had done there. So our nodalization was similar in that case. We had the same walls. I mentioned about the --

MEMBER BANERJEE: Are those dotted lines your nodalization?

MR. TILLS: The dotted lines are the nodalization.

MR. WALLIS: Did you have condensation on the pool?

MR. TILLS: Yes.

MR. WALLIS: You do?

MR. TILLS: Yes, we do.

MR. WALLIS: So how do you calculate the force convection over the pool?

MR. TILLS: It's not force convection.

MR. WALLIS: Well, it must be.

MR. TILLS: Well, it's not in this model.

MR. WALLIS: You can't get the film thickness for condensation unless you have some sort of force convection model. Otherwise, it just builds up forever.

MR. TILLS: Well, no, it doesn't build up forever if you use a correlation. The correlations will not let the film go up --

MR. WALLIS: It does, because the non-condensables are dragged down to the surface, unless there is something to take them away.

MR. TILLS: What happens is the lower cells do get high concentrations of non-condensables. That's clear, and that tends to shut it off.

You know, I'm not going to defend horizontal heat transfer off of a pool at this point. I'm just not going to go there, and I think that is the standpoint of what GE is doing with even the ceiling.

The reason that they have gone with that thing is that, you know, TRAC cannot defend the horizontal.

MR. WALLIS: Well, you've got some arrows there showing circulation in there.

MR. TILLS: Well, it's not --

MR. WALLIS: Which is really happening, and how big is -- How intense is that circulation?

MR. TILLS: I don't know.

MR. WALLIS: It makes a big difference.

MR. TILLS: Again, the issue is if you wanted to do best estimate, you could argue me down on that. If you want to go to bounding, I think we have a rational reason for why this is --

MR. WALLIS: It's not best estimate, but you made some assumption about the circulation. You didn't assume it's stagnant.

MR. TILLS: No, it is stagnant. I mean stagnant from the extent that there is no implied or force transfer coefficient.

MR. WALLIS: Well, if it's completely stagnant, then you cannot have anything that is scrubbing the film off the wall. The film would just build up forever. You've got to have convection on the wall to get a film.

MR. TILLS: Right.

MR. WALLIS: Got to get a coefficient.

MR. TILLS: And that's what you call in when you use the analogy concept.

MR. WALLIS: But you can't do that. I

mean, what happens in a room with heated walls and cooled walls? Everything is interconnected. The currents go around the room. They determine the boundary layer, thickness on the wall, and everything is interrelated.

Once you start making assumptions, you are changing all the reality in some way, which I don't understand.

MR. TILLS: Well, you know, I think I would support what you are saying, except that that -- you know, we've done a number of -- a number of containment experiments where we have the same type of geometry as this, and very much the same type of deal. And we get very good results with what we do, and to calculate pressures and temperatures.

MR. WALLIS: And you have --

MR. TILLS: Locally -- Locally, I would agree with you that there is local variations that we cannot account for, but when you are looking at something like global pressure, we do a very good job with an analogy type concept.

You know, what you want is something that is not really achievable today.

MR. WALLIS: No, I think, well, I'm in this room, and that wall is cold and that wall is warm, and then there's steam oozing in through the ceiling.

MR. TILLS: That's right.

MR. WALLIS: Doesn't the steam just spread along the ceiling?

MR. TILLS: That's right.

MR. WALLIS: Does it get swept down the wall by the convection, or not?

MR. TILLS: Some of it does.

MR. WALLIS: How much?

MR. TILLS: Well, I mean, I think that would be an issue that you could raise, you know, and probably not decide within the next few years, really.

It's probably a pretty good time to stop.

CHAIRMAN CORRADINI: So now we know at least the base models, and then we are going to come back and see the analysis.

Can we come back at 1:15? Is that acceptable? I think, if you are going to get through this meeting, you have to. Okay, 1:15. Thank you.

(Whereupon, the foregoing matter went off the record at 12:13 p.m.)

CHAIRMAN CORRADINI: Okay, let's get started. We'll come back into session. Jack, we'll let you start with your next slide of your presentation.

MR. TILLS: Yes. I thought to save time here, I'd go onto what the reference calculation looks like in Melcor space, and because you've asked this question before, of having a few of the events listed on the figure so you can kind of follow along and see what's happening in the containment.

This Slide 8 is an expanded procedure, log scale. It kind of gives you a pretty good highlight of both short term and then the long term. Because this plant has a fairly small wetwell space, probably about five times smaller than the Mark III, and that the vents are significantly smaller, the main vents, the issue of short term is not something to just, you know, basically pass over. You do have to take a look at it.

And so this basically takes you through the vent openings, when the reactor isolates and the peak pressure that occurs in the short term at about 75 seconds. Normally, in a Mark III or so, these pressures are lower, and they occur very rapidly in the first few seconds.

You can see that after that first peak occurs, which is basically adiabatic compression in the wetwell, the source is dropping off a bit, and there's a decline in the pressure. Until the ADS activates, the DPV valves open and you get an additional source, hence to level that out. Soon after that --

MR. WALLIS: Well, that seems to be important to me, because in the blowdown, everything gets stirred up. You have a well-mixed drywell.

MR. TILLS: Yes.

MR. WALLIS: And so the non-condensables are swept into the wetwell pretty effectively. But then when the vacuum breakers open --

MR. TILLS: This is DPV.

MR. WALLIS: They stumble and come back out again, don't they?

MR. TILLS: That's correct, that's correct.

MR. WALLIS: And the vacuum breakers also open in that space, don't they?

MR. TILLS: Well, they open just a little bit later than that. After the GDCS begins to drain down, and it takes some time to quench the RPV steaming. What causes the vacuum breakers to open is the termination of basically the source coming in, and the PCCS is still activated and operating.

MR. WALLIS: Assuming that the vacuum

breaker's open and that pressure drop is associated with passive gas from the spectrum.

MR. TILLS: That's correct.

MR. WALLIS: It seems to me that by then, the mixing up in the drywell has slowed down a little. You don't have steam. You don't have blowdown anymore, do you?

MR. TILLS: It's not blowdown at all.

MR. WALLIS: So this stuff coming out of the wetwell won't have much incentive to mix with what's above it?

MR. TILLS: No, and in this case, the main steam line, the level in the GDCS does not draw up as fast as it does say in the Piedwater break case. But there is a dropping.

There's almost a sucking that's occurring at the same time that the vacuum breakers are opening, because there's this drawing down of the GDCS tank level, and gases that are coming in, they're coming in at the diaphragm floor level, which is above the annulus and the lower drywell.

So the real active area is going to be pretty much in that region of the upper drywell.

MR. WALLIS: And then the gases that are coming out of the vent of the vacuum breakers are cold. They're colder than what's in this, and they are rich in non-condensables, which are heavier than steam.

So my -- a realistic outflow is not expected to flow along the floor, go down into the lower drywell. Flow along and fall down into the lower drum.

CHAIRMAN CORRADINI: Just for order, I know you guys are talking. Is it a seepage or is it a blast of air, of gases?

MR. TILLS: What we're saying in terms of the calculation, which pretty much mirrors what they're getting with TRAC calculation, is about a quarter, almost a quarter of the inventory of the initial drywell comes back in.

MR. WALLIS: It doesn't come along with much velocity does it? It squirts out sideways through these valves?

MR. TILLS: Because these are big valves.

MR. WALLIS: But it squirts out sideways, doesn't it? It doesn't squirt sideways along the rim of this vacuum break. So it's squirting out horizontal.

CHAIRMAN CORRADINI: But can I just -- just to make sure. They squirt out horizontally, but there's a valve that they have --

MR. TILLS: Okay. It's actually upstream.

CHAIRMAN CORRADINI: Upstream?

MR. WALLIS: Oh, it's upstream?

CHAIRMAN CORRADINI: Oh, it's upstream.

MR. WALLIS: So they fall on the floor, and then they fall down into the lower drywell presumably.

CHAIRMAN CORRADINI: Right.

MR. WALLIS: But do you assume they mix with everything upstairs, up above them?

MR. TILLS: Well again, the same thing occurs here, is that even though we mix, that's a conservative case, because as soon this begins steaming again, they go out more rapidly than if we would have trapped them. So basically where we used our hand calculation.

MR. WALLIS: Well then if long conundrils (ph) did pull down into the lower drywell, which is not very well connected to the upper drywell, presumably they would stay there a long time.

MEMBER SIEBER: Which would reduce the overall pressure.

MR. WALLIS: Well, it might do that, but that's the realistic expectation --

(Simultaneous discussion.)

MR. TILLS: Well, the realistic, and you can see the pressure down here and then it rebounds. The rebounding is due not to, you know, the K heat not being taken out. The rebound is back --

MR. WALLIS: This advises me. In the traditional calculations, we're moving away from Appendix K and all those assumptions to realistic calculations, trying to get an idea of what really happens with some uncertainties.

You seem to have gone back to sort of a pseudo-idealistic model of what happens, which is not realistic at all in some aspects. That is considered okay. I would think in the modern world, you'd make an effort to do the realistic calculation.

CHAIRMAN CORRADINI: What do they have from a licensing basis or a design basis to do a better calculation? I don't think they have anything.

MR. TILLS: This is, I mean, they're absolutely, positively sure that this is up, this is giving the upper bound on the pressure. But to do anything better, you'd have to have a fairly sophisticated --

CHAIRMAN CORRADINI: I think Jack answered it somewhat differently before, but he admits that he can do it better, but I'm not sure he can focus it better --

(Simultaneous discussion.)

MR. WALLIS: Well, this is the issue. I mean this is okay for regulatory purposes maybe, but if I have a class and I present to them some curves for their consideration, and say "This is what happens in an accident."

In fact, your curves are not what happens in an accident. They calculated it using what seem to be more realistic assumptions. They come up with something different.

It seems to me somehow you are shortchanging the virtues of this design, by compiling all these conservatisms on top of each other, and then presenting curves as if this represents the way it behaves.

MR. TILLS: Now let me address that. You know, I think that's one of the reasons why we pursue the scaling experiments, you know.

In this case, I have to admit that in some sense, the experiments are at the edge of not answering all the questions, because in the case of the Panda, you know, there's no concrete walls. The scale is off.

But even in that case we saw in the Panda, when they started at one hour and they put gas in there, and ejected at the K heat rate, the drywells were purged. You know, I think, you know, from my experience, that people tend to underestimate the degree at which when steam comes in, either at a K heat rate or certainly at a blowdown, how much mixing occurs.

There's tremendous amount of momentum-driven mixing that occurs in the --

MR. WALLIS: During that stage?

MR. TILLS: During that stage where you have a source on. If you turn to source off, you tend to get these trapping areas and stuff. But if you've got a significant source, and even at the K heat level, that's a significant amount of steam coming in.

The tendency of things to be quiescent and lay in the low areas is very low. That's what we saw with Panda. Could the experiments be better? Could we have -- would have liked to seem them go out longer periods of time, more prototypical in terms of heat structures? Certainly.

But you know, that's what we have in terms of --

MR. WALLIS: I think that's very good. I

think I agree with you. It's in the later stages, when there isn't much that's stirring up anything, and you've got all sorts of stratifications of things everywhere, wetwell, drywell and so on where it might be worthwhile.

Maybe some day it will start producing more realistic analyses, and it may well show that the pressures don't go up anything like as much as predicted now.

MR. TILLS: Right. You know, the difficult part of this, of course, is that last part, and it's showing up more on a log scale there, and that's this beginning, you know, somewhere around ten hours or so, and then you start getting this heating of this wetwell space that's driving the drywell pressure up.

You can see that's the difficulty at the end there, you know, that you're faced for design purposes.

CHAIRMAN CORRADINI: But Jack, just to unwrap that last part which is rising here, because of just the way the scale is showing it. If there was not radiolytic decomposition, as you had said it before, and let's leave out the leak scenario, if it's not radiolytic decomposition, I'd expect the red curve to flatten out. It doesn't go down.

MR. TILLS: It doesn't completely flatten out, but the slope really goes down a lot. And when we were first doing these calculations back a year and a half ago, we were focusing on the feed water line break case, and there was another reference.

We did an ESBWR containment performance study, and when we were looking at that, at that time we didn't know about radiolytic gases. We didn't have them in.

We compared again with GE with their TRAC calculations, but the curves were significantly flatter than they are here. That was because we didn't have the continuous bounding up of PCCS and this large pressure differential remaining.

So things changed about a year and a half ago, in terms of the slope of the lag time performance.

CHAIRMAN CORRADINI: So just to say it back, just to make sure I understand, when you say "bounding up," is you're producing -- you're generating additional non-gases or gases which are coming out slow enough that you essentially degrade the performance of the PCCS.

So you go through this kind of behavior, where you've got to generate enough of a delta between drywell and wetwell, force it through and --

MR. TILLS: That's right, and bounding is a different phenomenon than degrading by flow passing through, and just degrading the heat transfer along the tube wall.

The bounding is actually a stagnant layer of gas filling up the bottom, and basically cutting off. Instead of you having two meters of tube length, you've got one meter.

CHAIRMAN CORRADINI: Right.

MR. TILLS: That you're working with.

CHAIRMAN CORRADINI: Okay.

MR. TILLS: So that's the reference calculation. The next slide, Slide 9, it just goes down and gives you a comparison based on events that are occurring, and you know, the first clear one is the vent clearing times, and you can see we're matching pretty well what the TRAC calculation is occurring.

The reactor isolation is an input time. It's not calculated. It's input. The biggest disparity, of course, and I mentioned it before, was with the short term or the blowdown peak between the two codes, and I mentioned what was the difference, in terms of trapping.

The other events are all pretty much straightforward, except you get down to the time at which the PCCS pooled has dropped to about a third of the -- a quarter to a third of the top of the tubes have uncovered.

At that point, a signal is given, and there's a storage tank which floods again the PCCS tanks and recovers some of that unflooded area of tubes. There's a time shift that's occurring here. It's only really due to the volume of water that we had versus what was in TRAC.

I don't know if the issue was that we took credit for equipment that was in there, and didn't have quite the same volumes. In any case, it doesn't make any difference, because even at this time, there's much excess capacity in the condensers. So we don't show any variation as a result of this flooding.

If you look at all the curves, you won't see any blip or anything that is a result of additional water coming in. That's because the PCCS is already over capacity, and it's not making a big difference. But that's something that we may need to resolve with GE.

The final deal is the pressure. We're

within about five percent of what they were at 72 hours. We're a little bit lower, and our belief is probably that it has to do with heat transfer and the wall.

MR. WALLIS: I have an observation here, Jack. Yes, they look similar, but if you take the slope of your pressure versus time over the last day and a half or so, it's twice the slope predicted by Track G over the same period.

So you're raising the pressure at twice the rate, which means that something is very different about the two calculations, it seems to me. If you actually draw the line, it comes out --

MR. TILLS: At the 72 hours, when we look at also the calculation where the double the leakage rate, to compare to what they are right now, we come up with 400 kilopascals --

MR. WALLIS: I'm not looking at the absolute value. I'm saying that the heating is what's causing the rate of rise.

MR. TILLS: That's right, and it's a --

(Simultaneous discussion.)

MR. WALLIS: And your rate of rise is roughly twice what TRAC is predicting. So something is different about the models.

MR. TILLS: Well, and it would be nice -- I mean when you look at a DCD and you're doing audit calculations, it would be nice, of course, to have what the heat transfer rate is that they're predicting on that wall, outer wall.

But that's not generally given. What you're looking at is, you know, primary values like pressure and temperature, and you're not given the details. So certainly that would be something to look at.

MR. WALLIS: We'll see if I compare the curves. Your rate is lower at the beginning and it's twice as much as the end. So something is different about the modeling there.

MR. TILLS: Yes, yes. I mentioned to you the pedigree of an empirical correlation, you know, versus what we're using, being a best estimate. I believe it's probably tied up in --

MR. WALLIS: Earlier you said that if you ignore the heat transfer to the cold wall --

MR. TILLS: That's right.

MR. WALLIS: Which may or may not include the ceiling -- I'm not quite clear about that -- that the pressure goes up above 400 kilopascals.

MR. TILLS: Yes, about 430.

MR. WALLIS: 430 you said or something?

MR. TILLS: Yes.

MR. WALLIS: So that is an important thing?

MR. TILLS: Yes.

MR. WALLIS: Okay, thank you.

MR. TILLS: And then the last two points on that figure, this is a 10, a slide. It's just indicating what those dominating areas are.

You know, look at the, you know, the loss factor, coefficients on the leakage term, and then also realize that radiologic gases are a prime contributor to this pressure rise.

I'll just go on to summary, which is the last point. The model that we chose to look at was quite different, in terms of where it came from than the TRAC calculation. Also in terms of the pedigree, what we consider the pedigree for doing containment type studies.

Quite different from the TRAC, which is basically a new addition to the containment analysis area. We developed it independently as much as possible, not taking TRAC input but rather deriving it from what their design values were.

And you know, in general I would say that we've confirmed some of the major players in the, you know, the whole analysis. The peak pressure, we're pretty well in within reasonable tolerance with theirs. There's nothing that jumps out at us there.

I mentioned a little bit about the short term, that clearly if we were in a short term analysis area, we would have some problems in terms of just doing the DBA calculation. Even though having said that, there's still below the margin that they needed a standard design --

MR. WALLIS: Now your third bullet here I don't think is quite right, because the way I calculate it is that the pressure dropped from the drywell to the wetwells, made up of two parts.

There's the pressure drop into and through and out of the PCCS, and then there's the hydrostatic submergence. The submergence is the bigger part of the total pressure drop.

MR. TILLS: That's correct.

MR. WALLIS: So it's not true that it results from bounding of the pieces. It results more from the submergence, and then you add a little bit more because of the bounding.

I think you have .9 kilopascals or something from the submergence, and you have .3 or something from the bounding part. So the bounding isn't really the part that's the reactor.

MR. TILLS: Well you know, it is the bounding. If you did not -- if those PCCSs were not bound, you would get very good communication with the wetwell.

MR. WALLIS: You've still got to overcome the submergence, though.

MR. TILLS: The only reason why you have to overcome the submergence is because the PCCSs are just barely leaking through, and letting gas through there. If those gases were not there, you'd have plenty of capacity to take down the pressure, and basically the pressure would come down until you've either got --

MR. WALLIS: But if there were just a tiny trickle of gas, you'd still have to overcome the submergence.

