Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
ESBWR Subcommittee

Docket Number: (n/a)

Location: Rockville, Maryland

Date: Tuesday, November 17, 2009

Work Order No.: NRC-3195 Pages 1-384

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, as reported herein, is a record of the discussions recorded at the meeting.

This transcript has not been reviewed, corrected, and edited, and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

SUBCOMMITTEE ON ESBWR

+ + + + +

TUESDAY

NOVEMBER 17, 2009

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Dr. Michael Corradini, Chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

MICHAEL L. CORRADINI, Chairman

SAID ABDEL-KHALIK

J. SAM ARMIJO

SANJOY BANERJEE

DANA A. POWERS

JOHN W. STETKAR

CONSULTANTS TO THE SUBCOMMITTEE PRESENT:

THOMAS S. KRESS

GRAHAM B. WALLIS

NRC STAFF PRESENT:

CHRISTOPHER L. BROWN, Cognizant Staff Engineer and Designated Federal Official

AMY CUBBAGE

HANRY WAGAGE

MOHAMMED SHUAIBI

JOHN McKIRGAN

ILKA BERRIOS

BRUCE BAVOL

JAY LEE

DENNIS GALVIN

JAMES O'DRISCOLL

PAUL PEIRINGER

ED FORREST

SYED HAIDER

AMAR PAL

ALSO PRESENT:

STEVE MOEN

WAYNE MARQUINO

MATT SOLMOS (via telephone)

MD ALAMGIR (via telephone)

JON McLAMB

JESUS DIAZ-QUIROZ (via telephone)
JACK TILLS
RICK WACHOWIAK
DONALD KALINICH
ANTONIO BARRETT
MIKE ARCARO
MIKE SULVA (via telephone)

T-A-B-L-E O-F C-O-N-T-E-N-T-S

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

8:30 a.m.

CHAIR CORRADINI: Okay. Why don't we get started?

The meeting will come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards, the ESBWR Subcommittee.

My name is Mike Corradini, Chairman of the Subcommittee.

Today's Subcommittee members in attendance are Said Abdel-Khalik, Sam Armijo, John Stetkar and Sanjoy Banerjee. And our consultants Tom Kress and Graham Wallis.

The purpose of the meeting is to discuss open items, containment, dose and PRA associated with the ESBWR DCD. The Subcommittee will hear presentations by and hold discussions with representatives of the NRC staff and General Electric Hitachi Nuclear Energy regarding these matters.

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

Christopher Brown is the Designated

Federal Official for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the *Federal Register* on October 22, 2009.

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

It's requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We've not received any requests from members of the public to make oral statements or written comments.

I'll ask that everybody check their cell phones, make sure they're turned off or put in the silent mode.

We have people on the bridgeline, I thought. Is that correct?

DESIGNATED FEDERAL OFFICIAL BROWN: Yes.

CHAIR CORRADINI: Okay. Could you state your names and affiliation, whoever is there?

MR. MOEN: Hello. I'm Steve Moen. I'm with --

CHAIR CORRADINI: No, no, on the

bridgeline. That's all right. We'll get it later. Okay. We'll skip that part.

Let me give some background statements and then I'll turn it over to Amy Cubbage of staff to try to introduce the speakers of the day.

This is kind of our third meeting over the last couple of years on containment issues. So we're coming together on the first topic to, essentially, review some of the calculations we saw back in June 17th and to get a better understanding of the applicant's calculations in comparison to the staff's audit calculations for containment for design basis accidents.

Also, we're reviewing from, I think, about 18 months ago work done on ventilation and dose issues, and tomorrow PRA and human factors engineering.

So with that, I'll turn to Amy and have your introduce the day's events.

MR. CUBBAGE: Good morning. This is Amy Cubbage, Lead Project Manager for ESBWR.

As we had our meetings last month, the same situation this month. There are a number of topics we're going to discuss. We're discussing them for a variety of reasons, some of which there were open items that the Committee had expressed in previous interim letters, and in some areas we were not done with our review at the time of the briefings in the past. So I'll just run down the events here.

On the containment topic there are still some remaining open issues we're resolving with GE. So this morning you're going to hear some presentations from GE, some of which have not been formally docketed to this staff at this time. So the staff will make our presentation of the MELCOR calculations. We may or may not be able to comment on all the materials that's being presented by GE this morning.

And similarly on the ventilation and dosage issues, on control and ventilation there still are remaining open items. We may be hearing from GE this morning or this afternoon on how they intend to address those open items.

And the design basis dose area, there are no remaining open items. So this will be a comparison between the staff calculations and GE's calculations.

And then tomorrow we'll be discussing PRA and human factors.

So I think GE's going to start off here

this morning.

CHAIR CORRADINI: Is Wayne our leader here?

MR. MARQUINO: I'm speaking to the first presentation.

MEMBER STETKAR: Let me ask one thing about the topics. When we met earlier this month I had some questions about the new isolation and bypass for control rod drive. Is that part of the--

MS. CUBBAGE: Tomorrow.

MEMBER STETKAR: That's tomorrow?

MS. CUBBAGE: Tomorrow morning GE's going to make a presentation on that design change.

MEMBER STETKAR: I just wanted to make sure where it fits in. Thanks.

MEMBER ARMIJO: Mike, are we in closed session?

CHAIR CORRADINI: No, we are not.

MEMBER ARMIJO: Okay.

CHAIR CORRADINI: So there are pieces of information that have been given to the members and consultants that will not be discussed, but you have them as backup reference.

MEMBER ARMIJO: In this package?

CHAIR CORRADINI: In this packet.

Everything will be open here, all proprietary information has been removed.

MEMBER ARMIJO: Okay.

CHAIR CORRADINI: And so we will look to the GE folks to hold us in check

MEMBER ARMIJO: Okay.

CHAIR CORRADINI: Wayne?

MR. MARQUINO: My name is Marquino. I work for GEH.

Matt Solmos, who I hope is on the phone line, contributed the calculations we're presenting and as well as Gels and John Burns.

Next slide, please.

In June there were several staff and ACRS observations on the TRACG model applied after 72 hours. I'm going to cover calculations we made to address those observations. Cover vacuum breaker leak detection and design features to address radiolytic gases in the piping and heat exchangers of the ESBWR.

Next slide.

One of the ACRS consultants noted an error in the plat of noncondensible gas pressure, an RAI response. The upper drywell, which is Level 34, Ring 6 had been plotted as zero noncondensible partial pressure. And we've corrected that plot and provided a revised RAI response to the staff.

CHAIR CORRADINI: Now can I just ask about that, Wayne? We may have to roll back a bit, your memory is probably better than ours. So this has now been transmitted to staff?

MR. MARQUINO: Yes.

CHAIR CORRADINI: Okay. Can you identify what changed on this plot?

MR. MARQUINO: Yes. There's a burgundy line which --

CHAIR CORRADINI: Labeled what?

MR. MARQUINO: Labeled upper drywell. In the legend it's labeled upperdry Level 34, Ring 6.

CHAIR CORRADINI: Okay.

MR. MARQUINO: And at 84 hours the value is about 10, a little less than 10 kilopascal. And previously that line was at zero through the time period.

CONSULTANT WALLIS: Level 34; I had a lot of trouble figuring out where it is. It's not labeled in one of your figures you showed in July. And as this is drawn, it seemed to be at the top of the RPV, which is actually way up in the head. It doesn't make sense to me. So part of my question at that time was what is Level 34, where is it, and why is it characteristic of the upper drywell.

MR. MARQUINO: Yes. We had additional discussion on that in June. The location of Level 34 is given in DCD Figure 6.2-7.