MR. TILLS: Yes, that's right, that's right. But this has that in there, and you can see that in the previous slide that had the delta P across there. That delta P, as you correctly mentioned, is made up of two components, the dynamic losses through the inlet, and also the yield.

Now this alone would say okay, do you have an experiment that shows that you can predict all of this yield, and we do. Panda, you know, clearly has hit this pretty well, I think, you know, of being able to predict what that pressure differential is, in a bounding, what I would consider a bounding or accumulated gas situation.

MR. WALLIS: Now wouldn't it be possible, rather than letting the vacuum breakers open, to simply vent the wetwell, because there's no significant radioactivity release in the first hour or so when the pressure goes up in there.

It would simply get rid of some of these gases and vent them out. Wouldn't that be possible? Vent them to the world.

MR. TILLS: You're out of DBA space at that point --

CHAIRMAN CORRADINI: I think you have less time --

(Simultaneous discussion.)

CHAIRMAN CORRADINI: --based on DBA calculations or DBA assumptions, the amount of radioactivity would not allow that. You would not essentially meet your dose, based on DBA assumptions. I think that's what we heard last time. We asked that, I seem to remember.

MEMBER MAYNARD: I'm not sure you'd be able to legally do that and count it as containment. It depends a little bit on how you -- I think you'd run across --

CHAIRMAN CORRADINI: But ABWR does have that capability for late time. They do fill to vent. But I think it's for a different accident sequence for different situations. But I seem to remember we asked staff that last time, and that's the answer we got back, was the amount of -- based on the assumptions, the amount of radioactivity in the atmosphere, it should be leaking out.

MR. WALLIS: These are realistic assumptions?

CHAIRMAN CORRADINI: No. They are design, DBA assumptions. But I think that --

MR. TILLS: Well, I'm pretty much done. I would have to say, though, that we're -- this design that you're seeing is somewhat dynamic. It's still changing somewhat, and you know, we will be redoing, revisiting the audit calculations based on significant changes.

So I'd just like to mention that if you have some suggestions or things that you would like to see us perform, you know, give me an e-mail and we can talk about it, and we'd be glad to run anything.

These calculations run fairly quickly. It takes about a half a day to run out a three-day scenario. So there's no problem with that.

MR. WALLIS: Well, your report was very useful, because you did discuss the mechanisms and you discussed why things happen the way they do, in a way which was very helpful, that I had difficulty extracting from the other communications that I got from the various parties. So that was helpful. Thank you.

CHAIRMAN CORRADINI: Jimmy, you want to now go on to the post 727 --

MS. CUBBAGE: Go ahead, Hossein.

MR. ESMAILI: Hossein Esmaili, Research. I'm just going to show the results of what happens past three days. I'm picking up where Jack left off, and just focusing on the three to seven days.

CHAIRMAN CORRADINI: Do we have this Hossein? Do we have this in front of us? We should.

(Simultaneous discussion.)

CHAIRMAN CORRADINI: We'll catch up.

MR. ESMAILI: Okay. All right. So what are the modeling assumptions at three days? First, we are refilling the PCCS pool at 200 GPM, at a temperature of 100 degrees Fahrenheit.

Just to give you an idea, at about three days for a 4,500 megawatt reactor, you need about 110 just to remove the K. It goes on to about 90 GPM at about seven days.

So part of the pool refilling is going into removing the --

MR. WALLIS: Can I ask you something here?

MR. ESMAILI: Yes.

MR. WALLIS: The gas flow you have through these vent valves, it's 727 CFM through each of six vent valves?

MR. ESMAILI: Through each of the six vent valves, each.

MR. WALLIS: Is 73 cubic feet is sunken, which is about half of the steam flow you need to extract 20 megawatts. So it indicates to me is that what's going into these PCCSs is one-third non-condensables. But there isn't that much non-condensables around to possibly make that amount. How come there's such tremendous flow through these valves?

MR. ESMAILI: This is the rate of condition for the fans --

MR. WALLIS: It makes no sense. You can't pump something which isn't there.

MR. ESMAILI: I can show you the flow rates for the PCCS. It's in one of the slides.

MR. WALLIS: Well, according to this, to remove 20 megawatts, you need 160 cubic feet per second of steam is what I calculate, and you're taking out 73 cubic feet per second of non-condensables with it? It doesn't make any sense.

MR. ESMAILI: Right. Something goes through with it also. So you have steam and non-condensables going through the PCCS.

MR. WALLIS: So most of what is going through the fan is steam?

MR. ESMAILI: Yes.

MR. WALLIS: Okay. So then you're bubbling steam into the GDCS pool?

MR. ESMAILI: No. We are taking steam and non-condensables from the drywell, oh sorry, from the bottom of the PCCS, the lower half, and pumping it back into the drywell.

MR. WALLIS: Well, the picture shows it being pumped back into the GDCS pool.

MR. ESMAILI: In the analysis, you know, based on our discussions with GE, I think --

(Simultaneous discussion.)

MR. WALLIS: So the -- in the GE presentation is wrong?

MR. CHEUNG: Figure 3 is wrong.

MR. ESMAILI: This is an assumption that we made, based on our discussion with GE, that they are pumping into the drywell. It doesn't -- to tell you honestly, it doesn't matter that much.

MR. WALLIS: Well, if you're blowing a lot of steam in the GDCS pool, you change its temperature and you have pumping and all kinds of stuff going on in there.

MR. ESMAILI: You're not pumping into the pool; you're pumping into the atmosphere.

MR. WALLIS: The figure shows you pumping into the pool.

(Simultaneous discussion.)

MR. WALLIS: You have a cartoon which is incorrect?

MR. CHEUNG: This is what is shown. This one probably we did not get a chance to discuss it. Once the vent is activated, the PCCS to bottom of it, and the drywell pressure goes down real quick. Then the wetwell, the vacuum breaker opens.

MR. WALLIS: Where does the fan exhaust? Where does the vent fan exhaust?

MR. CHEUNG: The vent exhausts in the GDCS pool, where it's about ten inch of a submergence. It's ten inch.

MR. WALLIS: Under water? Under water?

MR. CHEUNG: Under water.

MR. WALLIS: Okay. So he says it goes into the gas?

MR. CHEUNG: No. In the calculation that we have, the first calculation of this morning that we have also go into the drywell, and --

MR. WALLIS: But it doesn't actually -- is it designed to go in -- you say it's designed to go into --

MR. CHEUNG: The mixed stuff is designed into the GDCS pool with submergence, to make sure that is sealed off, there's no backflow.

MR. WALLIS: And it has a loop seal or something?

MR. CHEUNG: Yes.

MR. WALLIS: So these -- as I said this morning, these design details are important.

MR. CHEUNG: Absolutely, yes.

MR. WALLIS: There's a difference to what happens.

MR. CHEUNG: Yes. But the point I'm

trying to make is once it activates, the drywell will be the full to about .2 or the mass fraction is about .2 or 20 percent air and non-condensable gas, and then it goes with the steam that's coming out of the DPV and then go back to the --

MR. WALLIS: How big is the pipe that goes into the GDCS pool?

MR. CHEUNG: I do not have the number. It's probably 16 --

MR. WALLIS: It's got to be pretty thick, because you're pumping a lot of steam and gas through those lines.

MR. CHEUNG: Yes. We have six of them.

MR. WALLIS: It just seems overkill to pump so much stuff, if it's all steam. All you need to do is make steam go into the PCCS. Not much has to come out in order to make that happen. Why do you have such a big fan?

MR. CHEUNG: It pump out the non-condensable gas.

MR. WALLIS: But there isn't any.

MR. CHEUNG: No. But once it opens, it's kind of gas going back to the drywell, and the drywell -- once it goes to the drywell and goes back into the PCCS --

MR. WALLIS: It recirculates around.

MR. CHEUNG: Recirculates. That's why we call the drywell --

MR. WALLIS: So it came out of the vacuum breakers?

MR. CHEUNG: Yes.

MR. WALLIS: Okay. So you assume that what comes out of the vacuum breakers then mixes up with everything?

MR. CHEUNG: Will mix up with the big drywell volume. And once it's activated, look at it. The drywell, the wetwell pressure is going to be a very small difference. Sometimes the drywell pressure most of the time is lower than the wetwell pressure.

The pump keeps circulating, and now once it's activated, the condensation power or the PCCS depends on two things. The mass fraction, the non-condensable mass fraction coming from PCCS, and then the flow rate.

MR. WALLIS: And the vent fan is never switched off, because if it's switched off, you're going to suck water up from the drain into the vent fan.

MR. CHEUNG: The one other case that we have is two of the PCCS have no fan, and that two

PCCS, just they don't turn it on.

MR. WALLIS: I said you musn't switch it off, because if you switch off the fan, you're likely to have water sucked up into the fan from the GDCS.

MR. CHEUNG: Why suck up?

MR. WALLIS: Because of the hydrostatic in the other one.

MR. CHEUNG: No. The other one, the one that have no fan belt, the vent turn off the water, just seal off the tail end of it. The other four, they still have the pump. They keep pumping, circulating the non-condensable gas back into the GDCS pool gas space.

MR. WALLIS: I'm just thinking of cold water seeing steam and rushing up to meet it by condensation.

MR. CHEUNG: Once it seal off, the bottom half of the PCCS vent is always full of non-condensable.

MR. WALLIS: Wow, okay.

MR. MARQUINO: We'd like to let the staff continue. We do have a couple of slides on this that we can talk to, if there's time available.

MR. WALLIS: We're just wondering whether the staff accepts all of the arguments of GE, or whether they asked the kind of questions that we're asking?

MS. CUBBAGE: We've just received this information from GE just a few days ago. We did the best we could to come here and present calculations, to show what we think happens with this system. We've not made any conclusions about this yet.

MR. WALLIS: So it's not surprising that your assumptions might be different from GE's?

MS. CUBBAGE: Well, we tried to use the same assumptions to the extent we understood them, based on some communications in a meeting we had.

CHAIRMAN CORRADINI: Go ahead, Hossein.

MR. ESMAILI: Okay. So anyway, so we have six vents, 727 discharging, reacting to the drywell atmosphere. This is based on the discussion we had with GE.

The PARs are activated, again at three days. So we do not generate any new non-condensables. Whatever we had generated during the past three days still remains. That means that we are not explicitly modeling the PARs.

Next slide. Okay. So you've seen the results of the first three days. Immediately at three days, once we start the fans, you see a dip in pressures. What happens is that they -- the fans start to purge the bottom of the PCCS tubes, and condenses steam.

So you get a very, very fast reduction in the pressure.

MR. WALLIS: Does it condense something like 64 megawatts though?

MR. ESMAILI: I can actually show you the -- I will get to the PCCS heat removal in a few slides, on Slide 6. I don't think it's 60 megawatts but, you know, we matched -- initially, there is a very, very high heat rush from inside the PCCS tubes.

MR. WALLIS: --so good, you might as well run it from the beginning.

MR. ESMAILI: No, but after some time. After some time the pressure is, you know, equilibrating. So you're not going to get that much flow through the PCCS.

MR. WALLIS: But you wait until you have to run it before you start it? You could start it earlier.

(Off the mike comment.)

MR. WALLIS: Oh, 72 hours.

MEMBER MAYNARD: There's a lot of things they would probably be doing in the first 72 hours.

But for credit --

MR. ESMAILI: Okay. Right show --

MR. WALLIS: You're not allowed to start it until 72 hours? Is that it?

CHAIRMAN CORRADINI: They're not taking credit for it.

MR. WALLIS: Credit for it.

CHAIRMAN CORRADINI: You've got to stay with the rules of the game, Graham.

MEMBER ARMIJO: But I think it's their intention not to run it for the first 72 hours.

MR. WALLIS: So the rules are very interesting. I mean the picture throws a fast ball, and the rules of the game says I've got to play a curve ball. So I strike out.

MEMBER MAYNARD: Now what they're doing is consistent with other licensing basis deals. It's what you take credit for and what you have. You always remember --

(Simultaneous discussion.)

MR. WALLIS: Always remember.

MEMBER BLEY: But Sam, what Sam suggested, they wouldn't use it until the 72 hours. And from the last meeting, I thought they hadn't decided about that.

MEMBER ARMIJO: Well maybe we should ask GE. But is it the intent of GEH that the fans be used before 72 hours?

MEMBER BLEY: If they're available.

MEMBER ARMIJO: If available.

MR. MARQUINO: The fans are going to be used if available and the power's available before 72 hours. They'd have the beneficial effect on the containment response.

MEMBER BLEY: Are the procedures likely to tell people to do that?

MR. MARQUINO: Yes, although we haven't worked through the emergency procedures yet.

MEMBER ARMIJO: But you've found no downside of operating them right away?

MR. MARQUINO: There's no downside, that's correct.

MEMBER ABDEL-KHALIK: Oh, wait a minute.

(Off the mike comments.)

MEMBER ABDEL-KHALIK: Is there a check valve at the end of the discharge line of these fans?

MR. CHEUNG: The check valve is a ball type, you know, floating ball.

MEMBER ABDEL-KHALIK: Whatever. Something to prevent water from going back up from the GDCS tank to the --

MR. CHEUNG: Yes, yes.

MEMBER ABDEL-KHALIK: Okay. So there is a check valve, right?

MR. CHEUNG: There's a check valve.

MEMBER ABDEL-KHALIK: At the discharge?

MR. CHEUNG: Yes.

MEMBER ABDEL-KHALIK: Okay, thank you.

MR. ESMAILI: I just want to clarify my position. I'm just doing an audit calculation, using the same assumptions that GE has done, and based on.

MR. WALLIS: Well, I think it would be better if you presented this thing as a design, and said we thought about water being sucked in, so we up in a check valve.

If you said all that in your presentation, we would understand it. We don't have to extract it by waiting until the right question comes up.

CHAIRMAN CORRADINI: Well, that's partly my fault, because we ran out of time.

MS. CUBBAGE: That's not for the staff to explain. That would have been GE's, but they didn't get an opportunity. Let's move, yes.

MR. ESMAILI: Okay, so in the insert, you saw that we were talking about the bypass catching it for the first three days. We have steam going from the drywell inside the wetwell. At three days, once the fans start working, they're purging all the non-condensables from the PCCS tube.

As a matter of fact, you will see we have reverse leakage. That means that we have at times leakage from the wetwell back into the drywell. These are the leakages from the vacuum breakers.

As a matter of fact, the vacuum breakers, I don't have the figures in front of me, but they only open right at about 72 hours. They open for a very, very short period of time, and maybe for the next four days, maybe two times more.

MR. WALLIS: Well, let me ask you a question. If you have the fans operating all the time, would you need the vacuum breakers at all?

MR. ESMAILI: Well see sometimes the drywell pressures at certain instances in time, from three to seven days, the drywell pressure falls below the wetwell pressure enough to actuate the vacuum breakers.

MR. WALLIS: No, I'm suggesting if vacuum breaker leakage is a big problem in all that, then if you had the fans operating all the time to make --

MS. CUBBAGE: But they're not going to do that.

MR. WALLIS: --it work, you might not need --

MS. CUBBAGE: So it's not really worth talking about.

(Simultaneous discussion.)

CHAIRMAN CORRADINI: Yeah, but the initial blowdown will carry a lot.

MR. WALLIS: Oh, that's the initial blowdown or something.

MS. CUBBAGE: It's a passive design.

MR. WALLIS: Okay, right.

MS. CUBBAGE: So if you were to credit the fans from day one, you'd be an active plant with safety-related diesel generators and the whole nine yards, and then they could take out the GDCS and put in pumps.

(Simultaneous discussion.)

MR. ESMAILI: Part of the reason we are doing this calculation is trying to understand. I mean this research is trying to understand what's going on from three days to seven days with the fans working.

Next slide. Next. So this is what happens to the PCCS pools. By about three days, we have two-thirds of the tubes covered. After that, you see that water level is going up, but it's saturated and that's actually four days to completely recover the water level to the top of the tubes.

Next slide. Okay. Here you see -- actually you see what's happening inside the tubes. In the first three days that Jack was mentioned, you know, the insert shows a steam void fraction inside the tubes, okay, from the upper half all the way to the lower half.

In the bottom portion of the PCCS tubes, you can see that, you know, see more fractions of the order of, you know, like 40 to 60 percent. So there's a non-condensables accumulating there.

At 72 hours, once the fans start to work, we are sucking all the non-condensables back into the drywell, and you see -- you get a more or less uniform distribution of the non-condensables and steam inside the PCCS tubes.

What happens is that at 72 hours, you also because of the reverse leakage and the short duration of the vacuum breakers operating, you can see that, you know, the non-condensable gases that were originally pushed back into the wetwell are coming back into the drywell, okay.

As a matter of fact, if you look at the steam concentration inside the upper half of the PCCS tubes, it's following whatever is happening inside the drywell. So initially the drywell is full of steam --

MR. WALLIS: I guess I'm interested in the figure we saw right at the beginning. Curve 6 shows that there's a lot of pressure drop across the pipe that feeds the PCCS.

So if you are now running these fans and they're pumping steam, which isn't condensed, it seems to me you have an ability to have more steam going into the PCCS than ever before.

MR. ESMAILI: Actually, the next --

MR. WALLIS: That pressure drop going into it will be bigger than ever before, and will open -- could open the top half.

MR. ESMAILI: No. The top end never opens.

MR. WALLIS: Well, I'm just saying, that you have to calculate the pressure drop now, because you're sucking all that steam all the way through the PCCS, and blowing it out through the fan, and you've got steam being condensed in there.

So I'm saying the total flow rate going in could be bigger than it's ever been.

MR. ESMAILI: Well, here's the flow rate actually going to the PCCS. I'm showing it right here.

MR. WALLIS: Going through it or into it?

MR. ESMAILI: Well, the top one -- you see for the first three days? You see, that's the steam flow right through the PCCS, going to the top of the PCCS, okay.

The first three days is passing. After the fans start working, immediately at 72 hours you see a big spike, in terms of flow of steam and non-condensables into the --

MR. WALLIS: Is it bigger than it's ever been?

MR. ESMAILI: It's about, I don't know. It's about maybe 13, 14 kilograms. That's a very short duration.

MR. WALLIS: That probably opens the top half then, because the pressure drop goes as V squared, and that's over twice as much as before.

MR. ESMAILI: You're talking about that main horizontal vent?

MR. WALLIS: Yes.

MR. ESMAILI: They never open, because as a matter of fact, what happens is that once you're equilibrating the pressure between the drywell and the wetwell, you are recovering the water level. So if I show you --

(Simultaneous discussion.)

MR. WALLIS: But a parallel path. I mean the pressure drops or the PCCS has to match the other path that goes down through the vent path.

MR. ESMAILI: But nothing goes through there. You know, once --

(Simultaneous discussion.)

MR. WALLIS: It does, if the pressure drop is big enough to open the vent. If the pressure drop between the drywell and the wetwell is big enough, it will open the vent.

MR. ESMAILI: Yes, it will open the vent, but it's not.

MR. WALLIS: You've got this humongous steam flow going in. It just seems to me that could be enough to give you enough pressure drop by what you showed us before, or Jeannie showed us at the very beginning, to open the top vent.

Not that it matters that much, but you know, you need to calculate the pressure drop associated with this slide.

MS. CUBBAGE: Mike? We just need to do a

time check, because I know that Jose needs to catch a plane. We've got like five more presentations.

MR. WALLIS: Well, go ahead. I will stop asking questions.

MR. ESMAILI: Okay. So you've got the spike, and then you've got flow through the PCCS. As a matter of fact after that initial spike, you can see that the heat being generated inside the vessel and the steaming rate is perfectly matched with the PCCS removal.

The next slide is just the bypass leakage and the sensitivity to the bypass leakage area. You know, you go to two centimeters, of course you're going to get through the design by about three days.

But you get -- because now you have a bigger area between the vessel and the drywell. You are depressurizing the containment faster. Eventually, you get a twin equilibrium state.

So in the final analysis, we are confirming, you know, some of the calculations that GE has done.

MEMBER ARMIJO: Because you activate a margin, do you actually get more margin as GE calculated?

MR. ESMAILI: We're actually a little bit higher than -- you're talking about that seven days?

MEMBER ARMIJO: Yes, right at the end, the spread --

MR. ESMAILI: At the end, for the one centimeter spread, and I'm referring to one of the figures that GE did not present, but it's in their handouts, they come to about three PARs at seven days. We are sitting at about 3.2, 3.3 bars at the end of seven days.

MEMBER ARMIJO: And they didn't take credit for PARs but you did?

MR. CHEUNG: Our understanding was that they did not base, you know, the assumptions that PARs are activated, so was based on the discussion we had with GE. So I don't know. You'd have to ask if they assumed that the PARs are activated or not.

In the presentation that I pass out this morning, the PAR was not on, or no credit for the PARs from three days to seven days. But we have another set of calculations, three days to seven days. We have the PARs turned on.

But basically, the mass, they redistribution from wetwell to drywell. So a little bit of turning off the rate algebra test is not going to make a big difference.

MR. ESMAILI: We actually did a sensitivity to the PARs activation, non-activation. It just changes the total pressure by about a tenth of a point. It doesn't make that much of a difference.

CHAIRMAN CORRADINI: Thank you very much. Yes.

(Off the mike comment.)

MEMBER ABDEL-KHALIK: --that maximum flow rate in the PCCS after about an hour or so is 310 kilograms per second? Look at the beginning of the graph.

MR. ESMAILI: Oh yes, the first. Okay.

MR. WALLIS: Do you have some more copies of those things somewhere?

MEMBER ABDEL-KHALIK: In the best of circumstances, this is all steam, and going through the PCCS, and it's fully condensed as it goes through the PCCS? You'd be removing about 23 megawatts. Why GE claim that they're removing --

MR. ESMAILI: All right. Let me paraphrase something. I forgot to mention. This is the rate -- the proof. So I'm just showing you three of the PCCS units. So whatever you see here, you have to multiply by two. This was not made clear.

Okay. So this is about, you know, just

multiply ten by -- so 20 kilograms per second. This is half of it. The other half is just exactly the same. It's just --

MEMBER ABDEL-KHALIK: All right.

MR. WALLIS: So the fan is pumping mostly steam?

MR. ESMAILI: The fans are pumping mostly steam. But it goes down as time goes on, because you're getting more non-condensables back from the wetwell into the drywell. Whatever is coming out is constant, because I'm assuming a constancy in that.

CHAIRMAN CORRADINI: Do we have the next set from the staff?

MS. CUBBAGE: Great. Yes, we're going to switch gears here. I have the handouts.

(Pause.)

MR. WANG: Okay. I'm Weddington Wang, and today we are going to present the GDCS main line confirmatory calculation for the ESBWR stability. Before we do this confirmatory calculation, we would like to address a few new IRAs to address, from the last ACIS meeting concerns.

The first IRA is about the GDCS main line. Dr. Wallis asked the last time when the GDCS starts, the water level inside of vessel actually is below the inlet of the GDCS.

So we asked GE to address if there's a possibility of the steam flowing back, and if TRAC has the capability to TRAC on this phenomena, or what is the design to prevent this phenomena.

We also issued new IRAs on chimney modeling. From the outlet of the core to chimney, there's a non-fully developed flow. We would like GE to address if this TRAC can model it correctly, because strategy has a static flow regime.

This is non-fully developed flow regime. If it cannot be modeled correctly, what's the impact on the safety?

Also, we would like -- we issued another IRAs to address the turbulence of the slug in the chim, turbulence transitions, which basically is kind of noisy noise in the chimney. We would like to see what the impact on this phenomena, and also if strategy can model it correctly.

MEMBER BLEY: Excuse me, just to get me on the right page. Exactly which pipe are we talking about?

MR. WANG: For GDCS? For GDCS, there is a GDCS in pipe, right.

MR. WALLIS: Which in later drawings has a loop seal in it?

MR. WANG: That's what we're asking for GE to address, and we haven't got a response back yet.

MS. CUBBAGE: No, no, no. Not for that drain. This is the actual injection line into the vessel that we're talking about.

MEMBER BLEY: Oh, the one to the vessel.

MR. WALLIS: Yes, it does, it does. It has a down and up again in the later drawing I saw.

MS. CUBBAGE: Yes. This is a question we're actually raising as a result of some of the comments from you all at previous meetings, about concerns about whether there could be any blockage in that line.

MR. WALLIS: I think we need to have a design which is stabilized, because some of these early drawings show one kind of pipe design, and then another one shows a different pipe design, and tomorrow it could be another pipe design.

The shape of the pipe makes a difference, to whether or not this phenomena can happen.

MEMBER BLEY: Also, the isometrics would really help us.

MS. CUBBAGE: Right. Are you speaking about the GDCS injection line? We have the PNID. I'd be happy to get that to you.

MEMBER BLEY: It's not the PNID. It's the isometrics.

MS. CUBBAGE: The isometrics?

MEMBER BLEY: --to the actual layout.

MS. CUBBAGE: Well, we don't -- I don't think we have that. GE would have to submit it, and then we'd be happy to give it to you.

MEMBER BLEY: There were others this morning they talked about, giving us the isometrics.

MEMBER BANERJEE: I guess there's a general concern which Amy you're aware of, from the committee about the trapping of gas in this line, which needs to somehow be dealt with.

MR. WANG: We can move to the next slide. Okay. Our main calculation is going to be confirmatory calculation, using LAPUR curve. The LAPUR curve was developed by NRC and maintained at Oak Ridge Laboratory in the 70's.

There is a manual actually, I think. At the last meeting, we have distributed to PM, and hopefully you have a look at what the LAPUR code is. It is a frequency domain solution, and calculates the transfer function. It can estimate decay ratios from three stability modes: channel, core-wide and regional.

Next slide please. I will briefly discuss about what the LAPUR model is and Jose from Oak Ridge, he'll discuss about detailed input and also the calculation results. The model, we use a quarter core model, and in later slides, we'll show a rough idea of what the core quarter model is.

Basically, it can capture three modes of instabilities: core-wide, channel and regional, since it's symmetric. It's using, it generates from PANACEA.

The main portal we use from PANACEA is 3-D power distribution, like axial and radial power show, and void reactivity coefficients, and also the flow rate. So that's steady state condition.

In the chimney, we see made with an outlet pipe module, which have a single chimney per bundle.

MR. WALLIS: I thought there was a chimney for four bundles?

MR. WANG: Yes. This is a limitation from this LAPUR code. But however in this LAPUR simulation, we mainly focus on this core, and also chimney is not significant for this instability study, because mainly chimney has pressure job on gravity and frictional pressure job is less important.

MR. WALLIS: But the void fraction in the chimney is very important.

MEMBER BANERJEE: The gravity --

MR. WALLIS: Yes. That's what's driving the whole thing.

MEMBER BANERJEE: I mean it doesn't circulate if we don't have gravity.

MR. WANG: Okay. This model actually is only model the core. We focus on the steady state to calculate the solution from the core, and then we have perturbation, and from the perturbation we have the transfer function and calculation of the K ratio.

MEMBER BANERJEE: So let me ask a question here. Suppose you put in, in the chimney, fairly large amplitude noise. Would due to actually the RAI you asked GE to do, would there be a wave number selection here, where it would couple to any of the modes?

MR. WANG: I believe it's not. Maybe Jose you can --

MEMBER BANERJEE: I mean why not?

MR. WANG: Because this model, we mainly for the core, and this is a code limitation.

MEMBER BANERJEE: But this would be driving, right? I mean if you put in a driving, broad

-- not a broadband noise, but let's say noise with substantial amplitude. Why wouldn't one of the modes couple?

MR. MARCH-LEUBA: It will drive the reactor. It will be eventually you put perturbations of density on the chimney, you will have different heads driving the inlet flow, and the reactor will see there's a change in the inlet flow. It will have some fluctuations of the inlet flow.

The question you're really asking is what the amplitude of the flow? If you went to Susquehanna, we were there last year, and we saw the APRM was 83 percent up and down, and that is because the flow is changing in the reactor.

It happens in Susquehanna, it happens in Hatch, happens everywhere. The question is when they build it, we have a one percent flow, we will have ten percent, 25 percent.

If it's 25 percent, it won't be able to operate. We fully expect that this noise will be there at one to three percent as normal reactors.

MEMBER BANERJEE: But yes. Maybe you are right, maybe you are wrong, because nobody knows this at the moment. But is there -- I mean your code is a linear stability analysis code, right?

MR. MARCH-LEUBA: This is correct.

MEMBER BANERJEE: So you don't have any amplitude information here right, in this code?

MR. MARCH-LEUBA: None whatsoever.

MEMBER BANERJEE: So the only couplings that you would see would be through some mode coupling, but as it's not a non-linear analysis, how would you know the amplitude effect?

MR. MARCH-LEUBA: If it's a noise driving a linear system, then it's just a noise driving a transfer steam. But this multiplication is probably the --

MEMBER BANERJEE: But there would be some wave number to represent this.

MR. MARCH-LEUBA: Yes. Now there is the obscure or the difficult probability that it is non-linear. And just because you have a mold in the chimney, you're suddenly producing a different physical phenomena. Something like that --

(Simultaneous discussion.)

MEMBER BANERJEE: But turbulence is.

MR. MARCH-LEUBA: Yes. Something like that --

MEMBER BANERJEE: I don't know, because you see there's so much numerical dissipation in these codes, that it's hard to know whether there would be a coupling, because there are two things that happen as you know. Even if you fix the dissipation, you still get dispersion.

MR. MARCH-LEUBA: Yes.

MEMBER BANERJEE: And the dispersion will take things out of wave number and then tend to flatten it. So it's very hard to know without a spectral code, whether actually this will happen or not.

MR. MARCH-LEUBA: The real answer to your question is that we were concerned about all these issues, and we receive a commitment from General Electric. Once they fill their reactor, they'll test it, okay. So we will not know the answer to your question.

MEMBER BANERJEE: Because I don't think they need to build the reactor to test it.

MR. MARCH-LEUBA: To test it.

MEMBER BANERJEE: I think it would be very helpful to have a little bit more information on even the experiments they have done, the experiments on void fraction that they've done. There was a question asked as to whether there were large amplitude fluctuations in the gravity head, even in this channel.

Now the reason it couldn't be got is they were also having fluctuations of pump flow. I looked at that data, the Ontario Hydro report. So you couldn't separate out easily.

But there were two gamma densitometers, and if you could find the cross-correlation function with large density fluctuations which was correlated, then you would have a measure other than the pressure losses, because the pressure losses were coupling to the pump.

MR. MARCH-LEUBA: Yes.

MEMBER BANERJEE: So it wasn't a perfect experiment. But if the experiment was done more carefully, this question could be answered, I think, directly.

CHAIRMAN CORRADINI: Can I ask another question? You mentioned some operating experience. So what is it about this design that could make it non-linear, where you were mentioned with current BWRs.

If you have something in the chimney which causes an oscillation, it will just feed back because of the recirculation ratio?

MR. MARCH-LEUBA: I have not -- I cannot

come up with any physical phenomena that would make it non-linear.

MR. WALLIS: But it's not a question of non-linearity. It's a question of response to an actual external source, isn't it? You don't get --

MR. MARCH-LEUBA: If it's a linear response, it will be a response from an external source, and the only question is how much the amplitude and the noise in the reactor will be.

MR. WALLIS: If you had sort of slug flow bubbles that form themselves with some kind of a frequency, it would give you perturbations in the chimney. Does that -- what effect does that have on the whole circulation? Does it get amplified? Does it get damped out very much or what?

MR. MARCH-LEUBA: It will not get amplified. It will get propagated.

MR. WALLIS: How much does it get damped out?

MR. MARCH-LEUBA: Right.

MEMBER BANERJEE: So if you force at a certain frequency, is there a frequency of forcing, where you will get some sort of a coupling and a resonance effect?

MR. MARCH-LEUBA: Obviously. It will be

the frequency of the oscillation. That's where you get high amplification.

MEMBER BANERJEE: Yes, but what is that deficiency?

MR. MARCH-LEUBA: That I can't tell you with reference to this, yes. LAPUR can tell you. LAPUR can tell you what the frequencies and what the amplification factor is. So it doesn't function from flow to power, for example.

MEMBER BANERJEE: Well, the question then is even a fairly small forcing at that frequency can lead to some sort of amplification, right?

MR. MARCH-LEUBA: Yes, especially is the factor is close to one, then amplification is larger and larger; correct?

(Simultaneous discussion.)

MEMBER BANERJEE: I mean is that frequency considered out of the question or what?

MR. MARCH-LEUBA: That frequency is about .7, .8 hertz. We call it one hertz in ESBWR.

MR. WANG: We'll have some results from the calculation, right. Yes.

MEMBER ABDUL-KHALIK: Does the fact that the actual chimney being pumped as a super cell, versus the single bundle, introduce another mechanism for non-linearity, if you have significant radial power gradients?

MR. MARCH-LEUBA: They're always non-linear. The word is non-linear, but fortunately behaves most linearly, and the possibility does exist. But I don't see the non-linearity really doing anything of relevance. What mechanism were you thinking about? I cannot think of one.

MEMBER ABDUL-KHALIK: Well, I mean if you had significant differences in steam flow between neighboring bundles within a single super cell, that would cause significant mixing in the lower part of the chimney.

MR. MARCH-LEUBA: Yes. That would be linear, though, I think. I think it would be linear. It would be a perturbation, and it would operate linearly.

MR. WALLIS: Well, it might lead to sort of intermittent behavior, where you release a bubble, then another bubble and another.

CHAIRMAN CORRADINI: If I could just ask, so what was the name of the reactor that was mentioned?

MR. MARCH-LEUBA: DODOWR.

CHAIRMAN CORRADINI: And what is the size of that, in terms of how many bundles to the chimney? I can't remember.

MR. MARCH-LEUBA: It had a single chimney.

CHAIRMAN CORRADINI: Oh, I thought it was more than that.

MR. MARCH-LEUBA: DODOWR was not partitioned, was it? It was partitioned?

(Off the mike comment.)

CHAIRMAN CORRADINI: So four to one?

MEMBER BANERJEE: But the chimney was what diameter?

(Off the mike comment.)

MR. MARCH-LEUBA: I believe he was saying that the chimney in the official DODOWR is four by four bundles or 16 bundles, and the chimneys on the ESBWR were two by two. So that's four bundles.

MEMBER ARMIJO: They were big chimneys on DODOWR.

MS. CUBBAGE: DODOWR. You said ESBWR a couple of times.

(Simultaneous discussion.)

MR. MARCH-LEUBA: What?

MS. CUBBAGE: You said ESBWR twice?

(Simultaneous discussion.)

CHAIRMAN CORRADINI: So the reason I guess

I'm asking is that -- so this one has it such that it's larger, there would be larger land scale between the transverse distance. But was anything seen in DODOWR that would indicate at least in the two by two that you would see some sort of different amplification?

MR. MARCH-LEUBA: Just next to DODOWR, there was a very good Delph (ph) University people, which have really very qualified noise analysis, and they have great reputation in the area. They were studying the noise of the reactor for many thesis, and they never saw anything. It was a very quiet reactor.

MEMBER BANERJEE: Yes. I was on the review board. It was Vanderhoggen. But it was -- there was an action in GE actually to assess. Well, it's not an action but we certainly discussed it last meeting that assessed what applicability the DODOWR data might have on the ESBWR.

Maybe that is also something that you people might look at, because it's not clear that all the scaling and everything --

MR. MARCH-LEUBA: It's not the same reactor.

MEMBER BANERJEE: It was a reactor. But it could be that some of the data could be useful, in terms of setting our minds at rest about this --

MR. MARCH-LEUBA: In my mind, the chimney -- yes. DODOWR had a large, long chimney. It was not exactly a four by four. It was a two by two. But and they have basically even natural circulation, and they never saw much noise.

MEMBER BANERJEE: Yes. But that would be coupling to the density waves in a small set of channels. Sort of like if your stability was due to small group of channels taking off and oscillating, which of course happens.

MR. MARCH-LEUBA: There is something in the rolling of the core, and it's almost four symmetry. So once you capture four channels, kind of 16 look about the same as four.

If you take only one bundle per chimney, you're having big difference as well. Once you get four channels, you have the checkerboard pattern.

MEMBER BANERJEE: How many chimneys did DODOWR have?

MR. MARCH-LEUBA: Don't know really. One chimney would be four bundles.

MEMBER BANERJEE: Yes.

MR. MARCH-LEUBA: It was more reactor, much more.

MEMBER BANERJEE: 20 or 30 or 60?

MR. MARCH-LEUBA: Something like that.

MEMBER ABDUL-KHALIK: 65 megawatts. It wasn't much. It was a small plant.