CHAIR CORRADINI: You don't happen to have that electronically in front of you?

MR. MARQUINO: I don't. I can't put it on the NRC computer, but I do have a paper handout of that figure.

CHAIR CORRADINI: That would be very good of you.

This goes back to Graham's original question and we want to understand where it was and how it was connected to the next volume. So is that correct, Graham?

CONSULTANT WALLIS: Well, it's not shown on this figure. And this figure, as we found out in June or July, whenever it was, is not really realistic in terms of the actual geometry.

CHAIR CORRADINI: Yes.

CONSULTANT WALLIS: So I still don't know where Level 34 is.

MR. MARQUINO: Okay. If we could flip forward two slides. This is slide 5 and it's intended to address the discussion we had on the location of Level 34 and 35

CHAIR CORRADINI: Graham, can I just before you -- you handed out this figure. So, Graham, I don't think I understand your question. Level 34 as I see it here is at 24.6 meters. You're saying that's not correct?

CONSULTANT WALLIS: It's not labeled.

CHAIR CORRADINI: Right. But there's 32 and the next line is 33, and then a 34, is it not?

CONSULTANT WALLIS: But that's your implication. I mean, you could guess.

CHAIR CORRADINI: All the rest are labeled so I just counted.

CONSULTANT WALLIS: Yes, but then it goes across the top of the RPV, doesn't it? Is it on top of the RPV?

MR. MARQUINO: Yes. Now that's a feature of our nodalization. Yes. The elevation of Level 34 corresponds to the top of the RPV.

CONSULTANT WALLIS: But that sticks up into the dome. It's not in the annulus?

Anyway, we had the same discussion before

CHAIR CORRADINI: Wayne, I think, I mean I just want to make sure we don't go through this again. I think Graham's original question was: Where is it and what is it connected it? Where is it physically? Is that correct?

CONSULTANT WALLIS: But also when you look at the physical diagram it doesn't look like this. The real physical diagram from the real drawing shows that the reactor is sticking up into a dome-like containment, the reactor vessel?

MR. MARQUINO: Yes.

CONSULTANT WALLIS: Which is above Level 34. Level 34, the reactor head sticks up into Level 35. And I don't want to push this because we had this discussion before.

MR. MARQUINO: Okay. I want to clarify one. I'm trying to explain the discussion we had before about the elevations of the upper drywell and the TRACG model. The elevations of Level 34, 24.6 meters corresponds to the ceiling of the drywell excluding the drywell head. Okay. As you note, the drywell head extends above the flat ceiling of this drywell.

CONSULTANT WALLIS: Because it goes out of the picture in fact, well then in reality, right?

MR. MARQUINO: It extends above -- I believe it does extend above 27 meters a little bit.

CONSULTANT WALLIS: Right. Right. Thank you.

MR. MARQUINO: The elevation 27 meters, which is the top of Level 35 corresponds to the bottom of the PCC IC pools.

MEMBER BANERJEE: So it doesn't have that dome part? Because it's this dome part that sticks into --

MR. MARQUINO: Yes.

MEMBER BANERJEE: Maybe if you had physical picture, it would help as well.

MR. MARQUINO: Well, you're describing the physical picture. So I think you have a good visualization of what the physical picture is. And we don't have a one-to-one correspondence between the elevations, say the top elevation and the drywell head area versus the TRACG model. So there's some approximations that we had to make in the TRACG model.

MEMBER BANERJEE: Is it because you can't sort of capture a curved volume like that in TRACG or --

MR. MARQUINO: Well, yes.

MEMBER BANERJEE: -- is there some other reason?

MR. MARQUINO: Because we'd have to put in many, many more cells and make it a CFD type analysis if you wanted to capture the curvature.

CHAIR CORRADINI: I don't know what that buys you, though.

MR. MARQUINO: And I don't think it would buy us anything. So --

CONSULTANT WALLIS: Well, it may not. I mean, it depends if you've got stratification, you might get something happening that gets held up in that region, right, because its got this dome?

MEMBER BANERJEE: I don't know. But a lighter gas could conceivably accumulate there or not? I mean, give me an answer.

MR. MARQUINO: Well, I'm trying to answer the specific question about what are the elevations and what is in the TRACG models.

MEMBER BANERJEE: You said its not.

MR. MARQUINO: So the drywell head space, it is above the top of the reactor head but it doesn't up quite as high as it would in reality. It's maybe a meter short of that. But I think what we had pretty specific discussion the last time on the GDCS compartment. The GDCS compartment, which is the outer part of Level 35 goes up to 27 meters, whereas physically the ceiling there is 24.6. Okay.

So you were asking why is there this volume in Level 35. That is actually a small fraction of the geometric volume, about 5 percent. So we don't show the volume fractions on this nodalization diagram, but the volume assigned to Level 35 in the outer rings is very small. And we've done a sensitivity study on these in combination, and we didn't see any change in the result. Any significant change in the result.

MEMBER BANERJEE: But does the GDCS pool in the physical world actually go up to the containment walls or is there a space? I mean here I'm not clear, but if I look at, say, what you call GDCS pool on the left hand side of the diagram --

MR. MARQUINO: Yes.

MEMBER BANERJEE: -- I have some difficulty making this correspond to the GDCS pool as I visualize it to be in your design. Does that pool go all the way to the wall?

MR. MARQUINO: Yes.

MEMBER BANERJEE: To the containment wall, right?

MR. MARQUINO: Yes.

MEMBER BANERJEE: So what is this little

pool here then that you're showing in the diagram?

CHAIR CORRADINI: That's a catch pan.

MEMBER BANERJEE: That's a -- ahhh.

MR. MARQUINO: Yes, that's the fan discharge.

MEMBER BANERJEE: So it's not the GDCS pool, so why is it called the GDCS pool then?

CHAIR CORRADINI: IT just happens where they put the words.

MR. MARQUINO: Well, in the model that pan is part of the GDCS pool.

CHAIR CORRADINI: Right. So just for everybody's reference, the physical picture that Graham is talking about is on page 6.2-192 of Chapter 6 of the DCD. And the nodalization is four figures later on 6.2-198.

So you're trying with this to answering two questions, but I'm going to separate them. One is what was the volume above the GDCS pool, and that it's small. That's your first point.

MR. MARQUINO: Yes.

CHAIR CORRADINI: And let's go back to the first point that Graham made and Sanjoy is asking about. So you've captured the proper volume and the proper elevation of the junction with your TRACG model, but you've gotten the right volume but not at the right elevations above the head.

And so at least I want to get back to their question relative to how it communicates to the rest. It communicates through that junction below on Level 34, is that correct? Otherwise, it's an isolated volume above the head.

MR. MARQUINO: Yes. It communicates through -- it's vented through a pipe to the rest of the drywell. We're talking about the air space in the GDCS compartment, right?

CHAIR CORRADINI: Well, no.

MR. MARQUINO: No?

CHAIR CORRADINI: That one you've explained. I'm talking about the first question they had, which is above where you had you figure labeled drywell head's airspace.

MR. MARQUINO: Yes.

CHAIR CORRADINI: That's connected only down at Level 34 to the rest of the drywell, is that correct?

Do you understand my question?

MR. MARQUINO: Yes, I understand your question. Let me check on that.

CHAIR CORRADINI: Because based on the

physical arrangement that Sanjoy and Graham were asking about, that's the only place it can be connected.

CONSULTANT WALLIS: That's why I didn't understand where the gas came from at 104 hours, or something. There's a big squirt of gas into the drywell head. There's no gas in the drywell head at all until about 100 and something hours, isn't that correct? That curve that you've now corrected or is it in there?