MEMBER BANERJEE: Okay. Anyway, we should look at that data.

CHAIRMAN CORRADINI: Do we need to --

MR. MARCH-LEUBA: Move on?

CHAIRMAN CORRADINI: Yes.

MR. MARCH-LEUBA: In the interest of time, we'll move fast through this. I just was going to give you a presentation on what the input data of the LAPUR code was, and this shows the radial power distribution at the beginning of cycle and end of cycle is the blue line, and the flow distribution, which is the red line.

The only thing of interest I find here is that at beginning of cycle, you have all the gallenium still is in the core and all the control rows, and most of the high power channels cluster on a single peak.

Towards the end of cycle, you see those two peaks separating into themselves, and you see a high power bundle and a medium power bundle. That's bad for stability.

So whenever at the end of cycle, you have now significant function of the core, which is 130 percent radial power, whereas at the beginning of cycle everything was 120. That makes the number increase towards the end of cycle.

Next slide. The axial power distributions are also very important for stability and during most of the cycle, the blue line and the kind of dark line, dark gray line, are beginning at middle cycle. Only towards the end of cycle, when we're running out of uranium, there is a shift of the power towards the top of the core.

MEMBER ABDUL-KHALIK: What is the actual average value in terms of power to flow ratio in the previous TRAC? I mean 100 percent represents --

MR. MARCH-LEUBA: 100 percent is 4,500 megawatts divided by 1132 channels.

MEMBER ABDUL-KHALIK: Yes.

MR. MARCH-LEUBA: And the flow is same thing. So this is the average. 100 percent is the average channel, including the periphery.

MEMBER ABDUL-KHALIK: Okay.

MR. MARCH-LEUBA: So that's the axial power shape. It's fairly bottom peak early in the cycle, and then fairly top peak by the end of the cycle. So it's hard to make a decision about which one is going to be more unstable.

Next slide. This you are going to have to look at it on your own transparencies. One of the things we do when we do confirmatory calculations, the purpose of this one was to confirm the stability of the ESBWR, calculate the K ratio.

But we look at other things, and we are trying to figure out whether there's any physical phenomena that the vendor has not modeled.

MR. WALLIS: So you're predicting flows and pressures drops almost exactly the same as PANACEA?

MR. MARCH-LEUBA: Very much the same.

MR. WALLIS: Is this because it's dominated by a single phase region?

MR. MARCH-LEUBA: No. Actually, it's two phase region.

MR. WALLIS: And you have the same void fraction correlation?

MR. MARCH-LEUBA: No, very different. Let me --

MR. WALLIS: That's miraculous that the two phase four calculations are so close.

MR. MARCH-LEUBA: I don't have a pointer, but you can see somewhere here on the right there is a regional channel that has three and four bundles. Can you find it? There are two or three of those. That is where the control rows are.

So whenever we have channels with control rows inserted, you have lower power to flow ratio, and we have different void fractions. Then we have differences between the pool and the --

MEMBER ABDUL-KHALIK: Isn't this just a consistency check?

MR. MARCH-LEUBA: It's a confirmatory.

MEMBER ABDUL-KHALIK: Right. I mean you're using input generated by PANACEA?

MR. MARCH-LEUBA: No. We're using the power in the PANACEA. We're calculating the flow from First Vintage (ph).

MEMBER ABDUL-KHALIK: It's not --

MR. MARCH-LEUBA: We're using the same friction coefficiency, but --

MEMBER ABDUL-KHALIK: But the pressure drops are the same.

MR. MARCH-LEUBA: Pressure drop is also matches. So even though we have a completely different void fraction model, this is a slip model, LAPUR. This is PANACEA, which is a different model.

We do benchmark that, and in essence it's a good benchmark of LAPUR, because PANACEA is benchmarking reactors every day. So in PANACEA they're all standard, but we do get a good benchmark.

Next slide please. Okay. So here is the main result. We took the axial and radial power distributions and exposed the coefficient on 12 points within the cycle.

So we didn't do just a single calculation, but we took beginning of cycle, a couple of weeks into the cycle, all the way to the end of the cycle.

We show here on the first column the core-wide declination (ph). The second column is the regional declination, and the last column is the channel declination. LAPUR has a problem calculating channel declinations, which are very stable, because it just cannot calculate the frequency.

Instead of reporting them .03, .02, .01, I just put approximately zero. So you are not distracted by terms which are numerical and have nothing to do with the stability of ESBWR.

On the core-wide, where we see the core-wide, according to LAPUR, dominates the response and tends to be more unstable towards the end of the cycle, but still only .25 declinations. Very, very stable. The regional is very stable too, always less than .2.

So we confirm GE's calculations and claims that ESBWR will be stable and will be operable.

For the regional mode, we used subcritical reactivity that was caused by a separation of 80 cents that was calculated. That accurate number was .78.

An interesting thing that you can see is that the frequency keeps changing and becoming shorter towards the end of the cycle, indicating that we have like a longer transit time of the bubbles, the effective transit time of the bubbles. It is hard to explain, but that's what LAPUR calculates.

I will have to -- I mean everybody, when we were doing the review of this, everybody had expected it to be the other way around, as the axial power head shifts to the top. But it does not.

CHAIRMAN CORRADINI: So if you have a period base detection algorithm, you have a hard time figuring out what frequency you're looking for?

MR. MARCH-LEUBA: No, no, no. The period base finds the frequency that it happens to be oscillating at. For example, in Hatch, at 100 percent flow, the reactor always was at a .8, .9 hertz. When it trips, it only was .4, .5 as you change the flow.

So it's more variability with frequency, you know, than the reactors under ESBWR, because of the flow change. But an important feature of this is that, and GE is working on this, is for a long devolution, there are some hard wire parameters, like the corner frequency and tolerances, which need to be adjusted to these higher frequencies.

So one thing we have already told them is DSSCD is not applicable to ESBWR today, because it has some hard wire frequencies, which they need to take exception to and recommend new parameters.

So DSSCD will be applicable, but as it is in the books, we recommend the values of the parameters, it will not work for ESBWR for the reason we said.

Next slide. Now we do have some -- I've run some sensitivities to both power and the adiabatic separation for the core-wide mode. Here, on the left, the first two columns, flow and power over the start-up path. This kind of represents the natural circulation line on an operating reactor.

We calculated the decay ratio as we increased power, maintaining the core temperature. We see that even at the 120 percent power, which is above the scram line, we got a result of .03 for the core-wide.

And as I said, the adiabatic separation that we used was .8 dollars, and let's assume that these changes in Cycle 2, Cycle 3 is different loadings. At 60 cents or one dollar, you will see that even then, the decay ratio for the regional does not become a problem.

A bounding case will be for the adiabatic separation of zero, which is the very first column. That's a non-realistic, non-physical case, but there will be bounding. And even with the bounding case, at 120 percent power we get the result of .067.

CHAIRMAN CORRADINI: I'm sorry. Where does the flow percentages? Where do the flow percentages in the first column come from?

MR. MARCH-LEUBA: That was my calculation. I put into LAPUR 100 percent power, 100 percent flow, and calculated a delta P across the core. Now I set the power to 90 percent, and I kept taking on the flow until I got the same delta P as before.

CHAIRMAN CORRADINI: So you need 102 percent flow to get 90 percent with the same delta P?

MR. MARCH-LEUBA: Correct, and if you see if that's turned around, we always have discussion before of why the circulation is not vertical? It's not vertical. It's a parabola. It's a competition between flow and friction.

So those are the flows calculated by LAPUR, so that you have the same delta P, which is equivalent to the same level on that outcome.

MR. WANG: Let me make the conclusion. Basically, from this confirmatory calculation, we say yes, ESBWR exhibits high degree of stability, and as a calculation we found the flow distribution and the jobs predict by PANACEA is confirmed. Also, the flow declination value for all three density wave stability mode is also showed as very small.

And next, for this confirmatory calculation actually one bullet I didn't talk important is what we're using is just for nominal operation points, which is the feeder water temperature is just as T zero.

If you remember, there's a topical report that GE submitted later, and on the review is feeder water temperature operation domain. There's other operating points, and the next step we will do more calculations with those points.

MEMBER ARMIJO: With the feed water variation?

MR. WANG: With the feed water temperature variation, yes.

MEMBER BANERJEE: Is TRACS -- sorry. Is TRACE now able to do these calculations with PARs?

MR. MARCH-LEUBA: The valuation of TRACE for stability is ongoing and very successful.

MEMBER BANERJEE: I looked at some results, which looked very nice.

MR. MARCH-LEUBA: They look fantastic.

MEMBER BANERJEE: Are they actually validated, or does it look fantastic?

MR. MARCH-LEUBA: They look very good. I mean the errors are systematic. So I like a benchmark when the actual -- the results don't match the --.

MEMBER BANERJEE: In fact, it's much more reassuring when they don't.

MR. MARCH-LEUBA: Yes, they don't. And then when you find out what assumptions you made wrong on the modeling, there's very few. We went -- that's a different presentation.

MEMBER BANERJEE: Yes, but in any case, are there any plans to do independent confirmatory work on this very important subject with TRAC?

MR. MARCH-LEUBA: With TRACE?

MEMBER BANERJEE: TRACE, sorry.

MR. MARCH-LEUBA: TRACE ESBWR?

MR. WANG: Right now, it's not yet in plant.

MEMBER BLEY: Could I take you back to your Slide No. 2? The first item on Slide No. 2 you haven't talked about, unless I somehow missed it.

MR. WANG: So it's I-I?

MEMBER BLEY: The flow in the pipe. That was a question, but there --

MR. CHARY: Let me try to address that. This is Mohammed Chary. All we're trying to do with this slide is tell you we've heard you, you had a comment, you wanted us to pursue this and we've asked a question of GE to address this item. We're not ready to get into how we're dealing with this. That's all this was.

MEMBER BLEY: I thought it was an introduction to the PARs.

MR. CHARY: No, this is just we have heard you, you've asked the question from the last meeting that we had or the previous one. I forget which one. That's all we're trying to say on this one.

MEMBER BLEY: I assume you're going to get the isometrics for yourself, to think about that one?

MS. CUBBAGE: Actually not, what you're thinking of.

MEMBER BLEY: Oh?

MS. CUBBAGE: I mean that --

MR. CHARY: Let me just make sure. The isometrics are not the types of documents that we normally get on a docket for applications.

MEMBER BLEY: I understand that.

MR. CHARY: Right, so I wouldn't expect that we would be asking them for isometrics on these systems. We need enough information to make sure that we understand the response, that we've non-condensables in a way, that we've evaluated non-condensables in a way that satisfies us.

But that doesn't mean that we're going to be asking them for isometrics. We don't normally ask for isometrics in these applications.

MEMBER BLEY: We'll be interested to hear how you reviewed their work without understanding the layout of the pipe.

MR. CHARY: Well, I'm not -- understand, understand.

MEMBER BLEY: For next time.

MR. WALLIS: Now can you go back -- since you're on the first slide here, these seem to be questions that we asked quite a long time ago.

MS. CUBBAGE: Actually, yes. I believe

you asked them in January. We sent them to GE attached as RAIs.

MR. WALLIS: And all these questions we've been asking lately about how you calculate the temperature in the wetwell and so on, those are new RAIs or what?

MS. CUBBAGE: Those are old RAIs.

MR. WALLIS: No they're not, because we haven't asked those questions specifically before.

MS. CUBBAGE: How you calculate the temperature?

MR. WALLIS: How do you calculate the wall, what happens in the ceiling and --

MS. CUBBAGE: I think what you heard is there's a bounding conservative approach with some of these parameters. If there's some specific thing missing --

CHAIRMAN CORRADINI: I'm not sure what you're asking Graham. You're saying -- I was going to just -- are you saying the stuff we asked today or the last subcommittee meeting?

MR. WALLIS: These questions we asked in January.

MS. CUBBAGE: Right.

MR. WALLIS: We had a meeting here, and

there's been some other questions raised since then out there or not? You think those are all old questions?

MS. CUBBAGE: I don't know whether they're old or not. All I can tell you is that we asked specific RAIs to GE --

MR. WALLIS: Yes, but I mean these questions about the non-condensables that get hung up in the GDCS pool or above the reactor or something, where GE predicts something different from Melcor. You just -- you're not asking those questions? You're sort of assuming everything's okay because someone has a bounding calculation?

MR. CHARY: Let me go back a little bit to how we do this. You know, why is it that we're here telling you we're asking these questions? Obviously, we want to let you know that we're asking these specific questions that we've asked.

We come here and we present to the committee. There's a lot of dialogue that happens over a day, over two days. We hear a lot of things. We take some things back on our own initiative and we issue questions to GE to get answers back.

The rest of it, we wait for your letter to come out, and if your letter says you have an issue, we'll evaluate that. We'll look at it and we may send them to GE as additional RAIs.

But those specific questions that are on this slide are things that we took back as items from one of the previous meetings and we've asked questions. We don't have responses to these yet.

MR. WALLIS: You heard this morning -- I don't know if you were here or not -- you heard a lot of questions from various people here about how the energy balance, the mass balance, where the steam went, where the non-condensables went, will evaluate throughout the main steam line break.

There were all kinds of questions. Are those old questions to you or are those new questions? Are they going to be part of RAIs if they're not old questions?

MR. CHARY: There was a lot of discussion this morning, and we will take what we think is appropriate to ask in RAIs and we will pursue those, and you need to capture the rest of it, whatever you believe needs to be captured in a formal letter back.

CHAIRMAN CORRADINI: I think if you guys remember, we had the meeting, the two-day meeting in January, and we chose to hold off on this until we had this subcommittee to write a letter.

Then our plan is that after this, we'll decide, talk about it with the full committee tomorrow and Friday, to either write a letter or ask for another subcommittee in May. But we are not going to write a letter this month on this. That was the plan.

MR. WALLIS: But before there's a letter, you don't formally do RAIs?

CHAIRMAN CORRADINI: Well, I think they're in a situation now where they're trying to respond to a number of responses from GE on a whole bunch of things, and they're kind of picking the ones that they're sensing are the big ones from us, and they're trying to get ahead of the game.

But until we write them a letter as we did for the other chapters, they're kind of shooting in the dark.

MR. MARQUINO: Dr. Wallis, there's a lot of dialogue over the number of days that we have with the committee, and we don't take every comment that's made and turn it into an RAI. There's a lot of dialogue, there's a lot of back and forth.

You have comments. GE responds. You have comments, we respond. At the end of the day, we pick the ones that we think are appropriate RAIs and we ask them, and then we wait for your letters to address --

(Simultaneous discussion.)

MR. WALLIS: Well, what concerns me is that when we meet again, if we're going to meet again and we're going to discuss these issues again, you're going to have the same questions from us again.

MR. CHARY: Well, if we're going to meet again on this topic, we will work with you to get the specific issues that you want us to address, and we will come back and we will try to address those issues.

CHAIRMAN CORRADINI: So let me direct this a couple of ways, because we're -- time is passing. So the GE has three presentations. I've recommended to Amy just privately that they have one on stability and oscillations that in some sense mimics or at least is parallel to what the staff and their contractors have presented.

We do that. We take a break. We then have to choose. I want to go through Chapter 18, because there's a whole other contention of GE folks here only for human factors, that we have to do today.

There is a closed session on new data that staff just got on the Canadian experiments, relative to the different -- I should say the new ESBWR fuel bundle, and we can choose to look at those now or wait, okay.

There's also additional work on a third topic, which right now escapes me off the top of my head. But I don't think that it's possible that we can go through all fo those today. So my proposal is we have the presentation that mirrors what staff has just presented on oscillations, take a break, and then decide -- then I propose to do Chapter 18.

MEMBER BANERJEE: Can I ask you something, Mike, on this? So we're getting new data on predicting heat flux.

CHAIRMAN CORRADINI: Just arrived a few days ago.

MEMBER BANERJEE: Okay, fine. Now all this is going to filter into the process of the critical power issues and what is done for normal operation, transience, this, that and the other.

Presumably that's going to be a separate presentation at some point, that we will deal with at --

CHAIRMAN CORRADINI: Yes. We have gone long enough today that we don't have time to see. Again, it's a closed session presentation.

MS. CUBBAGE: Our plan is GE to do a

stability piece. It's a couple of slides, Chapter 18 and if there's any time left, we can go into closed session to briefly describe to you this report that was provided to Dave Bessette a few days ago.

You may or may not have it in your possession, but you know, that topic is an open item in the Chapter 4 safety evaluation report.

When we come to you with the final SER, we would need to explain how that issue was closed, as with the containment peak pressure. That was a primary open issue the staff still has in the Chapter 6 SER. So at this point --

MEMBER BANERJEE: Well, I don't know what is common in each of the chapters, but as long as things like critical power issues and all are covered in some detail after we've looked at these reports, and then there is also the issue as to whether, what sort of material they have, if there's any additional material measurements of void fraction in these bundles.

CHAIRMAN CORRADINI: Right. But I guess the path forward that I see is that we're going to have to decide, given the information we have, should we write a letter and give them some official feedback on Chapter 4, 6, 15 and 21, or have another subcommittee?

MEMBER BANERJEE: So where is critical power issue?

CHAIRMAN CORRADINI: Chapter 4.

MS. CUBBAGE: Chapter 4. I believe it's the intent of the new data to confirm what you've already seen, in the form of a correlation.

CHAIRMAN CORRADINI: Well, we should get the report and look at it, since they just received it, staff just received it themselves a few days ago. Should we go ahead now with the one presentation by General Electric? Then we'll take a break.

MEMBER BANERJEE: Where are those palm trees, by the way?

CHAIRMAN CORRADINI: Bermuda.

MEMBER BANERJEE: Not Santa Barbara, right?

MR. MARQUINO: I'm Wayne Marquino of San Jose. I'll try and give you a flow while we're setting up the presentation. In the review of the ESBWR stability application, there was a lot of discussion with the ACRS on the role of the chimney in stability, and numerical damping in the chimney.

In particular, there was a letter from GE. It's letter MFN-060336, where we use a finer nodalization with more nodes, and we show that we could essentially eliminate numerical damping in the chimney.

We got the same decay ratio in that case, as in the base case with our coarser nodalization. Based on that, we've proceeded with the coarser nodalization, since it doesn't have an effect and it's the same nodalization that we use from AOO analysis. So in the mechanical execution of our calculations, it is an efficiency improvement for us.

During the last meeting in January, there was a question raised on the GENESIS test, and you pointed to a paper that had been submitted at the NURIF Conference in Pittsburgh. We've gone back and re-executed the case that had been submitted for numerical damping in the chimney, and that's a lop oscillation case, where we magically changed the void fraction in the chimney and the downcomer, and we take mass out of the downcomer, put in the chimney, so that we retain the total mass in the vessel, but we have a perturbation of the density head and then we watch that cycle through.

MR. WALLIS: This is with the fine nodalization or is this --

MR. MARQUINO: This is with the fine

nodalization.

MR. WALLIS: So the Courant number is one or something? Is that the idea?

MR. MARQUINO: Yes.

MR. WALLIS: Thank you.

MR. MARQUINO: Next slide please. So with this -- George, can I borrow that? So what we are showing here is that in GENESIS, they had a simulation of neutronic feedback, and they were also able to turn that feedback off and just run the facility with a constant power.

When they run it with neutronic feedback, they see characteristic frequencies similar to what we calculate with TRAC, .7 hertz. When they turn the neutronic feedback off, they see a frequency of .1 hertz. So a loop long period characteristic.

When we turn off neutronic feedback in TRAC, we see the same thing. So we are producing frequencies that are very similar to what was measured in the GENESIS facility.

CHAIRMAN CORRADINI: Remind me. I'm sorry, but I should remember this. The GENESIS facility. Is this the one in the Netherlands?

MR. MARQUINO: Yes, this is the one in the Netherlands. It's freon and basically it simulates a single channel and a single chimney.

CHAIRMAN CORRADINI: Thank you.

MR. MARQUINO: Next slide, please. So this is reiterating the numerical damping. I went into this in more detail in the stability ACRS review, but with our coarse nodalization, the perturbation at the inlet to the chimney doesn't go all the way through, and it's somewhat damped at the exit.

When we apply a finer nodalization, we're able to eliminate numerical damping and we've explained before, it doesn't have an effect on our core decay ratio calculations, because that's driven by the fuel channel response.

(Off the mike comment.)

MS. CUBBAGE: Mike.

CHAIRMAN CORRADINI: The mike.

MR. WALLIS: I'm sorry. If you go back to Slide 3, I think you have a calculation somewhere, where the two frequency is combined? You can actually site both of them, and the big one decays and the other one decays?

MR. MARQUINO: That's right.

MR. WALLIS: But they're both there together?

MR. MARQUINO: Yes. So that's all I had.

I did want to answer that question that came up.

MR. WALLIS: That's very helpful. Thank you.

MR. MARQUINO: All right, thank you.

CHAIRMAN CORRADINI: Questions?

MEMBER ABDEL-KHALIK: On Slide 3, are these really a percentage of the average flow? Maximum amplitude is less than one percent?

CHAIRMAN CORRADINI: I'm glad somebody else has to do that.

MR. MARQUINO: That's percent of the initial flow.

MEMBER ABDEL-KHALIK: So these are just tiny variations in the flow rate?

MR. MARQUINO: Yes. It's kind of -- I think it's kind of arbitrary what magnitude of perturbation we apply. We've done, in the full stability review, we did a lot of sensitivities on what the magnitude of perturbation is, the pulse width and also whether you perturb flow, pressure. It didn't make much difference in terms of the decay ratio.

MEMBER ABDEL-KHALIK: (off mike) Well, how do you appreciate that instability in TRAC G? Sorry.

MR. MARQUINO: Usually in TRAC G, we perturb the inlet velocity to the fuel channels.

MEMBER ABDEL-KHALIK: And usually you do that by what percentage?

MR. MARQUINO: I think it's about one percent. It's a relatively small perturbation.

MEMBER ABDEL-KHALIK: Well if I recall, it's ten percent.

MR. MARQUINO: I'll have to check on that. Your memory may be better than mine.

MEMBER ABDEL-KHALIK: I think it would be a good idea to verify this TRAC.

MR. MARQUINO: All right. I'll get back to you on that. So the question is what's the perturbation in Chart 3 and what's the perturbation in our normal stability calcs?

MEMBER ABDEL-KHALIK: Correct.

MR. MARQUINO: Okay.

MR. WALLIS: What's the perturbation in GENESIS?

MR. MARQUINO: I do not know.

MR. WALLIS: I think it's bigger than this, but again, we'd have to look it up.

MEMBER SIEBER: (off mike) The chart on page four, if I ignore everything after that. Wait a second. Increases in --.

MR. MARQUINO: On Chart 4, it's showing the flow perturbation moving up the channel.

MEMBER SIEBER: Okay. The second cycle is larger than the first, and that is damped. I was curious as to why that happened?

MR. MARQUINO: I think that has to do with the -- we changed the void fractions in two regions, in the downcomer and the chimney. So I think this is showing the time lag that it takes the void to cycle around into the chimney again.

MEMBER BANERJEE: Yes, it's an interesting point.

MR. WALLIS: It grows and then suddenly disappears.

MEMBER SIEBER: Yes. I can't think of any reason why it should do that.

MR. MARQUINO: So the question is why is the -- why is the perturbation larger at five seconds than at two seconds?

MEMBER SIEBER: Yes.

MR. WALLIS: And then why does it suddenly disappear between 6 and 12?

MEMBER SIEBER: Right. That's magic. I know about magic. It goes away.

MEMBER BANERJEE: What is the magic?

MEMBER SIEBER: The magic is it goes away all together in the second cycle.

MEMBER BANERJEE: Why? That was the question, I think.

CHAIRMAN CORRADINI: Other questions. Okay, thank you very much.

MEMBER SIEBER: I guess we should understand this.

CHAIRMAN CORRADINI: So I would propose that we take a break for a few minutes, all right.

MEMBER BANERJEE: Just what is the transit time for the perturbation? What is it?

CHAIRMAN CORRADINI: And then we'll come back with Chapter 18, Human Factors.

MEMBER SIEBER: In how many minutes are we due back?

CHAIRMAN CORRADINI: Ten, ten after. Return at ten after.

(Whereupon, a short recess was taken.)

CHAIRMAN CORRADINI: Mr. Jenkins, are you the --

MR. JENKINS: Yes.

CHAIRMAN CORRADINI: Organizer here?

MR. JENKINS: Yes sir. My name is Tom

Jenkins, and I manage the human factors for the ESBWR program, and we're going to run through that program, Chapter 18 and go from there.

So we'll go, we'll dig right into it. This is the draft concept of our control room, and it's a highly digital plant. You can see that most of it is computer screens, and I don't have a pointer, but I'll try to walk you through some of it.

If you look at the left-hand side of the sitdown console, you'll see the safety-related screens. No, down below. There we go, thank you. Then there's a redundant set of screens on the side panel, just to the left of it.

That represents the safety-related systems in the control room, including some dedicated switches and hard wire controls, but mostly computer-driven.

If you go to the large panel, what we call the wide display panel, that is all non 1E equipment driven from our non-safety related distributed control information system. That's all dynamic. It's huge VDUs and we intend to use that throughout the operation of the plant, in different modes of plant performance.

So start up will have its own set of screens. Normal operations, shutdown, refueling. So we consider that a substantial advantage. The sitdown console is patterned after some of our other work, including our advanced BWR work, and it's a number of screens running right to left.

It's in dual pairs of VDUs, because part of this design concept is heavy use of computerized-based procedures. So we'll be putting those procedures on the screen at the same time that the operator is operating with the other screens.

Right now, there's a large number of screens, but we'll be, as we go through our program, we'll be evaluating whether we really need that many screens. We've identified an outer envelope, we think, of the construct.

Let's see. What else did I have here? On the right-hand side, there's another control panel, and that's for functions that are rarely used or in some cases just used at start-up. So they may be on there, the generator, synchroscope. Certainly the fire protection is going to be on that side panel, and possibly some other generator controls, diesel generator controls potentially.

In the back there is the senior reactor operator's desk. It's kind of horseshoe-shaped. Partly we take advantage of the real estate there, to have a place for the reactor operator, I mean the reactor engineer on the left-hand side, and other folks visiting the control room on the right-hand side.

Okay. So that's as much as I had to say about this slide. Yes sir.

MEMBER BLEY: That big panel is clearly visible from the central area, there where the --

MR. JENKINS: Yes sir, and we have -- we're doing all the anthropometrics on that. It's very similar to what we did on our Lung Min (ph) plant, and we fit the same anthropometric envelope that Lung Min had developed.

MEMBER BLEY: Now none of this is in the DCD?

MR. JENKINS: This picture is not in the DCD.

MEMBER BLEY: Or any of the kind of detail that you were just telling us?

MR. JENKINS: That's correct, that's correct.

MEMBER BLEY: Is it going to be or is that a ITAAC item or --

MR. JENKINS: That's an ITAAC item.

MEMBER BLEY: That follows design cert?

Is that how that works?

MR. JENKINS: That's correct. So this is a program that gets certified, and then we apply that program, and then we come back in through the inspection test and acceptance criteria. We resolve it. We follow the program.

MEMBER BLEY: Okay, now that's my impression of essentially everything in Chapter 18 in this program.

MR. JENKINS: Uh-huh, that's correct.

MEMBER BLEY: So everything in the design cert is programmatic; nothing real until --

MR. JENKINS: Well, except that as we walk through the program, we'll be trying to close some of those ITAACs even before we actually get the certification.

MEMBER BLEY: But that's not a requirement for the certification?

MR. JENKINS: That's not a requirement, no.

MEMBER MAYNARD: What's the purpose of showing this dead space under the floor?

MR. JENKINS: Oh, that's just where they'll be running cable work. It's an elevated floor. This is the actual design that we have internally for our use.

MEMBER ABDEL-KHALIK: So would all the alarms and enunciators show up on the big screen, or would some of them show up on one of the many screens?

MR. JENKINS: Well, there's various forms of alarming that will be done. There will be on the large panel, similar to what you have in existing plants, alarm windows. They'll be in soft control, but they will be there.

They will direct you to other areas of the control room or the seated areas, where you'll have detailed alarm response procedures and scrolling alarm screens, and all of that is in process to be thoroughly fleshed out in the human factors program. We'll be picking up some of the new things in the industry on how to deal with those alarms.

MEMBER ABDEL-KHALIK: So whatever is on the small screens will be essentially amplification of something that is exhibited on the large screen?

MR. JENKINS: Yes, yes, yes. So you may see a flashing valve on the large screen and you'll jump to the system on your smaller screen if you don't have it already up, right.

MEMBER BLEY: Do these things come in from local digital systems to the boards, or do they all get processed through some control room computer before they're up on any screen?

MR. JENKINS: Well, there's various levels of control system and computers, and when you do Chapter 7, I believe they'll march through all those layers. There's certainly a display layer and a controls layer, and there's actually several different layers.

MEMBER ABDEL-KHALIK: We'll get the detail on that in Chapter 7.

MR. JENKINS: That's correct.

MEMBER MAYNARD: Again, what is the overall intent of how much of this is to be done in the design certification stage, versus COL? It looks like from what I'm seeing and what you're saying, a lot of this is just -- this is a commitment to do a good job in accordance with the regulations on this.

I'm trying to figure out what our role is in reviewing this, and what do we come out with at the end of the design cert stage?

MS. CUBBAGE: Sure. I mean from a staff perspective, I can tell you that we do have a few slides to explain the design acceptance criteria or DAC process, where this all gets verified. The design gets completed in accordance with the process that's been approved. So at this stage, it's more of a process that we're going to be reviewing and approving, and then the design gets fulfilled through the ITAAC process.

MEMBER MAYNARD: Why do this chapter this way and not for the other approach? I mean you could almost take that approach with --

MS. CUBBAGE: The Commission has set policy in this area, where in the control room design and I&C, because of the rapidly-evolving technology, because a certification lasts for 15 years and then after that, a combined license applicant would take some period of time to build the plant, you could have as much as say 20, 25 years down the road before the plant comes on line. So the technology is expected to evolve.

MEMBER MAYNARD: Okay. I understand.

MR. JENKINS: So I just wanted to spend a few minutes on our approach to this, and what objectives we had, as it is programmatic. First and foremost, of course, is compliance with applicable regulatory basis. It goes without saying. I think the staff is going to discuss that a little deeper.

The second item up there is elimination and mitigation of human error. I'm certain that's embedded in it. I think keep in mind this is beyond just what is done in the safety systems, but it's well what also occurs in the secondary of the plant, because we're protecting the safety, but we're also trying to protect the efficiency of the rest of the systems.

So it does cover things like inspection and maintenance, and how that relates to the operability.

Then part of our development here is that we're trying to reduce the number of design iterations, particularly in detailed design on needs to add instrumentation late in the plant project or a change of display graphics and those things.

So this top-down process I'm going to speak to in a few minutes, is heavily focused on trying to reduce the number of iterations.

MR. WALLIS: When you do those iterations, do you have -- sorry. When you do these iterations, do you have some sort of criteria you're trying to meet, in terms of the level of human error and operability risk? How do you know when your design is good enough?

Has it met some sort of criteria which says the probability of human error is below some level or something, or is it all just that it feels good?

MR. JENKINS: Well, it's not just that it feels good. There are quantitative measures and they're sort of -- not sort of. There are risk assessment measures in our human reliability assessment. But I'm going to talk in a few minutes about the verification and validation of these efforts, because I think that's --

MR. WALLIS: Because when I read the SER, I was full of the same sort of refrain all the time, which was saying you've set some sort of high level discursive objectives. But there's no indication of how you're going to analyze them in order to meet them.

It kept on repeating throughout the SER. I could give you quotes here, but I mean the same -- yes, you've set these objectives which sound good, but you haven't put in place a mechanism to make them happen.

MR. JENKINS: Well sir, I don't know if you've had a chance to review all the plans that have been submitted in licensing topical reports, but there's a thousand pages of plans. That's quite literal. There are a thousand pages of plans that describe every step of the process that I'm going to walk you through in a few minutes.

I also wanted to mention that we do consider this a process that helps to integrate the plant design in many areas. It is cross-functional with many of the other disciplines, very much like the PRA and some of the safety analysis work. It touches all aspects of the engineering design process, and we take advantage of that.

Then last, we also take the opportunity to bring in customer requirements at an early stage of the development. This is done like what's done in airline industries and many other industries.

So at the center of our program is the concept of human-centered design. This is terminology right out of our new Reg 0711. But basically, it simply says that all of design aspects should think about operability.

Again, it's not all that unusual. It's very much the military's been doing this for many, many years. We design the helicopter around the helicopter pilot, as a key and critical part of the overall function.

So the new regs that define the guidance, new Reg 711 and 0700, and I'm just going to quickly walk through some of those materials shortly. It includes all the plant systems that are germane to the safety and economic operation of the plant, including what gets displayed and operable from the main control room, the technical support center, the remote shutdown system and safety-significant local panels. So those are the panels out in the field.

As well our group has the organizational design authority, which the staff looks for very carefully. I'm on the same level as my peers in mechanical and electrical and I&C systems, to help drive human factors requirements into the rest of the design process.

MR. BONACA: You don't have yet EPGs developed, right?

MR. JENKINS: Yes sir.

MR. BONACA: You do?

MR. JENKINS: No, we don't have EPGs today, but we will, yes. I mean Wayne Marquino from GE spoke earlier about the development of EPGs, but they are an integral part of the human factors process as well.

MR. BONACA: Because I mean some of the location of the instrumentation may be keyed on some critical EPG.

MR. JENKINS: That's exactly right, and you'll see as we do this, early development of this instrumentation is critically important.

I've got another slide to walk you through when that happens. There was a question over here I didn't quite hear, sir?

MEMBER BLEY: No, go ahead.

MR. JENKINS: Okay. The new reg is rather prescriptive on suggesting what a team of human factors folks might look like, and I'm going to walk through that just quickly. But it is multidisciplinary and very comprehensive.

Then we also track issues that are developed out of human factors, in a process that drives for resolution.

I would like to jump to operating experience. Certainly, we have a program that captures operating experience from not only the existing BWR fleet and non-BWR nuclear power plants, but we also look outside the country.

We have spent quite a lot of time looking at the performance of the ABWR in Japan. We've talked to the French folks who have got quite a lot of digital equipment in the N4 plants, and in the non-nuclear industry, we've been talking to people who run fossil power plants, as well as -- I'm jumping ahead, but in the interest of time.

We collect predecessor plant data, and that is what were the design basis for the previous BWRs. Most notably, the ABWR and the SBWR, where we developed some simulation of these processes.

The ABWR for Lung Min follows new Reg 0711 Rev 1, and we've built upon that in our development here in Rev 2.

MEMBER BLEY: Can I ask a question about that?

MR. JENKINS: Yes.

MEMBER BLEY: You cited the Japanese experience with the ABWR and the DCD talked about that too. Are you really getting real information out of the Japanese plant?

(Simultaneous discussion.)

MR. JENKINS: Yes sir. I think you'd be surprised. What happened here is that we took a trip there that was well organized in advance. You recall that we have a Japanese partner, Hitachi. They hosted us quite well.

We went with a questionnaire of 50 questions. They answered them rather clearly. So it's mostly verbal. But they also gave us some

Japanese material that we had interpreted with some help, and yeah, it's a substantial report on their experience.

Just to give you one example, they changed the size of the screens after they had the VDU screens themselves. They were too small from the original design. That plant had a black background for those wide display panels with a contrast experience with that, versus the green background that we had in our Lung Min, Taiwan plant.

So there's several questions we went there with, and we got some pretty good answers. We were surprised that we could get such answers. We didn't expect that.

MEMBER BLEY: I think the one in Taiwan's not running yet, right?

MR. JENKINS: That's correct.

MEMBER BLEY: But are you getting information somehow? Are they having operators interact with --

MR. JENKINS: Oh yes. We are -- in fact, we just recently completed the site acceptance test of the simulator, and they've been running plant operators through the simulator, and we have collected experience from that as well. Yes sir. They've been, I think, quite supportive.

Okay, let's move on. Now this is a bit of an eye chart. If you can look at your paper, this chart comes pretty much derived from the new Reg 0711.

MEMBER BLEY: Before you start on that --

MR. JENKINS: Yes.

MEMBER BLEY: This page, the previous page, you talk about -- the previous page you talk about the operator participation in the control room design. I've been involved in three of those projects, and that's probably the most important thing.

I would also use the operator as well as senior operators, because they're the ones that day to day have to manipulate the controls. I think you need your procedures before you design the control room.