There's some sudden events which didn't make sense to me. And I think it disappears from some of your later curves. This is flashing in the GDCS pool, I think.

CHAIR CORRADINI: You understand his question?

MR. MARQUINO: Yes, I understand.

Matt, are you on the phone? Can we open up the phone line.

CHAIR CORRADINI: Can we open up the phone line?

MR. MARQUINO: Your question is what's the connection area between the --

CONSULTANT WALLIS: How does that gas suddenly get into the drywell head at 100 and something hours, that big surge at the bottom there? Do you see that? Where does it come from and why does it go there since the drywell head is at presumably an equilibrium with everything else pressure wise, there's no reason flow should go in there.

MR. SOLMOS: Hello. This is Matt Solmos at GEH.

MR. MARQUINO: We can hear you now, Matt.

MR. SOLMOS: Well, the drywell head is connected to the rest of the drywell just through a vessel connection down at the interface of Level 34 there. And that flow area is roughly equal -- but there's also a connection between the GDCS airspace, and that's part of the sensitivity study that Wayne mentioned earlier and will be presented a little bit later. So there is an action between the GDCS airspace and the drywell head.

CONSULTANT WALLIS: Does it show that on this figure? Is it pipe 82, or what is it?

MR. SOLMOS: Pipe 82 and pipe 81.

CONSULTANT WALLIS: So it's at the drywell head?

CHAIR CORRADINI: And that's there in the design for just pressure equalization?

MR. SOLMOS: It's in the model just as a way to connect the volumes -- GDCS airspace and the drywell.

CHAIR CORRADINI: Right. But from a design standpoint, forget about the model for the moment. But from a design standpoint that's pressure equalization between the upper drywell head and the GDCS airspace?

MR. MARQUINO: Yes. And there is a slot designed into the upper GDCS airspace that equalizes pressure with the drywell.

CHAIR CORRADINI: Okay. So just to repeat: There's connection via the equipment hatches to the rest of the drywell. There's pressure equalization connection to the upper GDCS airspace via this piping. And Graham's question is at 104 hour what's happening that you get this bump in noncondensible gas.

CONSULTANT WALLIS: It also happens again at 158 or something.

CHAIR CORRADINI: Yes. Can you help us there?

MR. MARQUINO: Well, in TRACG, it's admitting noncondensible into the drywell head area.

CONSULTANT WALLIS: Why? Why? It was a

big surge. It must be driven by pressure or something. I mean, in later figures it doesn't appear. This is an old figure. If you look at newer figures, that's not there. I think it's the old history of flashing in the pool.

MR. MARQUINO: So let me go back. So Matt answered the question about the Level 35 communication and there's no communication at Level 35. The communication is at Level 34.

CHAIR CORRADINI: Right.

MR. MARQUINO: So we have pressure fluctuations in the model, I should say they happen at different point. And when the pressure changes and we have a movement in or out of the drywell head compartment, that can allow noncondensibles if they're present at the connecting cell to move into the drywell head.

CONSULTANT WALLIS: But you see I think there's a lot of history here. That wiggle at this 100 and something hours was originally explained as being flashing in the GDCS pool. And you talked about a piston of steam driving out noncondensible. I remember this about a year ago. And that now has disappeared from this scenario. Because in later figures this wiggle isn't shown.

I think probably you want to throw away this figure because it's not the story today.

MR. MARQUINO: Well, that's --

CHAIR CORRADINI: Don't agree with him.

MR. MARQUINO: But we had to make a correction because the plot was incorrect.

CONSULTANT WALLIS: But isn't the --

MR. MARQUINO: The story today is in DCD Rev 6 where we have this calculation with crediting only four fans and we've provided additional detail to the staff in an updated RAI 6.2-140. So that had the same parameters, and actually more parameters covering fan performance. We had sent it with six fans operating and then we have recently formerly sent it with --

CONSULTANT WALLIS: Because they're different. So should we just ignore this figure?

CHAIR CORRADINI: Wait a minute. Wait a minute. Let's not go there just yet.

So just to be clear DCD Rev 6 that we have in front of us is the current calculation. And you did a recalculation with four fans, and that's what we're looking at here?

MR. MARQUINO: No.

CHAIR CORRADINI: Okay.

MR. MARQUINO: This is with six fans.

CHAIR CORRADINI: Okay. Excuse me. So this is with six fans.

And so I think at least to start with, I want to understand -- to get back to Graham's original question what's happening at 104 hours and 158 hours that caused this oscillation. Can anybody on the phone line answer that?

MR. SOLMOS: This is Matt Solmos, GEH.

There could be a couple of factors that could show this kind of oscillation or lead to this type of oscillation. The first would be the PCC pools -- we've seen that. As you add water to the PCC pools the efficiency of the PCC's heat exchangers changes slightly, actually it upsets the equilibrium of the system.

There's also the PCC fans themselves in our TRACG model that have a way of oscillating when a change in either drywell conditions or PCC heat exchangers conditions change.

So that would just be my guess as to what's going on here.

CHAIR CORRADINI: So let me just make sure. So we can take it as something you can look into, but I do think it's at least fair to ask the question so we get a clean answer on this.

So you're telling me that there might be some operator action or some refilling of the pool and that changes the PCCS efficiency, or vent and fan performance?

MR. SOLMOS: My guess is in this figure, yes, that could lead to that.

CHAIR CORRADINI: So could you take it as an action item to check that out?

MR. ALAMGIR: -- RAI 6.2-140 there's a corresponding figure SO4-C4 that gives you the latest equivalent of this 6.2-139 RAI.

CHAIR CORRADINI: Can you please --

CONSULTANT WALLIS: That shows none of these wiggles. Excuse me. That figure shows none of these wiggles, the one you just cited. So I assume the wiggles have gone away.

CHAIR CORRADINI: So can you just cite it again? I didn't write it down fast enough.

MR. ALAMGIR: Yes., 6.2-140 S04-C4.

CONSULTANT WALLIS: Okay. And on that there are no wiggles like the ones we're talking about?

MR. ALAMGIR: This is the latest calculation.

CONSULTANT WALLIS: So we should throw away this one?

CHAIR CORRADINI: I need an answer.

MR. MARQUINO: Yes, the pressure response of this figure is superseded by the 6.2-140 figure in DCD Rev 6 figure.

CONSULTANT WALLIS: Well that should be made clear right away. Right away. Then we wouldn't waste time with it.

Okay. If this is old stuff, we're not talking about it, that's fine.

MR. MARQUINO: Yes, it's old stuff.

CONSULTANT WALLIS: Thank you.

MR. ALAMGIR: I want to correct myself. The figure number if 6.2-140 SO5-C4. Not S04.

CONSULTANT WALLIS: S04 shows a bounding case, is that right?

MR. ALAMGIR: We had to update to S05 based on some of the questions from NRC. So --

CONSULTANT WALLIS: So S04 itself is superseded with something else?

CHAIR CORRADINI: I'm sorry. I'm now confused. Can you repeat --

CONSULTANT WALLIS: But I know S04-C4.

CHAIR CORRADINI: But let them answer

first so it's clear what we're doing.

So the gentleman on the phone, can you please repeat yourself?

MR. ALAMGIR: Yes. This is Md Alamgir from GEH.

The figure that we sent to NRC for 6.2-140 S05-C4 is the latest and it has the corresponding noncondensible pressures in the drywell and GDCS airspace.

CHAIR CORRADINI: Okay. Thank you.