MR. JENKINS: I think --

MEMBER BLEY: Everything should be in order if you can do it that way.

MR. JENKINS: So I'll jump ahead. We have 21 senior reactor operators on our staff, and that's representing more than -- that's 21. That represents more than 400 years of senior reactor operator experience.

MEMBER BLEY: And they're current?

MR. JENKINS: They are current.

MEMBER BLEY: Not used to be.

MR. JENKINS: They are current.

MEMBER BLEY: On actual operating plants?

MR. JENKINS: Yes sir. Out of -- I got several out of the Brown's Ferry restart. I have several from Brunswick, and I have several who have had experience with digital upgrades at power plants. Put in either fuel water cold system upgrades --

MEMBER STETKAR: That's not an integrated digital upgrade. Do you have any experience with people who have gone through complete digital upgrades, as have several plants internationally?

MR. JENKINS: I personally have. I worked at the Temela plant in the Czech Republic, and we learned quite a lot out of that.

MEMBER STETKAR: You worked at Temela? Okay.

MR. JENKINS: Yes. I was directly involved in the independent V&V of the I&C system that Westinghouse established there.

MEMBER STETKAR: By the way, I certainly didn't get the impression of the depth of operating experience that you have on the team from the information in DCD, where in fact in the DCD, it's notable that the operating experience requirements on the team are much less than any other discipline.

The DCD indicates that you need an SRO with two years of operating experience, where everybody else needs at least four years of experience. So I didn't hear that you have that.

MR. JENKINS: We were very aggressive at this, because for a number of reasons. Firstly, we asked for utility SROs from our customers, and they supplied four actually, who've been living with us from day one.

They're in our offices; they work under our procedures to develop the HFE. But going beyond that, the engineering management for ESBWR is an ex-SRO and plant manager from Brunswick, and that has certainly helped us to gather that experience.

MEMBER STETKAR: Well but again, ex-SRO and plant manager isn't the same as a real reactor operator. I'm an ex-SRO, but I never sat on the boards in my life, except for one night.

MR. JENKINS: Well, I'm referring to -- I'm referring to licensed operators who stood watch.

MEMBER STETKAR: Stood watch.

MR. JENKINS: Including our engineering manager.

MR. STADDLE: Actually, because beyond that --

VOICES: Use the microphone.

MR. STADDLE: I'm Rick Staddle. It actually goes beyond that, because we also involve the current operators at our customers in our review of these topical reports and also the RAI responses. That's built into our process as well.

MEMBER STETKAR: That's a lot better.

MR. JENKINS: Thank you. The next slide. So again, this comes right out of the new reg. I just want to walk through this as quickly as I can. Across the top are design inputs. Certainly, the DCD, heavy influence from the probabilistic risk assessment and its associated human reliability assessment.

Again as well, a heavy influence of operating experiences, and that includes going through databases like the INPO database and the NRC database, as well as OE from outside the industry.

The element there called the baseline review record, BRR, is our internal collection of previous BWR designs and design data. Then the D3 is the Defense Indepth and Diversity Analysis of the I&C system, and that is to deal with common cost failures of the DCIS.

All of that is fed into, and more, is fed into our operational analysis, going to the question earlier the gentlemen asked this. This is where we determine how this plant will be operated.

It begins with the functional requirements analysis, FRA, identifying exactly what functions we need, what sort of redundancy we desire. We then jump into the allocation of functions, where we determine whether that function is going to be automatic, manual or both, and most of the elements here are both.

Finally is the detailed task analysis, and this task analysis walks through every system and determines point by point how will those valve line-ups be, what pumps get started first. It's very specific and it leads to procedures, to your earlier question.

That's similar to a job task analysis, but it goes beyond that. It does convert rather carefully and closely to the actual procedures of the plant. It also develops concepts and requirements that go into the staffing and qualification of the operators.

We do begin with a baseline, but then we have the ability to modify that baseline for particular skills sets or education. We circulate on these things more than once, including things like the

HRA, where we're going back and forth with the PRA folks as the detail plant design evolves.

Going beyond that, they feed into three big boxes. In the middle there is the human system interface, and this is the primary interface with the operator. This is all about the development of alarms, the development of how the screens look, how do you interact with the computer-based procedures, as well as what does the lighting look like, what does the furniture look like, very much of the anthropometrics and ergonomics you've heard of before.

We have developed a mock-up of how this will look. It's in foam board at the moment, but it will be replaced with plywood that will include the mounting of display units, and then of course we are building a part task simulator as we speak, that will simulate most of the plant functions.

MEMBER BLEY: I've got a little bit of a general question for you. With this new design you're working with, with all digital I&C systems and control systems, can you tell me just a little bit about the interaction between your group and the group that's doing Chapter 7, and now you have a machine that really has an integrated control system that's a little different from the machines before, where operators knew the machine well and the I&C was kind of an overlay.

Your possible problems, I'm guessing in the I&C, can lead to a machine that might not respond the way just the hardware system would, and how is that being factored into your derivations?

MR. JENKINS: Well, we have another slide on it, but let me jump ahead. So we develop requirements for the I&C folks, including response requirements. How fast does a display need to update? I mean it goes well beyond that. What do colors look like? What does symbology look like?

So we developed those requirements. They go into the I&C system. They're partly -- they're wholly tracked by the software QA elements of the I&C production. Then we come to the back end of it, and we do verification and validation, that they've implemented the design that we specified.

So we're a specifying group.

MEMBER BLEY: Well, one last question. Coming back the other way, you had to work with the idea that failures, faults in the digital systems, either software or hardware, how that can affect the operator and how that works into your procedure planning?

MR. JENKINS: Yes sir. So again, it's been part of our working together with them. But to give you an example, one of the requirements that we've developed is that if you have loss of communication with your digital network, okay, we want to see that clearly in the operator's face.

We want him to have, you know, some color code or some flashing mode that tells us that he's lost communication on a particular parameter or a group of parameters. So we're back and forth with them rather -- well daily, I would say.

MEMBER BLEY: Are you co-located with them?

MR. JENKINS: I'm sorry?

MEMBER BLEY: Are you co-located with them?

MR. JENKINS: Well no, except that they have staff that are co-located with us. It's a small staff, but --

MR. WALLIS: Can I ask you something here? I'm trying to follow this process. We heard this morning that lots of other things that are analyzed in the DCD are conservative analysis for various regulatory purposes.

When you get down to a simulator, I would think you'd want to have a realistic model of what happens?

MR. JENKINS: That's correct, sir. It's a best estimate model.

MR. WALLIS: Right.

MR. JENKINS: Yes sir, that's correct.

MR. WALLIS: And it may be rather different from what's in the DCD then?

MR. JENKINS: That's right, and in fact, you asked earlier about the EOPs, and how those procedures are developed. Well, they're developed in this process. They use a best estimate simulation to decide what are the operator actions that would be taken within that first 72 hours, for example.

MR. WALLIS: So when you're on the simulator, the pressure in the wetwell doesn't follow the curve which is in the DCD then presumably?

MR. JENKINS: Well, I can't answer that specific. Our guys have run out, I think.

MR. STADDLE: Yes. A lot of these things come out when the operators perform the task analysis. So we're developing the simulator. We're building the simulator in parallel with this whole HFE process. So that's why we're using part task simulator, to kind of learn from how -- what the operators need to see in order to respond to the various events.

We take those, and we feed those back into not only the simulator development but also the plant development processes, so that we can evolve the design.

MR. WALLIS: So the accident to which they are responding is a realistic accident. It's not the design-basis accident. It's something which is more realistic than that?

MR. JENKINS: Yes, and let's leave that for the safety analysis folks to answer. But sir, our approach to the simulator build is that it will have TRAC as its middle point, and it will be running the best estimates decks of TRAC, if you will.

MEMBER BLEY: Can you fill in the gap of my knowledge? What's a part task simulator?

MR. JENKINS: Well, this ANS 3.5 now has an appendix that describes what is a part task simulator. So it may be part, in terms of the number of systems that it models. But those systems are modeled to the full fidelity of what you find in the rest of the ANS 3.5 requirements.

Okay. So again, it's critically important to understand that both the procedures, the plant design, if you will embodied, in simulation and the training program get validated and verified as a composite holistic set. Then there's feedback to the rest of the plant design on do we have to address procedures? Do we have to address the human system interface? Where do we have to add instruments, as someone asked earlier?

MEMBER BLEY: Have there been cases so far where your work has led to some modification in the design?

MR. JENKINS: There have been cases where we have recommended modifications to the design. They are still under consideration, whether those recommendations will be made. But I'll give one example where it was made, and that is that there is a new floor plan layout for the control room.

We've moved some walls around and that will be an update in the next DCD update. So that's direct impact of actually the application of 0711, and operating experience.

MEMBER ABDEL-KHALIK: If TRACG is going to be the heart of the modeling engine in the simulator, how would you independently validate it?

MR. JENKINS: Well, this is always a question in simulation, especially as it relates to training simulators. The validation is not meant to be the same level as safety-related validation, okay. It isn't. But we will have a simulator validation that walks through various scenarios.

Again, if you look at ANS 3.5, it defines the acceptance criteria of those scenarios.

MEMBER ABDEL-KHALIK: But it's defined in terms of percentage difference between --

MR. JENKINS: Yes, it is.

MEMBER ABDEL-KHALIK: --the simulated values of the parameters. But what other tool are you going to compare against?

MR. JENKINS: You mean in terms of other codes?

MEMBER ABDEL-KHALIK: Right. I mean if this is the best tool you've got, and it's the heart of your simulator, what are you going to apply these acceptance criteria in ANS 3.5 to?

MR. JENKINS: I will have to get back to you on that question, with the safety analysis folks and whatever tools they're going to use. There is a process within GE for code validation, and it will be applied here. But they're the right folks to answer that question.

MEMBER ABDEL-KHALIK: Okay.

MEMBER STETKAR: Tom, I need some help

getting something straight in my mind, and that is if I place an order for ESBWR today --

MR. JENKINS: Thank you.

MEMBER STETKAR: You're welcome.

(Laughter.)

MEMBER STETKAR: Is there today, could you show me the control room design, and then tell me how?

MR. JENKINS: No.

MEMBER STETKAR: You could not?

MR. JENKINS: I could show you the mock-up; I could show you our conceptual design that I'm showing you here. But it will go through several iterations before it's finalized, including -- let me give you an example of capturing later technologies.

We haven't yet decided whether those screens will be plasma or they'll be LCD or real projection LCD.

MEMBER STETKAR: Those are small details compared to the bigger things that Dennis alluded to, and that is if I'm an operator, one of my operators, because I'm ordering this plant, needs to know how to interact with the integrated digital instrument control system.

How do I reset signals? How do I override certain signals? Under what conditions? What type of human interaction does that take? I don't have any idea how that will be done right at the moment, do I?

MR. JENKINS: Except for specific areas, and you mentioned overrides, the nuclear instrumentation, for example, and its bypasses are still done in basically four position toggle switches that are on the left-hand side of that.

MEMBER STETKAR: I'm talking about larger, larger integrated --

MR. JENKINS: Right, right. That's going to be evolutionary.

MEMBER STETKAR: Thanks. That helps me at least to get a picture of where we are, specification versus design versus something that's actually real space.

MR. JENKINS: So, okay. Let's move on to the next screen. I can't read this, but basically the skill set, it comes out of the definitions as established in the Reg 07 web, and then what I wanted to do with this slide is show you how we apply those skills sets to each of the various activities.

MR. WALLIS: Do these people have to know anything about thermohydraulics?

MR. JENKINS: Well, there's certainly the plant operations. But don't leave out this system engineer column, if you see that second column there. That system engineer comes from the mechanical part of the project. It comes from the safety analysis part of the project. That's a generic term for other disciplines.

MR. WALLIS: Well, I was intrigued, because on Side 4 you said you were integrating HFE into all engineering disciplines.

MR. JENKINS: That's -- well, there's not a lot of impact to civil, for example, but some, as the example I just gave of the changing around the control room structure.

MR. WALLIS: So do these guys read the DCD or something? What do they do?

MR. JENKINS: Yes. They study the DCD. They participate in design reviews. They're trained in all the same procedures, yes sir.

MR. WALLIS: So they pretty well understand a lot of the technology, how it works and where the energy goes and where the vegetables go and things like that?

MR. JENKINS: A large percentage of the reactor operators, for example, are degreed engineers, and have been system engineers in their previous life. They do get loaned out to other groups to assist in some ad hoc issues. We've had one of our engineers heavily engaged in some of the DCD revisions that are going on right now.

Okay. I think we've got so much more to cover. The next slide really does try to address your question about the design integration, and the -- so these boxes are color-coded to show which disciplines are engaged in this particular example.

The operating experience review, for example, is actually managed by the system engineer, mechanical engineer, electrical engineer. We support him; we provide him with the tools. We do a lot of the searches for him. But he owns the answer and the result there.

This is not a sidebar project. This is integrated deeply into the plant system development. Moving right along, as we go down that path, requirements coming out of our functional area and allocation and task analysis do get embedded in the system design specs, that again the system engineer owns, as well as drive into the I&C logic development in the green boxes.

Then you see that we come back and we're responsible --

MR. WALLIS: These remind me of the

various sections of your document and of the SER. There's FRA, gap analysis, function allocation, task analysis and so on. When I read the staff conclusions on almost all of these items, I saw the same things I said before, that you've sort of put in plans at a very general level, but there aren't any specific criteria for analysis. Are you going to give more specifics in the future?

MR. JENKINS: Again, I could let staff discuss that, but we've submitted a thousand pages, and behind each of those thousand pages there are the work instructions and other work plans.

MR. WALLIS: It just didn't get, didn't come to the surface somehow?

MR. JENKINS: Yes, that would be my opinion.

MEMBER ABDEL-KHALIK: But there are systems that heretofore have not been built anywhere.

MR. JENKINS: I'm sorry?

MEMBER ABDEL-KHALIK: There are some systems that don't exist in any other planes.

MR. JENKINS: That's correct.

MEMBER ABDEL-KHALIK: So where do you collect the operating experience the guides the civil engineer?

MR. JENKINS: Okay, so our group has done a review, for example, of DODOWR. DODOWR came up earlier in this conversation. We've also done a review of some of the older plants that did have, for example, isolation condensers. So we do collect operating experience anywhere and everywhere we can get it.

Let's jump to the next page, and this goes to the question that was asked earlier, about what is our integration with the I&C and the software development.

I briefly explained on the bottom there is the software life cycle. That's a Chapter 7-described process, following IEEE standards for software development. On the top there is the HFE process, and we're just showing some very specific interface between those two processes.

They're also embodied in the main MMIS, that's man-machine interface system human factors engineering program plan that describes this back and forth.

On the top level, it means we're sending in requirements, and they're verifying and validating those requirements as they're being developed.

I missed on the bigger chart, I missed one element that I'd like to talk about here, and that is that computer screens can be changed, right? It's not so hard to change what a video looks like. But this program has, is referred to as Human Performance Monitoring.

It goes into the plant. It's a plan that the operator absorbs from our process, and he has to maintain that design basis. So that means that if he makes or suggests that he make modifications, he actually has to back up and go through these earlier elements to convince the staff that he is still following the overall plan.

MEMBER BLEY: Could you give us an example of something like that?

MR. JENKINS: Yes sir. So before, you made a substantial change to maybe how the piping looks on a safety-related screen. You would go through an analysis that says does it still support how the task analysis was written? Does it still support the procedures that were constructed, and then can you test it in a simulator with operators, and determine that it still meets the criteria?

You can include evaluating if he made -- in that first evaluation, did he make errors trying to use the system. You can actually capture that with a good simulator, and that's what we're building here.

Let's jump to the next one. I've already mentioned the LPRs and the staff is not just reactor operators. There are human factors engineers; there are simulation engineers; and human system interface design folks. Some of those HSI folks are I&C-based folks, with a lot of years experience.

Then there are two people assigned to our group, that interact with the PRA and the HRA groups on a regular basis. But they are trained in HRA and they are trained in PRA, but they're assigned to my group.

We've hosted three audits from the staff, demonstrating compliance, reviewing interim products and detailed work instructions and methodologies. So back to the question earlier about where's the detail.

We've been able to show them some interim products similar to some we showed here today. We've established the integrated engineering process in a formal way within our project, and we have developed an integrated schedule, again capturing the logic that you've seen in these previous charts.

We've established the issue tracking system. I've covered the other elements. Go ahead. I've already mentioned the visits to Japan, the ABWR review, the French Connection, if you will. We did back on the SBWR development we go to France.

INPO recently went to France, and we have their result from their benchmarking study. We also made some calls to France recently about their use of computerized procedures and their use of touch screens. They have abandoned touch screens, and they are still refining how they use computerized procedures.

MEMBER BLEY: Why have they done that?

MR. JENKINS: I'm sorry?

MEMBER BLEY: Did they tell you why they've abandoned the touch screens? What kind of problems did they have?

MR. JENKINS: Yes. They had reliability problems. They were replacing them quite often, and of course you need to keep in mind they had -- they've been in operation for 10, 12 years already. So they're wearing out, if they were good to begin with.

MEMBER BLEY: Touch it and it doesn't work.

(Laughter.)

MR. JENKINS: I've already mentioned -- I did also go to Boeing. We looked at how they use interacting devices at Boeing. They use a fixed touch pad on the pilot's right hand, and they also use for the equivalent of their flight bag, they have a touch screen on the left-hand side. So they actually use both. But we learned a bit from that.

We went and looked at the Osprey development. That was quite interesting as well, is how they use colors. We are in fact looking to adopt some of their color scheme. Let's see if I've covered these already.

MR. WALLIS: How about chemical plants? Have you looked at chemical plants?

MR. JENKINS: No, not in visits. We have some reports, I believe --

MR. WALLIS: They have a similar problem, and they have a big system and they have all kinds of screens and defense and so on.

MR. JENKINS: We focused on two fossil power plants to get a better view of that. You know a number of process plants aren't quite as integrated as you might think a power plant is.

We've done functional requirements analysis of 16 systems, operating experience reports, specific reports for 16 systems. The last bullet here. We have prototyped our process all the way through to the development of procedures and training, and that was something that we showed the staff in one of their audits, again deriving procedures from the task analysis.

Let's see. One more point here. It's not just General Electric Hitachi doing this. Our architect engineers also have a responsible part of this. They're doing the functional requirements analysis first time through under our guidance and training. Then we are evaluating the results and providing feedback and control.