CONSULTANT WALLIS: And could you tell me, does then supersede S04-C4?

MR. SOLMOS: Yes, it does.

CONSULTANT WALLIS: So, again, we keep getting these things to analyze which then we're told is superseded by something else which we don't have. It's very difficult.

MEMBER BANERJEE: So do you have a copy of that figure?

MR. MARQUINO: I have a copy on my computer. I don't have a print of it.

CHAIR CORRADINI: Well, I've been looking through as you guys have been talking, I've been through at least what I have as RAI responses. I have S04, as Graham does. But I don't seem to have

S05.

MS. CUBBAGE: S05 I don't believe has been formally submitted to the staff. And that's what I alluded to this morning that you may be hearing things that we don't have yet.

CHAIR CORRADINI: Okay. So let's move on. I think at least I understand where we are.

So just to summarize, now we understand the connections, but in terms of the response given that we understand the connections we have to look at something that is still to be submitted to staff, is that correct?

MR. MARQUINO: Yes.

MR. McLAMB: It was actually submitted.

I'm sorry. I'm Jon McLamb.

It was actually submitted yesterday evening, so it should arrive shortly.

CHAIR CORRADINI: Just in time submittals. I live it.

MR. McLAMB: Just in time, right.

CHAIR CORRADINI: Okay. Let's move on.

MEMBER BANERJEE: But what is the material difference? I mean it's okay that it was submitted yesterday. But what is the --

MR. MARQUINO: Well the material

difference is four fans versus six fans.

MEMBER BANERJEE: Is that it?

MR. MARQUINO: This curve is with six fans. The S04 curve is with six fans. The S05 curve is with four fans.

CHAIR CORRADINI: Which was requested by staff.

MR. MARQUINO: The DCD is with four fans. We informally provided that data to the staff previously. I'm sorry that the formal transmittal--

MEMBER BANERJEE: That's okay.

Now the difference between what you've got here and S04, is it? What is the difference between those two?

MR. MARQUINO: Six fans operating versus four fans.

CHAIR CORRADINI: Higher stable pressure. The pressure is lower here with six fans operating versus the four fans operating for long times post 72 hours. That's the material difference.

MEMBER BANERJEE: Okay. Post 72 hours.

CONSULTANT WALLIS: But there is a curve which updates this particular one?

CHAIR CORRADINI: Yes.

MEMBER BANERJEE: There's no difference

pre-72 hours?

CONSULTANT WALLIS: And I think in the new one there are none of these wiggles we were talking about. So something has happened in the analyses or something to make the wiggles go away. I think it would be nice to have an explanation of what they were and why they went away.

CHAIR CORRADINI: I think that's fair. Why don't take it as an action item and move on?

MR. MARQUINO: Okay.

MEMBER BANERJEE: So the wiggles did go away in the figure?

CONSULTANT WALLIS: In S04 they went away and then they've come back in S05. I don't know.

MR. ALAMGIR: This is Md Alamgir from GEH.

There are some differences. One of the differences is it's a full refuel rate. But as you mentioned, we'll look into it and provide you through an NRC response.

CHAIR CORRADINI: Okay.

MR. MARQUINO: Let's see. I'll go to slide 4, which referenced to the S5 6.2-140 supplement 5. It an update of the post-72 hour depressurization for the staff review. And it's updated to DCD Rev 6. And four of six fans operating.

We also defined the head flow characteristic of the fan to envelop the TRACG analyses at the staff's request.

CONSULTANT WALLIS: You're not going to present anything about the head flow factor 6 of the plan in your presentation today?

MR. MARQUINO: Well, I have a handout with that information.

CONSULTANT WALLIS: Well, I had some problems with it. It didn't seem compatible with the text and you had numbers in the text which didn't lie on the curve. And you had backflow, I think, at least in Jack Till's slide. He put in a figure from 204D6 and flow going backwards through the fan, which puzzled me.

And it also has a very flat characteristic. I mean, it's very insensitive to pressure, which makes things a little difficult when you're trying to balance it against liquid levels here and there. I'm not sure that's a very good choice of a fan where flow rate is very insensitive to pressure difference.

And these questions, again, I don't think we're going to have time for today.

MR. MARQUINO: Yes. But we have reviewed available equipment that could meet the head flow characteristics that we've specified. It may provide -- so when you're saying it's flat, it means when you get to low DPs its flow is going up as much, right?

CONSULTANT WALLIS: No. Say the flow rate is insensitive -- it's very large flow rate changes over a very small change in head. Because it means you've got a few more inches of water somewhere and the flow rate changes immensely. And that's what bothered me. And I'm not sure you know those levels that accurately. So that was one concern I had about whether this was a good fan for the job.

MR. MARQUINO: Well, I think this is an equipment performance question. At some pressure drops the fan -- we have to provide a fan that will meet the performance characteristic at the most challenging pressure drop.

CONSULTANT WALLIS: But, see, the problem I have is if there are waves on the pool or anything that perturbs the pressure drop a little bit, the fan tries to vary its flow rate a lot. And maybe that's a good thing. But I wasn't sure it was, and I thought I'd like to see an analysis of why that's good and why it's adequate when there are things not quite on design conditions, or maybe oscillations and so on.

Again, I've just raised a question. Maybe sometime we'll hear about it.

MR. MARQUINO: Well, we have done a sensitivity to the fan rated head and flow, and it varied then within 10 percent.

CONSULTANT WALLIS: Okay.

MR. MARQUINO: Reduced the flow by 10 percent. You'll see that in a later slide.

CONSULTANT WALLIS: Well, that was useful. And the flow rate, a negative flow of 30 cfm is okay?

MR. MARQUINO: The fan actually has a check valve in the line, as indicated in the DCD. The TRACG model does not have a check valve. That's why you see negative flow in the TRAC analysis.

CONSULTANT WALLIS: So aren't you going to put the check value in TRAC because that would help the realism?

MR. MARQUINO: It would help, but we don't plan to credit that in the TRAC analysis.

I'll pass around --

CONSULTANT WALLIS: Excuse me. Could I

ask the staff, I mean you're quoting from an RAI we don't have so it's very difficult for me to know what I'm reviewing. For one thing could we see that RAI. And in future, could we please see the RAI before we come here?

MS. CUBBAGE: I would love for GEH to have submitted it in time for us to support this meeting. And we have a Project Manager trying to track that formal response down that I haven't seen in my inbox yet.

MR. MARQUINO: Professor Wallis, you asked about the fan head flow curve. And this is a simple addition we made in the DCD. We extended the table at low DP to capture a higher flow rate that bounds the TRACG analysis. This was at the staff's request.

CONSULTANT WALLIS: So this is a new fan, Wayne, because in the response RAI 6.2-139 you said it supplies 307 cfm at 2400 pascals. At 2400 pascals in this table its down to less than -- well, I guess it is. Because it's CFF. Okay. Thank you.

MR. MARQUINO: Yes. This table is a much definition of the fan characteristic than we had before DCD Rev 6.

CHAIR CORRADINI: Can we just back up

away from the details so I understand.

As I understand the DCD you have specified a fan performance curve but not a piece of equipment? And now staff with DCD 6 is going to, I think if I remember correctly in the previous discussion in June, both staff and you are using the same performance characteristics to look at the behavior of the accident. But as of yet, there is no piece of equipment necessarily that's going to meet exactly the curve. And that's why you did the sensitivity?

MR. MARQUINO: Yes.

CHAIR CORRADINI: Okay. All right. Thank you.

CONSULTANT WALLIS: Can I ask something now? When I looked at this 300 cfm at 2400 which is the text of an RAI, it agrees with the table you just gave me. But when I looked at the figure in S04D6 I got half the pressure drop at that flow rate. So something was inconsistent. Should I now throw away S04D6 and there's a new response which supersedes it?

MR. MARQUINO: That table is based on the TRAC head flow performance. So we simply looked at -- we used homologous axial flow curves in TRAC and they're defined in the documentation. We put in a rate flow and head. And then the code tells us how the flow varies during the 30 day period. We tabled that, and that's the spec for the fan.

CONSULTANT WALLIS: That's good. But now if I look, I don't have a computer. My colleagues have a computer. If they look at S04D6, figure 6.2-140 will they find a curve that's compatible with this table or will they find something which is not? Because when I looked at it in the paper version I found it incompatible.

MR. MARQUINO: Right. That table is consistent with the DCD and the --

CONSULTANT WALLIS: But not with the RAI?

MR. MARQUINO: -- S5, the 6.2-139 flows are different.

CONSULTANT WALLIS: So I should throw out 204 -- this is being superseded.

MR. MARQUINO: Yes.

CONSULTANT WALLIS: I think we need to have a list of what superseded what. Because I have a stack of paperwork. And if I look at it trying to reach conclusions, it keeps changing. And I don't have the updated paperwork and I don't have written on the updated paperwork this supersedes everything in S04 so-and-so. So it would help if that can be clarified somehow.

MR. MARQUINO: I'm sorry that you have to go through this material and then go through it again.

CONSULTANT WALLIS: But I haven't seen it again.

CHAIR CORRADINI: But he's expecting to.

MR. MARQUINO: I don't know what the answer to your question is. We have some databases that we use and I think the staff has some databases or spreadsheets that they use also.

CHAIR CORRADINI: So just to summarize: You guys have a most recent RAI response that staff has just received and we will eventually receive that is consistent with the DCD and this page that you gave us for clarification?

MR. MARQUINO: Yes.

CHAIR CORRADINI: But what we have here is the fan curve, which I finally found, on S02D6 is not compatible for the S04; for the figure of the fan curve you got in the S04 response is not compatible because it had been superseded by your most recent response, is that correct?

MR. MARQUINO: Right. Can you say the RAI again, please?

CHAIR CORRADINI: S04. The RAI is S0 --

MR. MARQUINO: 6.2-140 S04?

CHAIR CORRADINI: Yes, sir.

MR. MARQUINO: Yes. That had a text description of the fan characteristic versus a table.

CHAIR CORRADINI: Yes, sir.

MR. MARQUINO: And that text description is superseded by the table in the DCD. And then in this RAI we added another row to the table.

CHAIR CORRADINI: Thank you.

MEMBER BANERJEE: Mike, I have a broader question for you. This seems a work in progress. What is the action required of ACRS out of this?

CHAIR CORRADINI: I think I know what you're asking. Let me try a response.

We wanted to hear back this time to get an indication of containment -- so the reason we're having this meeting. These are detailed questions that I think to the credit of GEH they're trying to answer that I might characterize in the weeds, but things that we were concerned about and they're trying to clarify.

The biggest reason we're here today is because back in June there was a major disagreement about that.

MEMBER BANERJEE: I understand, yes.

CHAIR CORRADINI: Okay. So that's the main focus of today. These are some of the smaller questions that they wanted to clarify with us and essentially update some of the RAI responses.

If you remember, back in June staff wanted to see a series of sensitivity studies of six fans running, four fans running all the way up three to 30 days and they did not have the complete set of calculations done in June and they were in the process of doing so --

MEMBER BANERJEE: What is our product? Are we going to write a letter?

CHAIR CORRADINI: For this? No. For long term cooling on containment response, yes.

MEMBER BANERJEE: When is that letter due?

CHAIR CORRADINI: December.

MEMBER BANERJEE: Oh. And by then we have to resolve --

CHAIR CORRADINI: Not these details, but--

MEMBER BANERJEE: But the MELCOR, TRACG?

CHAIR CORRADINI: Correct. Correct.

MEMBER BANERJEE: Okay. So in a sense

some of this can be done offline, right? We need to address the issues that we intend to address in the letter, right?

CHAIR CORRADINI: Correct.

MEMBER BANERJEE: Now Graham had a very detailed report which I went through. Is it possible that the issues he raises be sort of addressed by the staff directly --

CHAIR CORRADINI: No, I think --

CONSULTANT WALLIS: -- that we have other input as needed by GE?

CHAIR CORRADINI: I think we can pass on Graham's detailed comments to the staff through Chris.

DESIGNATED FEDERAL OFFICIAL BROWN: Amy has them.

CHAIR CORRADINI: Amy has them.

MEMBER BANERJEE: Well then --

CHAIR CORRADINI: We can do it offline.

MEMBER BANERJEE: Yes. otherwise, this is going to take three days before his comment is extremely detailed and he and ACRS is owned a detailed answer, I think. Because he raises my points which may or may not be germane to the issue, but we should have something if possible documented.

If not, you know, that would be ideal. Then we can sort of take this off the table. Then if Graham is not satisfied with the answers, we're not, then we can go in for another round of clarifications.

CHAIR CORRADINI: That sounds fine.

MEMBER BANERJEE: But just suggesting. Because to go through each point they're here --

CONSULTANT WALLIS: It doesn't make sense.

MEMBER BANERJEE: -- is going to take you -- this thing is seven pages or eight pages long detailed stuff.

CONSULTANT WALLIS: Now the problem with the work in progress is what are we reviewing when we keep getting changes in what we're looking at.

MS. CUBBAGE: Maybe if I could just put it in context to let you know where we're at right now. I think we share your frustration. It's been a long and difficult review. We are to the point where we're converging on what's left to be resolved. And this RAI response that's yet to be sent to us, we should be receiving it today I understand, basically is going to document all the remaining staff concerns and if acceptable, we could get done. It's unfortunate that we weren't coming into this meeting at that point where everything was resolved and complete.

I think when you hear the staff's presentation, we'll put a little more context into what's open and why, when you see comparisons between TRACG and MELCOR.

So maybe if we could move on through some of this discussion and we could caucus at some point and discuss on the best path forward to address all of the concerns that have been raised in the consultant's report, because I don't think we're going to be able to answer all of them today even if we had enough time.

CHAIR CORRADINI: That sounds fine. Let's move on. Okay. Okay.

MR. MARQUINO: Okay. Next slide, please.

I talked about this before. The one item that came up in June and --

CONSULTANT WALLIS: Excuse me. I'm sorry

MR. MARQUINO: Yes.

CONSULTANT WALLIS: Is this table correct? I mean, in the discussion it says pascals for the units, 2400 pascals is the pressure. Now 2400 meters per second is 240 meters of water.

CHAIR CORRADINI: The density is one.

CONSULTANT WALLIS: Something --

CHAIR CORRADINI: The density of air is one. It's the same thing.

CONSULTANT WALLIS: Isn't it --

CHAIR CORRADINI: I think it's normalized. This is a fan. I assume --

CONSULTANT WALLIS: Oh, okay. So it's pascals. Essentially it's the same as pascals?

CHAIR CORRADINI: Right.

CONSULTANT WALLIS: Okay. Thank you. Because it doesn't say that. I mean, okay. Because often things are quoted in terms of feet of water or something, or head. Okay. Thank you.

MR. MARQUINO: All right. In June there was an observation by the staff that the drywell head volume extended into Ring 5. And that was a correct observation that in the DCD model the drywell head volume goes out to Ring 5. Part of the drywell head volume is allocated to Ring 5.