Next slide. Going a bit further on the program execution, I mentioned that we've already developed a simulation platform. We've developed a mock-up on the floor plan modifications. We've done several studies to support what we're doing, and a study of color schemes.

Man Machine Interface or Human System Interface, pointing devices, the debate over touch screens versus a mouse, anthropometrics and demographics, what's happening with the demographics of who's going to operate these plants over many years. There's been a debate around the units of measure as they show up in the control room.

MR. WALLIS: Are you going to go to some international unit, or are you going to stick with PSI and that sort of thing?

MR. JENKINS: Our customers clearly want U.S. customary units. A good part of our safety analysis is in SI units.

MR. WALLIS: These are things called ancient British units, you mean, the ones --

MR. JENKINS: Yes. That's U.S. customer. Yes sir.

MEMBER STETKAR: You mentioned the part scale simulators. What are your plans for final implementation of the full scope simulator?

MR. JENKINS: Well Thank you for mentioning that or asking that. Everything that we're doing in the modeling space build-up and when we've completed all the systems, and it is a full scope simulator for training purposes.

MEMBER STETKAR: So it's just growing?

MR. JENKINS: It's growing.

MEMBER STETKAR: But do you have a -- I hesitate to ask this, but a time line or a schedule for that? Because from the human factors engineering and evaluation process, until you have that integrated simulator, where you can look at real time evolution of responses, all of the man machine interface studies and kind of paper, regardless of what you do, they're not realistic.

MR. JENKINS: Right. Well, they're well along the way. I mean the part task simulator is going to cover, you know, 60, 70 of the 100 systems. So it's going to cover the primary loop and all the circulated systems, as well as the program is iterative, right.

So we'll do all that verification again on the full scope simulator, and that is a commitment. We've also been working with the COL applicants about when do we have to have that full scope simulator ready in order to train a number of new operators and different classes and all of that? So we're deeply into that conversation.

MEMBER STETKAR: But the plan is not to have that in place before, certainly before the design certification?

MR. JENKINS: That's right. It will be standard for all the plants, as will the procedures and the training.

MEMBER STETKAR: Yes, that was my -- yes. I mean the whole -- part of my confusion is if you're headed towards a standardized design for all of the plants, including standardized procedures and all of the human interface things, you know, when does that see fruition?

MR. JENKINS: The current plan is that the procedures and training developed for the first customer will be adopted by all the future customers, and so far they've agreed to that.

MEMBER STETKAR: At the lead COL stage?

MR. JENKINS: Yes.

MEMBER STETKAR: I'm sorry. You can wait until the staff's presentation if you want.

MR. JENKINS: Okay. These are just some of the other activities. I'll jump to the last bullet. So where we've been actively engaged in the program design manual that determines things like plant tags and equipment component numbering, and we've modified the basic GE previous years of standard.

As it is, a number of plants have retagged equipment after GE delivered it. With the support of the customers we won't face that in this plant. We will as well pass that obligation down to our vendors. So equipment that we purchased will have a human factor tag hanging on it when it's delivered to the plant. Okay. Yes. Any other questions?

MEMBER BLEY: Yeah, I've got a couple. In the beginning of the DCD, you talk about the HFE program goals, and there's a couple of them. I'd like to hear a little bit about how you've been able to reach these goals.

One is how you're ensuring that operator vigilance is maintained, and the other ones are how you're ensuring that personal tasks are accomplished within time limits.

MR. JENKINS: Okay. So the time limits, let me take the easy one first. There are certain assumptions made in the PRA and as well derived from data from the safety analysis, on how quickly an operator needs to take action.

From the safety basis, it's 72 hours. But not dealing with the question of what would we do beyond that. So that data is fed into our process, and we have to validate that that operator can perform whatever time constraints have been given to us, including that verification.

If he has to, you know, go out of the control room or send an auxiliary operator out to a local panel, we'll have to validate how long it takes him to actually get there.

MEMBER BLEY: Will there be some aspects of the PRA then feeding back to the operator, in places where the operator wouldn't normally know he had certain time limits?

MR. JENKINS: That's correct. The PRA input to us is substantial. They give us a list of what they consider to be requirements into our process, and we close the loop. We go through that and we come back to them and say "You know, that's unrealistic" or we think we can do better than that, and refine the PRA.

MEMBER BLEY: The harder question?

MR. JENKINS: Oh, I almost got through that. Operator vigilance in an all-digital plant where not much happens for 18 to 24 months is an issue in existing plants. You know, we can develop procedures. We'll develop training, but it comes down to how the operator or the infrastructure of the plant actually operates the plant.

What does the SRO do? What are his tasks, and even things like administrative tasks, what do they get engaged in on an hour by hour basis. There are certainly things that they -- data that they collect, like operator logs and other events.

It's not a simple answer. We're going to verify and validate as much as we can. We'll be looking for vigilance as we go through our testing, and the human performance monitoring aspect of what the owners are obligated to take on, we'll certainly be challenging that.

MEMBER BLEY: Was I misreading your goal? The way I understand it --

MR. JENKINS: No, the goal is clear.

MEMBER BLEY: You were trying to improve the vigilance through your design of the human system. I mean that is --

MR. JENKINS: Uh-huh. Yes, that is our goal, absolutely our goal. It's a question of how to measure that.

MEMBER BLEY: Ways to measure and do it. One last one if I might is there's a lot of talk in the DCD about how the PRA and the human reliability analysis feeds into the design work. Are your people directly involved in the HRA? That's the first half of the question.

The second half, are you driving the kinds of human actions that are to be modeled in the PRA?

MR. JENKINS: The first question yes. We are integral to the HRA development. We have been in discussions with them on what are their filtering factors or performance factors. So then we feed back to them as well, what might be adjustments to their program or their calculations.

MEMBER BLEY: That's what I was getting at. IU suspect there are areas where experience won't help them in identifying the kinds of actions and potential errors that might occur with these new systems. Your people might be better equipped to do that. Is that part of your role now?

MR. JENKINS: Yes it is, sir. Yes, it is. I mean the operating experience that we get out of, for example, the digital upgrades that we already have on individual systems in the U.S. has created quite a lot of operating experience.

That will go two ways. That will go into the design of the I&C system, and that would go back into the PRA as well.

MEMBER BLEY: I guess we're going to see the PRA next meeting or something like that?

VOICE: In June.

MEMBER BLEY: In June. Maybe some of your people will be at that meeting?

MR. JENKINS: Probably our HRA fellow, which is -- yes. Okay, thank you.

CHAIRMAN CORRADINI: Thank you. We turn to the staff now.

MR. GALVIN: My name's Dennis Galvin. I guess they're passing out the slides momentarily. I'm the project manager and the staff here is joining us.

Slide 2. You know, the purpose of the briefing today is to brief you on our continuing review of the DCD. I've just listed the sections of the DCD. We're covering all the sections in Chapter 18.

GE gave you a pretty good overview of all the reports they've given. The sections are the same. We're also here to answer your questions.

Slide 3. Again, my name is Dennis Galvin. I'm the lead project manager for the staff. Our technical reviewer is James Bongarra, and we also have today with us John O'Hara from Brookhaven. Jim Higgins also reviewed it. He is not available today.

Our presentation will cover the regulations, the RAI status summary. We've already have a brief discussion on DAC. I'll make a few more points again. Then the technical staff will talk about the review objectives we used, the NOR review of the review. There's raised review levels we performed. We'll give you an overview of the open items and then an overall summary.

So the key regulations, of course, are 10 C.F.R. 52. The particular regulation for human factors is 10 C.F.R. 50.34(f)(2)(iii). Control room design reflects state of the art human factors principles. That's the key regulation. All the rest flows from that.

Press review guidance. Again, new Reg 0800, Chapter 18. The majority of the detailed review criteria, acceptance criteria come from new Reg 0711, which was developed over many years, and also review of the human system interface draws on new Reg 0700.

Slide 6. Originally, there was a total of 266 RAIs. There's been a number of supplements. Number of RAI resolved is 200. Number of remaining open items is 66. That's what's in the SER. GE has responded to 54 of the open items, many rather recently, and the response is on 12 of the open items.

MEMBER BLEY: Is there anything about certifying a process rather than a design, that's caused you folks any difficulties or concerns?

MR. GALVIN: I think the technical staff can answer that question. I don't know. Do you want to say anything right now?

MEMBER BLEY: Well, I'll be glad to wait for it.

MS. CUBBAGE: Well, I guess the one thing I'll add is this is the fifth design certification. So we've done this four times before, and maybe Jim can elaborate, if he has anything specific to say about that.

MR. BONGARRA: If I may, Jim Bongarra. I'd like to try and address that when Dennis finishes his introduction, and perhaps in the process of going through the overall approach that we take, it might become clear that I think there, you know, there are problems, but we're trying to deal with them.

MR. GALVIN: I've given you the -- Slide 7 has the basic Commission policy statements. Design acceptance criteria is a set of prescribed limits, parameters, procedures and attributes which go into the DCD, which the NRC relies on in a limited number of technical areas, to support our final safety determination.

A list of design certification. That's in a case where the design is not complete. So in Slide 8, currently the three design areas where the Commission uses DAC is piping, instrumentation and controls, and the control room, which is human factors engineering.

I've got a statement. Amy said it previously. This comes from those four Commission papers. It's used repeatedly that I&C and the control room area is the area where the technology is rapidly developing. If you certify that design, then it's likely to become obsolete before it's implemented.

So you don't really have to do that. They've used -- you certify the process, and then through audits and inspections, you verify that the design was complete, that the design was done according to the process. So the staff has somewhat of an involvement in looking at the design.

Actually, I've included it in DCD Tier 1. It's a special kind of ITAAC. Normally, you can call it design ITAAC, and this would have -- there's DAC ITAAC and a normal ITAAC. The DAC ITAAC, both of those would apply to areas we have DACs, such as the control room.

Again, you verify that the systems were designed in accordance with the license and the regulations, with the process or the attributes or procedures or methods used put into the design certification.

MS. CUBBAGE: Getting back your question earlier, Mr. Stetkar, the ITAAC will become a condition of the license when we issue a combined license. They are completed and fulfilled post-issuance of the license, but prior to authorization to load fuel.

There are some specific regulatory requirements with some of the human factors area, that pull those completions to much earlier than loading fuel. For example, you have to have trained operators a certain period of time before.

MEMBER STETKAR: Those types of -- if I can talk about training and procedures, are one type of human factors, engineering requirements that are in a sense, if I can use the term, soft. They're easily changed. They don't affect anything substantial in terms of capital investment or basic design.

Many other parts of human factors engineering can and should have a direct impact on the design. How systems instrumentation and control are designed; how the control panels are laid out; response times; the type of information that's displayed; how it's displayed and hierarchic designers need to do this. It's not the same as rewriting a procedure.

MS. CUBBAGE: Right, and with having the two different types of ITAAC, design and as-built, the NRC will be involved in verification of the design portion prior to the construction. So you mentioned capital investment and things like that.

We're going to be involved at all stages along the line, such that we're going to make conclusions about verifying that they've designed the equipment in accordance with the license, and then later we can verify that the as-built is in conformance with the design.

MEMBER STETKAR: In time, that first review occurs at the COL application stage?

MS. CUBBAGE: After we issue the license. The ITAAC are a condition of the license. Those activities may be ongoing, but there's no requirement that they be completed or verified prior to issuance of a combined license.

MEMBER STETKAR: Thank you.

CHAIRMAN CORRADINI: But they must all be -- just to -- I thought I got you, in your answer John, up to a point. So that before loading fuel, all must be completed?

MS. CUBBAGE: All ITAAC, yes.

CHAIRMAN CORRADINI: But anywhere in the time period between the time that the COL is license and a load of fuel, these could be completed, but they will be checked at the end by some sort of inspection process?

VOICE: Before fuel up.

CHAIRMAN CORRADINI: Before fuel up.

MEMBER STETKAR: But the problem I have is suppose during the review you identify a substantial deviation from implementation of basic human factors engineering process, that would require a change to the control room layout.

Rather severe, but according to your process, you would not identify that until the permission to load fuel? That's it. That seems rather late in the whole process here.

MS. CUBBAGE: That's not what I said. There's two different types of ITAAC, and it's certainly incumbent upon any licensee to get us to verify that the design has been completed in conformance with the license prior to them procuring and fabricating and installing equipment.

MEMBER STETKAR: Well, it's incumbent on them, but there's also --

MS. CUBBAGE: And we're getting into a whole other area of DAC closure, which is something that the NRC is working on with the Construction Inspection Program, and the what and the how of DAC closure is still being worked out with industry.

But I guess what I'm conveying to you is the vision that these design portions could be completed and verified prior to installation.

MEMBER STETKAR: They could. I mean I personally would be, because I don't -- I haven't been on the committee. I haven't been through any of the other design certifications. I was quite surprised that the design certification didn't have that finality of control room design in it.

From a vendor and from a licensee's perspective, if I can be a bit cynical here, if I were the vendor or the licensee, I would like as much flexibility to postpone those decisions as long as possible, because that allows me that flexibility.

MS. CUBBAGE: And the Commission has allowed the use of DAC in these areas.

MEMBER STETKAR: Okay. Thanks. I'll have to learn how that process works.

MR. GALVIN: I would briefly mentioned that the staff has a RAI open with the applicant, that they need to work out the schedule. It's the reg guide, and it's open, so it hasn't been finalized yet.

The staff has repeatedly notified GE and the other applicants that they need to give us a reasonable schedule, or you're going to have the exact problem you discussed. So the staff's aware of that and is working the issue.

Next, technical lead Jim Bongarra will go into the details of the review.

MR. BONGARRA: Good afternoon. My name, as Dennis mentioned, is Jim Bongarra, and I'm the lead technical reviewer for the ESBWR human factors portion of the design certification review. Before I begin here, I'd just like to thank the ISO committee for allowing us to come before you today, to present our, really what I consider to be short of a status report here, more than certainly a complete report on where we stand with a review of Chapter 18 for ESBWR, because this is truly a work in progress.

As you know already, we have completed essentially a safety evaluation with open items. And as Dennis mentioned in his presentation, there are number of open items that we're still working actively with GEH to resolve. So there are many questions that remain open with us in Chapter 18, and we feel confident with continuing to work with GEH, that we will certainly resolve these questions before we actually write our final SE.

I'd like to also introduce or further introduce to you Dr. John O'Hara, who is sitting to my right. As Dennis also mentioned, John is with Brookhaven National Lab, and Jim Higgins, a colleague who is not with us today, have been principal contributors to the review of Chapter 18 for the SBWR. So I'm going to be calling on John from time to time, to say a few words as well.

I might also add here that John and Jim have worked with the staff for all of the design certification reviews that we've done over the years, starting with ABWR right on through to the AP 1000, and of course now ESBWR. So they've had a wealth of experience working with the staff, and we certainly appreciate having had them with us and we can certainly look forward to continuing to have them with us.

And also both Jim and John were principal contributors or are principal contributors to developing the staff's review guidance. That has been referred to a number of times in the presentation here. That is, new Reg 0711. I will just hold up there a copy of this document for you.

In case you have not been familiar with it, it's certainly available to the committee and the subcommittee, and we'll I'm sure make it available to you if indeed you wish to have it. But this is essentially our guidance and criteria that we use to review new plant designs, human factors aspects of new plant designs.

Okay. The next slide, which is already up, thank you. What I'm really showing here to the subcommittee is really an overview or in the sense of background here, the activities really that comprise the NRC's human factors engineering evaluation process.

Tom in his presentation really has already gone through, in a little different fashion, what you see up on the slide. This is indeed the process that we use to evaluate the human factors aspects of new plant designs.

I'm going to go into more detail as we continue here on these review activities, the 12 that you see in front of you, in just a few moments.

The staff has used the process that you see in front of you, with some variation and I think improvements over the past decade or so, to review all of the HFE programs for the four previously certified designs.

So it's not a new process. It's a process that has evolved, as our experience with reviewing, essentially as Dr. Bligh had mentioned, a process as opposed to a complete design. It's evolved, to allow us to hopefully do a robust job in essentially working with information that we have at the time of design certification.

One of the things that's on the slide is a statement here of rationale for the process, and I thought what I would do here, given the fact that Dr. O'Hara has indeed authored, through the document. I was going to give him an opportunity at this point to kind of go over just quickly with you the rationale for the program. John?

DR. O'HARA: Hi. As Jim said, he asked me to give a little bit of the rationale and background for this process. As you can see, I can see from some of your questions, this is a different approach than probably what you're used to seeing.

But this -- for those of you that remember back to the 80's, and even into the 90's, when the control rooms were reviewed post-TMI, basically what happened then was folks went into the control room. They had checklists, you know. They walked around the control room, they looked at the meters, they measured how high the work stations were, and basically did a review using the staff's available guidance, which came out in the 80's, in new Reg 0700 and they did detailed control room design reviews.

Okay. In the late 80's into around 1990, when the ABWR was submitted for the staff review and as you all know, that was the first of the Part 52 reviews. When you turn to Chapter 18, rather than seeing a control room, you saw some concept designs, some key features that might be in this control room, might be in this control room.

So we as the reviewers were left to ask well how do we review this? You know, we certainly cannot use the guidance that we have at hand, because the guidance we have at hand is deficient in two ways.

One is you need a control room, and we didn't have a control room. Secondly is the, you know, the new generation of control rooms are computer-based control rooms, tied up with digital information control systems.

The guidance available to the staff at the time was really for the 1950's, 60's type control room, pretty much analog technology, boiler gauges, flip switches, all that type of technology. So even if a control room was presented, which it wasn't, you really couldn't use the available guidance to review it because it was for a much older technology.

That set us off on a pathway to figure out a way to try to evaluate the control rooms. We knew the ABWR wasn't going to present the control room, and we had good suspicions based on what Westinghouse was doing and what Combustion Engineering was doing, that we weren't going to see finished control rooms for those applications either.

So basically what we did is we stepped back and started from square one, and asked well, if we don't have a control room, how are we going to do a safety review?

That led us to looking at well how are control rooms designed, not just in the nuclear industry, but in other complex safety-critical type systems like military systems, like aerospace systems? You know, what does a human factors program look like, that I could at least begin to look at something, in order to do an evaluation.

So we actually did a pretty extensive study, looking at again, you know, the nuclear industry, the standards for control room and human system interface design, what's done in other industries.

We basically boiled it down to saying you know, there's a set of core activities that has to take place, and those are the activities that are in that diagram that Jim has up there.