We did a sensitivity study which I'll cover on the next slide to see how changing the volume distribution affected the results. That sensitivity doesn't affect the early -- we're not trying to cover the zero to 72 hour period because we have other nonmechanistic features in the model that provide a conservative result for the first three days.

For example, you have double pipes venting the GDCS compartment. So we get essentially no credit for noncondensible holdup in the GDCS compartment. And then at three days we purge all the noncondensibles into the wetwell, compressing the wetwell pressure and increasing the containment pressure.

Next slide, please.

CONSULTANT WALLIS: Well, I have a question about this. And you can make these conservative assumptions about one thing and it turns out to be nonconservative later on about something else. Don't you really need a realistic analysis that says where the noncondensibles go and how much of them is nitrogen, and all that sort of thing? Because these bounding analyses get very confusing when they're so far from reality.

MR. MARQUINO: Initially in the pre-application review we had a pretty good focus on providing best estimate evaluations and then making specific changes and providing bounding evaluations. I'd say we kind of lost focus on that in the containment analysis because the staff is very focused on us providing a bounding analysis. And then it gets difficult to maintain both when you have things like nodalization changes where you've got things you would have to take time to undo some feature of the model to get back to a realistic result.

We do provide you a sensitivity study with venting the GDCS compartment to some place, to the lower drywell and we show some results there where we document a lower pressure, as you'd expect.

CONSULTANT WALLIS: If all the noncondensibles go to the wetwell, as it says there, then they're not available later to have any influence until they come out through the vacuum --

MR. MARQUINO: Okay. Now that specific bottom lost line on the right, that is a hand calculation outside of the TRACG model that's done to establish a licensing basis peak pressure.

CONSULTANT WALLIS: But it is bounding for that pressure?

MR. MARQUINO: Yes, it's bounding. And the intent is to have a number in the DCD that it is a maximum containment pressure in which there's no question about the noncondensible distribution and about how much leftover noncondensible and the drywell effects the decontainment pressure.

MEMBER BANERJEE: So does TRAC actually keep track of the noncondensible composition?

MR. MARQUINO: The composition --

MEMBER BANERJEE: Hydrogen, oxygen, nitrogen, whatever?

MR. MARQUINO: In TRAC we've converted the hydrogen and oxygen to an equivalent nitrogen amount. And we --

MEMBER BANERJEE: What does that mean?

CHAIR CORRADINI: I think his answer is no.

MEMBER BANERJEE: Okay.

CHAIR CORRADINI: That's what I think he just said.

MR. MARQUINO: Yes. We only --

MEMBER BANERJEE: It does not?

MR. MARQUINO: Everything is modeled as nitrogen and we have an addition of --

MEMBER BANERJEE: Well how do you handle what we know is a real physical phenomenon that you get the hydrogen on top and potentially -- I mean all these things are different densities so when you stratify a flow, your system, you're going to get separation. You're likely to get your plumes of hydrogen going to the top, right, and your plumes of whatever, nitrogen staying at the bottom. But how do you handle that in TRAC?

MR. MARQUINO: So we aren't completely capturing that in TRAC.

MEMBER BANERJEE: So what happens if it catches fire?

CHAIR CORRADINI: Well, let's just --

MR. MARQUINO: I'm covering combustible gas control in a couple of slides later in the presentation.

MEMBER BANERJEE: Okay. All right.

CHAIR CORRADINI: So just to --

MEMBER BANERJEE: You don't have the capability in TRAC to track G2?

MR. MARQUINO: We have the capability, but we are not exercising it in this calculation.

MEMBER BANERJEE: So just to be clear if you get a plume of hydrogen, it completely mixes? I mean, suppose there's hydrogen generation in a volume. I can imagine a plume of something rising in another gas, right, without mixing completely. This is completely mixed in TRACG, the volume that it's generating?

MR. MARQUINO: Okay. So it's generated

in --

MEMBER BANERJEE: In some volume, right?

MR. MARQUINO: We start with nitrogen in the drywell. We purge most of the --

MEMBER BANERJEE: So it comes out at the break?

MR. MARQUINO: -- a lot of the nitrogen and then we only generate hydrogen and oxygen in the core through radiolysis at pretty lean concentrations. And then it leaves the core with the steam.

MEMBER BANERJEE: Leaves the break, or whatever?

MR. MARQUINO: Yes, through the break and the DPVs and mixed with steam. And basically in TRAC it will mix all the gas components in a cell together. And then the gas-density differences are factored into the flow calculation.

MEMBER BANERJEE: But even the steam is lighter than the nitrogen, right?

MR. MARQUINO: Right.

MEMBER BANERJEE: Steam will rise to the nitrogen?

MR. MARQUINO: Right.

MEMBER BANERJEE: The plume.

CHAIR CORRADINI: But once mixed, it's not going to unmix except through the condensation.

MEMBER BANERJEE: Yes. But why should it mix? I mean, unless you've got a high level of turbulence.

CONSULTANT WALLIS: Well, at the beginning you've got the break.

MEMBER BANERJEE: Yes.

CONSULTANT WALLIS: You've got it stirring.

CHAIR CORRADINI: Well, I'd say it's mixed --

MEMBER BANERJEE: Later on it's just coming out, right?

CHAIR CORRADINI: Right, but it's coming out. I think the assumption that I hear Wayne saying is, you correct me if I'm wrong, is that they assume a well mixed plume of steam and any sort of radiolytic decomposition gases from the beginning.

MEMBER BANERJEE: The steam and the radiolytic gases I have no problem with. But once it issues from the break unless the Reynolds number are high enough, it's not going to necessarily mix with its surroundings.

MR. MARQUINO: As I understand, it's

hotter than the steam mixture in the drywell, so it'll tend to rise, yes.

MEMBER BANERJEE: Well, I don't know. So basically you've got a 1D calculation with well mixed assumption.

CHAIR CORRADINI: All the calculations for containment are 1D calculations. That is not one that we're going to see that is not.

CONSULTANT WALLIS: Not in TRAC.

CHAIR CORRADINI: No.

CONSULTANT WALLIS: TRAC has different--

MR. MARQUINO: They're 2D in TRAC, they're not 3D and it's not CFD calculations.

CHAIR CORRADINI: Well, we're going into thermal hydraulic mode here. But you basically have orifices and lumps. So you can call it 2D, you can call it 1D. You have lumps of mass and energy connected by orifices. So if you want to call it 2D, that's fine. But it's still an orifice and a --

CONSULTANT WALLIS: But it doesn't allow for plumes and circulation?

CHAIR CORRADINI: No. No. Not at all. Nor does MELCOR.

MEMBER BANERJEE: Why are we using these codes?

CHAIR CORRADINI: I'm not going to answer that. I'll let staff answer that.

I guess I would let him go on and we can take this as a side comment. My sense of it is for this accident for long times you're still going to get pretty good mixing with the steam issuing forth in the drywell. But I --

MEMBER BANERJEE: What is the velocity of the steam coming out?

MR. ALAMGIR: Again, this is Md Alamgir from GEH.

Just to clarify TRACG descriptions has no the details section 313, basically the summary of your -- is that multiple noncondensible gases may be included or noncondensible gases assumed to be in thermal equilibrium with any steam and most the same velocity of steam, mechanical equilibrium.

CHAIR CORRADINI: I think the question that Dr. Banerjee is asking to calm is concerns is what's the Reynolds number of the long term steaming rate so that he decides whether we have mixing or no mixing.

MEMBER BANERJEE: Exactly. Put your finger on it.