We went then further to say well, if I go in and I look at these core activities, what can I look at to see if they're doing these core activities in a positive way? How would I know how well they're doing task analysis, or how would I know how well they're doing verification and validation?

It was that study that originally led to this approach of not only looking at the end product, because first of all we couldn't do that, but second of all we concluded that's not a good idea. There's a much better idea with systems that are highly tied in with software, where what you see with the physical control room itself is almost unimportant relative to how the information is displayed, how the alarms are processed.

Because everything's processed. You know, it's not like the old control rooms where if single sensors, single enunciator type of control room. No, these are processed, and they're processed using different rules.

The information that's displayed goes through signal validation. You know, you're not necessarily looking at straightforward information, you know, coming from the sensors, and the same is true of controls. There's various levels of controls. I don't want to answer Dennis' question now about vigilance, but a lot of the current approaches to automation have keeping operators in the loop mentally as part of their logic.

You know, you could start up the plant on auto, but it's not a good idea to do that. So basically what we did is we set out. We developed this review model. It had the key activities, it had the review criteria which we developed into it.

That was reviewed by your ACRS; not you guys, ACRS, but the ACRS back around the ABWR time frame. It's also been out for public comment and review on several occasions, and we have revised it several times based on lessons learned.

You know, the ABWR, the first time this approach to review was published, it was published as an appendix to the SER for the ABWR, and then it was published as a new reg unto itself and then revised, you know, based on use and lessons learned.

I might also just throw in, this document is used very broadly. It's used in other industries; it's used by the military. It's used -- portions of it have been adopted by various standards organizations like ISO and IEEE.

So through our use of it and through our experience using it and getting feedback from others, you know, we have made modifications to this process over time. But it is a process and product-oriented review, as you've seen.

MR. CHARY: Thank you, gentlemen. I think we're going to try to speed this up a little, hoping to be done with this topic by five o'clock.

MR. BONGARRA: Okay. I had planned to talk in some level of detail, and I think I'm going to try and shorten that up a little bit, about each of the 12 elements that you saw in the figure in front of you, which is no longer in front of you.

But what I was really trying to get across here in these next few slides is essentially you've heard already from Tom Jenkins, essentially how Westing, I mean GEH -- apologies, apologies.

VOICE: Apologize to me.

(Laughter.)

MR. BONGARRA: I knew that was going to happen. How GEH has essentially proposed to address the elements, and what I just simply want to do is tell you what we do as the staff, in terms of reviewing those elements.

Let me just start with the first one, which is on your slide. It's identified as human factors engineering program management, okay. Now we have certain objectives, and these are objectives are called out in new Reg 0711 and in the standard review plan.

This is the, represents our objectives for ensuring that each one of these activities or elements is met, and along with those objectives, we have criteria. Somebody asked earlier about criteria. Well this is where we the staff have criteria. They are included in our review document.

So the staff's objective for, and if I go too quickly here, please stop me. The staff's objective for evaluating the activity of human factors engineering program management, as an example, is to verify that the applicant has the human factors engineering design team, the processes and procedures and the technical program to carry out an overall human factors process in place, to make sure that human factors engineering is incorporated in the overall engineering design of this new plant.

That's what we look for essentially in that particular element. We want to verify that those items are there, that those items are incorporated in the plan.

Now I just want to mention here in terms of what GEH has accomplished here, they have provided us already, as part of their design certification, essentially a complete human factors engineering program management plan.

So what we have done, then, is we have been able to, and you'll see in a moment there are different levels of review that we accomplish, depending upon the level of information that's provided, we close this item out, as part of the design certification.

It's not an open item; it's complete, and we believe that that was the case because of the level of information that GEH provided us with.

MR. WALLIS: But isn't it like saying in order to play basketball, you have to have a team. It doesn't say anything about how good the team is, does it?

MR. BONGARRA: Well what it says, sir, is it's not just the team, but it has qualifications that are associated with the team as well. It's quite a bit more than just the team.

MR. WALLIS: Very specific, yes. Okay, thank you.

MR. BONGARRA: Okay. You're welcome.

MEMBER STETKAR: Can I just ask a follow-up, because we're not going to get through all the slides, so I'm skipping ahead here, but you've completed a complete element review for the program management plan.

You've completed -- you're in the process of performing an implementation plan review for all of the rest of the elements, which is just basic human factors engineering.

MR. BONGARRA: Yes.

MEMBER STETKAR: Is there -- will a complete element review be performed and finished, of all of those other elements of the human factors engineering, before the design certification SER is issued?

MS. CUBBAGE: No.

MR. BONGARRA: No, no. We are --

MEMBER STETKAR: So we don't even have a complete review of a plan or process.

MR. BONGARRA: No, we have a complete review of implementation plans. In other words, by the time the design certification is complete and we issue our final SE, we will have -- hopefully we will have a complete implementation plan for each of the remaining 11 activities that compose the overall program.

MEMBER STETKAR: What's the difference between a complete element review of a plan and an implementation plan review of a plan? It sounds to me like if I was reviewing a plan, I would want to review the whole plan.

MS. CUBBAGE: The difference between an element being complete and an implementation plan being reviewed and approved, to be implemented later and verified --

MEMBER STETKAR: Well, is this like an implementation plan, as I plan to drive from Washington to San Francisco, and that requires me to go from east to west, and that's an implementation plan, compared to a complete plan, which would be the actual roads that I'm going to drive on and things like that?

I'm confused about the level of -- what's reviewed for the design certification?

MR. BONGARRA: We do have two slides on the difference between an implementation plan and a complete element review. Let me just quickly try and tell you what that is.

Essentially, an implementation plan identifies a process to accomplish a particular activity. For example, there is one element or one activity within that 12 activities I had in the first slide, and it has to do with completing a task analysis. We've heard this before, okay.

What GEH has indicated to us or given to us for review at this point is a methodology, a process for doing this task analysis, and it's a relatively robust methodology. I say that, and let me also just kind of circle back to a question I believe that was asked earlier or mentioned earlier.

The DCD for the Chapter 18 for the ESBWR is not terribly detailed, and the reason for that is because similar to other vendors in the past, what GEH has chosen to do was to put a good number of details, if you will, in their -- in NEDOs. These are documents that were also on your screen earlier.

So with that said, there is a methodology for doing a task analysis. They haven't completed doing the task analysis. If they had completed doing the task analysis, then we would review a complete element. We'd do a complete element review. We'd have a product, a complete product.

That's the difference between doing an implementation plan review, i.e. reviewing a methodology for producing a product, versus doing a complete element or complete activity review, i.e., looking at that final product, looking at a final task analysis, a complete task analysis. Does that clear things up, make sense?

MEMBER STETKAR: That helps me.

MS. CUBBAGE: I think I understand why --

(Simultaneous discussion.)

MEMBER STETKAR: I'm a little more confused, because they haven't really done the management. So I'm not sure --

MS. CUBBAGE: Well, I think what's confusing you as well is that first topical report, 33217, has the title of "Implementation Plan." But you've determined that they've done enough to complete that element.

MR. BONGARRA: Yes.

(Off the mike comment.)

MEMBER STETKAR: Well, not being part of the process and only being able to read what we can see, it's confusing.

MR. BONGARRA: And I'm sure you have --

MEMBER STETKAR: I come back to my analogy about driving across the country. I'm trying to figure it out.

DR. O'HARA: Yes. It's a little confusion. That first, you know, so-called element of human factors. I mean basically, you know, all that really is is their plan. So you have to separate that off from all the others. All the others are actually analyses or design efforts are going to be with products, with specific products.

MEMBER STETKAR: That's true, even though the NEDO documents all use the word "plan," because what we have so far is all in the plans.

DR. O'HARA: Right. We don't have the completed products of those plans yet. So but it's a bit of an unfortunate set of terminology, in the sense that that first element, you know --

MEMBER STETKAR: Is also called a plan.

DR. O'HARA: Is also called a plan, but really that's all you have is the plan.

(Off the mike comment.)

DR. O'HARA: That's what set up. The product is what gets produced by all these other implementation plans.

(Off the mike comment.)

DR. O'HARA: Yes. There would probably be a better way to represent it than what we did.

MR. BONGARRA: Hopefully that puts it in better perspective. Thanks John for doing that. I'm not going to obviously have time to go through these, and I'm not sure that the subcommittee wants to go through these, okay.

Let me then see if I could just quickly move on to some of the real meat here of this slide. What did you say Amy?

(Off the mike comment.)

MR. BONGARRA: Yes. Let me just skip through all of the other elements that I didn't talk about, and let's see here. Well, I could -- 15? Let me go to slide -- I've had a request for Slide 15, which is -- thank you. Okay. I apologize here. My slides are not numbered the same for some reason.

Okay, Slide 15. This just an overview here of essentially what GH has provided to us. Again, the material that we received from GEH is truly consistent with the proposed design acceptance criteria approach that Amy and Dennis have spoken to earlier.

That design acceptance criteria approach is what we've just been talking about really, in terms of the fact that what GEH is giving us for human factors engineering are methods. It's a process, not the complete product.

We don't have, as Tom mentioned in his presentation, a complete design, i.e., we don't have a control room. We have something close to it perhaps, in terms of the simulator. But nonetheless, the staff does not have an essentially complete design, as far as this human system interface goes, for the control room, and for that matter for any control facilities in the plant. So we're using the DAC approach, and that is indeed consistent with what we've done in the past for previous reviews.

MR. WALLIS: Fundamentally it's something I understand. I mean if someone said I have a plan to evaluate the energy and mass balances and the heat transfer in the LOCA, that sounds good. But we've learned that the devil is always in the detail, and until you look at exactly how it's done, you don't really have much of an idea about how good it is.

MR. CHARY: Let me try to address that. I guess this is one of those where --

MR. WALLIS: It's the same thing with these human factors?

MR. CHARY: Yes. Let me try to address that. This is one of those areas that have gotten all the way up to the Commission in terms of what level of detail we would be reviewing.

MR. WALLIS: But doesn't the problem eventually come down to getting the details right?

MR. CHARY: And we do that through the DAC process.

MR. WALLIS: That's when the real decisions get made, is in the DAC process?

MR. CHARY: That's where the detailed design in the actual control room is actually procured and designed and built and yes, that's where it's done.

But in those areas, and those are three unique areas, and you'll be hearing about those in the coming months. The first one is human factors. This is the first time we talked about DAC.

Human factors, I&C and piping design. Those three areas have been approved to use this process, the DAC process.

CHAIRMAN CORRADINI: What are the three again?

MR. CHARY: Human factors, which is this Chapter 18, I&C and piping.

CHAIRMAN CORRADINI: And is GE going to use all of those as DAC, or are they going to do the piping?

MR. CHARY: All three.

CHAIRMAN CORRADINI: All three?

MR. CHARY: Yes.

CHAIRMAN CORRADINI: Why piping? Or no, that's the wrong verb.

MS. CUBBAGE: June 18th.

CHAIRMAN CORRADINI: Oh, June 18th. Thank you.

MS. CUBBAGE: We'll defer that, yes.

CHAIRMAN CORRADINI: That's a perfect answer. Thank you.

MR. WALLIS: What does piping mean in this context? Is piping a technical term, or does it actually mean pipes that carry fluid or something?

MS. CUBBAGE: It's pipes, and we're going to talk about it on June 18th.

MR. BONGARRA: Okay. To keep things moving here, I'd like to know if there are further questions at this point. I'd like to go to Slide 19, which really is kind of the nub of things here. This slide is to identify really what are we consider to be some of the more pertinent open items that are remaining to be addressed, before we can actually complete our safety evaluation.

And as you can see from the slide I think, and certainly from probably the discussions you've had with other tech review groups, we really don't have many items of the 60 or so that were identified earlier, that I would consider that kind of bend the flagpole here.

We have a few, however, but they're not overwhelming. At least we don't believe they are. One of them in that slide that you're seeing there is identified as level of design in some implementation plans.

Most of the remaining items, open items, relate to requests that we have that are outstanding for basically what we have been kind of classifying, if you will, as clarification issues. There's just not enough information in some of the open items that we have to give the staff confidence that we have the technical background that we need in order to close out an item.

So a number of what the issues that we have are what are related to level of detail in these plans. Task analysis, HSI design, which we didn't talk about, and verification and validation plans. A very important plan, by the way that GEH has been working on to revise, and we have just received some input from them.

Pardon me. We still have need to look at those most recent responses. But when we put these slides together, that was an item that came up as being one of the open items that we wanted to mention to you. A second one is --

MR. WALLIS: I'm sorry. I'm just an outsider to this, but it seems to me that you're asking for the meat. When you're getting something, you're saying here, you presented us the philosophy and the sort of overview of things. Now give us the meat.

That seems to be a major task. What's missing seems to be something major here, isn't it?

MS. CUBBAGE: Well, in light of the fact that GE has responded to 54 of the remaining 66 open items --

MR. WALLIS: But if I were looking at this in terms of a critique of the sort of analysis I understand, I would say you've told us how you might approach it, but you haven't given us any analysis yet. That means that most of the answer is missing.

MS. CUBBAGE: Well, we've asked for more detail and it's being provided.

MR. WALLIS: Isn't it a lot that's missing, or is it just rounding out a few details? It's a lot.

DR. O'HARA: Yes. I think when you looked through the SER, you obviously saw all those open items related to detail, and that's more or less where we are now. But I just want to make -- since you probably haven't had a chance to really look at these NEDOs, these implementation plans, okay.

This isn't I'm going to Washington, D.C. I'm going to go west. These are very detailed plans that detail the scope, the specific analysis methods they're going to use, criteria they'll use.

You know, so for each of these activities, we're looking for a lot of detail, so I can be confident that I could say at this stage of the game, if they do these analyses in this way, document them this way, check them in this way --

MR. WALLIS: Are you saying the detail has to be created now, or is already in the NEDO. It just has to be articulated.

DR. O'HARA: In many cases, that's exactly what it is. If you look at GE's hierarchy of the way information is presented, you have the DCD. You have these NEDOs, which have additional detail. Then they have what they call work instructions.

Those are the things we've audited. I think Tom put on there that we've been to a couple of audits. So when we look at these plans, we generally will say okay, you know, here's what you're saying you're doing for -- we've been using task analysis -- for the task analysis.

We then go there and we look at how they implement those plans. Now they're not done yet. That's why we can't close that out. The plans are done, but the -- they will be done by the time design cert comes. But we can see specifically what they do.

Sometimes the details that we're looking for are in the work instructions.

MR. WALLIS: So the plan isn't like a sort of Lewis and Clark type of thing. We're going to go west until we find something.

DR. O'HARA: No, very detailed.

MR. WALLIS: There's more than that to it.

DR. O'HARA: It's got to be detailed. We sort of use two litmus test type criteria. One is when I read the level of detail in this plan, do I think they can give this plan to a qualified engineer and they could execute this plan in a reliable, consistent way? When the answer is no, we want more detail.

The other question we ask is this is intimately tied up with the DAC. Okay, the closure of the DAC involves doing what you said you were going to do in our NRC-approved plan, which is very detailed.

So when they're going to do -- the plans have to be detailed enough that at some point, you can look at what's produced --

MR. WALLIS: And check that it's being done.

DR. O'HARA: Exactly. You could have the verification criteria that that DAC has been satisfactorily addressed. So when we review those plans, we use those two criteria. Do I think I can hand this to somebody else and they could actually do this in a reliable way?

And secondly, is there enough detail here that downstream, somebody can use this plan and evaluate what they've done, along with the new Reg 0711 criteria, to make sure that that they've acceptably met that DAC commitment.

MEMBER BLEY: Mr. Chairman, we don't have any of those NEDOs. I think we need to see those.

CHAIRMAN CORRADINI: Yes, we do.

MEMBER BLEY: We do have those.

CHAIRMAN CORRADINI: Oh, we've got NEDOs.

MEMBER BLEY: I've got NEDOs about thermohydraulic stuff, and I haven't found any of these.

CHAIRMAN CORRADINI: No, I'm sure we do.

MEMBER BLEY: I'm not sure about the "we."

MR. SHACK: The two of us are kind of

interested in this stuff. Many of them are actually in ADAMS, public ADAMS.

MEMBER BLEY: Oh no. That's not a great help to some of us.

MS. CUBBAGE: I'm going to be quite honest here, that this is a challenge that the staff has, that there is an enormous amount of material available, and a lot of it is being provided in advance. I know you all don't have time to read all of this, but it has been made available.

MR. WALLIS: We're just smart enough to get hold of it.

MS. CUBBAGE: No. I mean it was given to the ACRS staff.

MR. WALLIS: Oh, okay.

(Simultaneous discussion.)

MR. BONGARRA: Well, I've been asked to end by five o'clock here. It sounded like somebody needed to do a presentation right on time, so I'm not going to go over the other three items essentially on the slides.

I'm just going to simply say here that over the past two and a half years or so that we, the staff, have been reviewing material from GEH, we feel like there has been considerable progress made to address open items through the RAI responses and the document revisions that they've made for us.

I can certainly just simply say to you that there have been a number of revisions. This has been a relatively intensive review for us, so it's been a learning experience, I think, for both parties.

So based on the progress that we see to date, it's our belief that there are no major obstacles that are expected to resolve the remaining issues. We think that GEH has used the state of the art techniques for human factors engineering, in terms of developing their HFE program.

And where the staff has completed its review, either of the program, the plans or an actual product, we think that the plans and the products have been pretty comprehensive. So thank you very much. I apologize for taking perhaps a minute or two longer. If there are any other questions, certainly please feel free to ask. If not, I will step away.

CHAIRMAN CORRADINI: Other questions?

(No response.)

CHAIRMAN CORRADINI: Okay. If I might suggest to the committee, there is one last thing that I'd like to get time to talk about, and that is GE would like to present their critical reflux data from the Canadian tests, and we'll have to go into closed session.

Other than I say that, I'm not sure what else has to be done.

MS. CUBBAGE: They have to change the transcript and we have to clear the room if there's anybody who's --

CHAIRMAN CORRADINI: A closed transcript.

MS. CUBBAGE: And we need to verify all attendees.

CHAIRMAN CORRADINI: Is this like --

MEMBER BLEY: (off mike) You look around and make sure we're all acceptable.

MS. CUBBAGE: Mike? Alrightee, thanks.

(Whereupon, at 4:58 p.m., the meeting was adjourned to closed session.)