All right. Just give me the velocity of

the issuing --

CHAIR CORRADINI: What don't you take it as an action item. I'll write it down and we'll back to it.

Let's move on.

MR. MARQUINO: Okay. Next slide, please.

So these are the results of sensitivity studies we did to address the observations in June.

We renodalized the upper drywell in the GDCS airspace and changed the GDCS airspace to drywell head connection. And in the post-3 day period we found that the reduction in pressure was small, not as great as the base case, but it was a small difference and its offset by some of the other changes like moving the GDCS airspace to the lower drywell.

CONSULTANT WALLIS: Why was there a small reduction in pressure? Less condensation or something, or the PCC didn't work so well?

MR. MARQUINO: So when we made this change we were changing the concentration at the PCC inlet.

CONSULTANT WALLIS: You've got more noncondensibles there?

MR. MARQUINO: Yes.

CONSULTANT WALLIS: It would help if you gave a reason why. Because TRAC just gets a bump in it, and there's no explanation, we'll eventually ask why.

MR. MARQUINO: Okay.

CONSULTANT WALLIS: You know, and it's nice to know. Why is it; because you've got more noncondensibles going into the PCCS because you let them come out of the upper drywell somewhere or the upper head airspace, or where do they come from? It must be they've come out of the head space and store in noncondensible, is that what it is?

MR. MARQUINO: Yes. So we've moved that small volume back into Wing 4.

CONSULTANT WALLIS: So it's something to do with the distribution of noncondensibles in the containment, which MELCOR wouldn't be able to-- is it MELCOR, whatever Jack uses wouldn't show that?

MEMBER BANERJEE: How do you move it? Is there sort of a cross flow or what?

MR. MARQUINO: No. In the input, instead of assigning the drywell head volume to Ring 5, we assigned into Ring 1, 2, 4.

MEMBER BANERJEE: Okay. I got it. Okay.

CONSULTANT WALLIS: So you mixed two nodes, is that you do?

MR. MARQUINO: I think we mixed four --

CONSULTANT WALLIS: Nodes.

MR. MARQUINO: -- nodes. So we took what was in Ring 6 and we put it back somewhere in Ring 1, 2, 3, 4 and again it's a small volume, it's 10 percent of the total drywell --

CONSULTANT WALLIS: So boxes with orifices that the Chairman talked about?

MR. MARQUINO: And they are boxes with orifices, yes.

MEMBER BANERJEE: So Ring 4 actually extends all the way down, does it?

MR. MARQUINO: Yes.

Okay. We also looked at the break discharge and the DPV pipe discharge and --

CONSULTANT WALLIS: Let me go back to that. You're saying then that the pressure is reduced less because more noncondensibles go into the PCCS and that lowers its efficiency?

MR. MARQUINO: Yes, a little bit.

CONSULTANT WALLIS: Well, what does the PCCS discharge into?

MR. MARQUINO: Into the GDCS airspace.

CONSULTANT WALLIS: In airspace?

MR. MARQUINO: Yes.

CONSULTANT WALLIS: Because in your figures you show it going into this train.

MR. MARQUINO: Okay. So the fan draws on the PCC lower header --

CONSULTANT WALLIS: Blows it into the DPVs.

MR. MARQUINO: -- it blows it into a try.

CONSULTANT WALLIS: Yes, which is full of water.

MR. MARQUINO: Yes, but the noncondensible are going to bubble through the water--

CONSULTANT WALLIS: No, no, no. The steam I'm worried about. It's not -- so it's got steam coming through. Steam is not being condensed because it's not --

MR. MARQUINO: Right, right.

CONSULTANT WALLIS: So why doesn't it condense into this pool it levels into?

MEMBER BANERJEE: And why do you need the PCCS --

CONSULTANT WALLIS: Of course, that was just as efficient as before?

MR. MARQUINO: Okay. Because the pool effects no net heat removal.

CONSULTANT WALLIS: Yes, it is. It gets the cold water --

MR. MARQUINO: Any steam that goes into this try which is about one square meter, 10 inches high, and any steam is going to heat that water up to saturation and that steam --

CONSULTANT WALLIS: But does it? Because the water comes from the condensate from the PCCS, which is cooled by the PCCS pool. So I'm not sure that it just bubbles through. I want to see an energy balance and so on for that. Because you've got cold water coming from the PCCS discharge.

CHAIR CORRADINI: You have saturated water. Why --

CONSULTANT WALLIS: It's not saturated. It's been subcooled by condensate of the cooling of the pool. There's a pool around the condenser which cools the water to less than saturation, subcools it.

MR. MARQUINO: So if we have a condition where the PCC is not condensing all the steam and there's steam being drawn out the bottom --

CHAIR CORRADINI: Less condensate.

MR. MARQUINO: -- in that condition we're not going to have subcooled condensate.

CONSULTANT WALLIS: Why not?

MR. MARQUINO: Previously when we didn't have the fan on, we could have some subcooling because the water's just dribbling down in the tube.

CONSULTANT WALLIS: You have a film running down the condenser, and the film on the wall is contact with the pool, and the film on the wall is subcooled on that side. This is all about basics of condensation. A condensate film is cooled by a pool on the outside is subcool on the average.

MR. MARQUINO: Yes.

CONSULTANT WALLIS: Because it's kept cool on the outside. So there is subcooling there.

CHAIR CORRADINI: Yes, but do you really believe that there's going to be enough subcooling to overcome the --

CONSULTANT WALLIS: I don't believe anything until I see an analysis

CHAIR CORRADINI: Okay.

MEMBER BANERJEE: I guess the issue is that you've got in the middle of the flow of mixture of noncondensibles and steam at whatever is the vapor pressure of the subcooled water. I mean, if you assume equilibrium across the tube. So when the subcooled water is it caught in the tray and you bubble this stuff through, you could potentially condense the steam which is mixed with the noncondensibles. Because, of course, it's at whatever --

CONSULTANT WALLIS: You will condense some.

MEMBER BANERJEE: Yes, you could condense some.

CHAIR CORRADINI: But we're going to need to move on because time --

MEMBER BANERJEE: Well, does that matter if --

CHAIR CORRADINI: Well, I think I know where Graham's going with this. Because this is a question you brought up in June that I think we're coming back to, which is his concern is if I rid myself of all the steam, now I've got an interesting mixture of gases. So is that where you're going with this?

CONSULTANT WALLIS: Well, where I was going with it, here I'm just talking about drywall pressure here. I'm saying that if you have subcooled water in that pool, and you may do because it's cooled in the header at the bottom. So there may be enough subcooling in the, whatever you call it, the drain pan to condense the small amount of remaining steam. In which case, we don't care what the efficiency is of the PCCS. Everything is 100 percent.

MEMBER BANERJEE: In fact, you're probably right. The thing will self correct because the self-cooled -- I think the whole thing is going to probably just condense all the steam. Yes.

CONSULTANT WALLIS: But we need to know the details of this drain pan.

MEMBER BANERJEE: Yes. You can probably do it by hand.

CONSULTANT WALLIS: Well, I don't think we know the temperature of the water that's coming out of the bottom of the PCCS condenser and going into that drain pan.

MEMBER BANERJEE: Well, you can just take a --

CHAIR CORRADINI: Before we do this, so I'll make a note of it and let's take it to the side and move on. Because I think where Graham's question is is consistent with what he asked back in June, which was he wants to understand the efficiency of the PCCS as you go through various stages of this long term to understand what's coming out of the condensate or coming out of the back end of the PCCS. One concern is potential combustibles for long term because I've got hydrogen and oxygen mixed with the nitrogen, right? As well as steam.

CONSULTANT WALLIS: There's no nitrogen.

CHAIR CORRADINI: I'm sorry, no nitrogen. But essentially steam and the gases.

And the other thing is what the condition in this catch pan. But I think that's a side note we're going to have to come back to. We're not going to answer it now.

CONSULTANT WALLIS: My first concern--

MR. MARQUINO: Is the question about when the fan is operating or before the van operates, or what?

CONSULTANT WALLIS: Yes. Well, before the fan operates you have an interesting mix to going down the pipe into the wetwell. But my first question is where does the pipe go? Because in June we had three versions.

Jack Tills is said into the airspace. There was a written RAI in which is discharges into the GDCS pool. And then there was another picture in the DCD which said it goes into a drain pan. So we have three versions of where the pipe goes.

Now we clarified that today, I think.

MEMBER BANERJEE: With the drain pan.

CONSULTANT WALLIS: The second time you answered you said it goes into the drain pan. The first time you said it went into the pool. But it goes into the drain pan?

MR. MARQUINO: Are we talking in the plant or in the TRAC model?

CONSULTANT WALLIS: In reality?

MR. MARQUINO: In reality it goes into a drain pan --

CONSULTANT WALLIS: TRAC model it goes into something else?

MR. MARQUINO: And in the TRAC model it goes into the GDCS pool. So we're using the GDCS pool to model the drain pan.

CONSULTANT WALLIS: But then you've got a humongous condensing capacity in the GDCS pool. It's just a suppression pool.

MR. MARQUINO: Well, I think we have two different concepts about whether that matters or not.

CHAIR CORRADINI: So go through those two concepts and then we'll move on.

CONSULTANT WALLIS: I am really bothered

by this. You have a TRAC model which doesn't model the reality. I don't know why you do that.

CHAIR CORRADINI: Let's just weigh in.

MR. MARQUINO: Okay. I think that --

MEMBER BANERJEE: But let's see what the consequence would be. Tell us why us why you think it's of no consequence.

MR. MARQUINO: I think it is of no consequence because there is no heat removal mechanism in that compartment to take energy out of the containment. We're taking the energy out of the containment to the IC PCC pool.

MEMBER BANERJEE: But, okay, that's not the no consequence. Imagine that you're wrong now because of the reasons Graham gave. What is the consequence if there was subcooled water in equilibrium with a mixture of steam and noncondensible coming into the pool and then since you have finer bubbles, you know now you can condense it? From film wise condensation now you're going to -- so imagine that's the scenario.

MR. MARQUINO: Okay.

MEMBER BANERJEE: Now what is the consequence of that? Any?

MR. MARQUINO: So if the pool was

subcooled and at 20 degrees C. Let's say it's at 20 degrees C. And we have steam coming out of the fan because the PCC didn't condense all the steam. The energy from that steam is going to go into the pool and warm the pool and heat it up until eventually it is saturated.

MEMBER BANERJEE: But that's not what he's saying.

CONSULTANT WALLIS: It's coming in cold.

MEMBER BANERJEE: It's coming in with subcooled water. Let's not get into that.

MR. MARQUINO: Okay.

MEMBER BANERJEE: Leave it. Is there any consequence if there is condensation in the pool?

MR. MARQUINO: I don't see a consequence if there's subcooled water --

MEMBER BANERJEE: Okay. That's the most important point.

CONSULTANT WALLIS: No, there is a consequences.

MR. MARQUINO: There's a continual subcooled drips coming through the GDCS line and that --

CONSULTANT WALLIS: Now look, Wayne, you're condensing 95 percent of the steam. So the flow of water that's coming out, which is slightly subcooled, is 95 to five as much as the steam. And if it's got 20 degrees subcooling, it could condensate all that 5 percent of steam. It doesn't take much subcooling with that large flow of water relative to the steam to condensate the steam.

The consequence is that the combination of the PCC as in the drain pan is 100 percent efficient and you get a better reduction in drywell pressure.

MEMBER BANERJEE: He's helping you?

CONSULTANT WALLIS: That's what I figure is the difference between what -- and that's why TRAC ought to model it. I can't understand this business of TRAC modeling something which has no view of the case.

MR. MARQUINO: Well, let me come back to you after we take a break. Because we have done some calculations where we've modeled it outside of the GDCS pool. And to my knowledge those calculations didn't show a significant pressure change. So --

MEMBER BANERJEE: I have, actually, a different feeling from what you were saying. I thought you were going to say I like having some steam around so that I am at the lower flammability limit off this hydrogen/oxygen mixture. That's what I thought your answer was. Now you're saying it doesn't --

CONSULTANT WALLIS: No, he hasn't got there yet.

MEMBER BANERJEE: He hasn't got there yet? All right.

CHAIR CORRADINI: Let's move on. I think we've got the point. We have to move on. I want to get to -- because we have less than an hour and I want to get to the staff's presentation too.

CONSULTANT WALLIS: Let's make it clear. The discharge now is into the drain pan? Because there was a question about that last time. And how it goes in and whether its a sparger that makes small bubbles or big bubbles makes a difference? So we can't just gloss over it, you know.

MR. MARQUINO: I have some material on that I can hand out. I think at that point we'd have to -- it's proprietary information.

We also moved the GDCS airspace vent to the lower drywell and that effected a larger reduction in pressure, which is counter to the first sensitivity study. So I think overall we have --

CONSULTANT WALLIS: What does this mean?

"The GDCS airspace is several walls away from the lower drywell."

MR. MARQUINO: Yes.

CONSULTANT WALLIS: It doesn't make sense.

MR. MARQUINO: To give some quantification to your observation that nitrogen would tend to accumulate in the lower drywell. Now in this node we've drawn the nitrogen back from the wetwell into the drywell. It's being pumped around. And in this sensitivity we discharged -- we connect the GDCS compartment to the lower drywell so the nitrogen goes to the lower drywell first. And that in TRAC reduced the noncondensible mass fraction, it caused the pressure to drop --

MR. QUEEN: I don't understand this at all. My point was that when the vacuum breakers open, the nitrogen comes out of the wetwell, is cold and it has a molecular weight of about 50 percent greater than the steam and its colder than the steam so it has a density of twice the density of the steam and just flows along the floor into the drywell. That was my point. I didn't understand what the GDCS airspace has to do with it.

MEMBER BANERJEE: There's nitrogen in the

GDCS airspace as well, right?

CONSULTANT WALLIS: Yes, but they can't get through the wall.

MEMBER BANERJEE: It has to -- yes, it has to go over the top.

CONSULTANT WALLIS: No. The stuff from the vent from the vacuum breakers is really much heavier than the steam around it. There is going to be a flow, there's going to be like sort of water flowing across the floor going down into the lower drywell. That was my point.

MEMBER BANERJEE: So you transferred the nitrogen from the surface of the GDCS pool into the wetwell, is that what you did?

MR. MARQUINO: Not the wetwell. The lower drywell.

MEMBER BANERJEE: Oh, the lower drywell?

CONSULTANT WALLIS: Lower drywell? How does it get back up to the PCCS or does it?

MR. MARQUINO: And then it has to diffuse and get back up.

CONSULTANT WALLIS: Okay.

MEMBER BANERJEE: I have a question which maybe you can have an answer to. Can we track the LFL of what's coming out, the lower flammability limit? Because you've got steam in there and according to TRAC you're mixing it in. So probably its always below its lower flammability limit. But could we have an answer to that? Because I'd like to know what the LFLs are in the various volumes.

CONSULTANT WALLIS: It all depends on how efficient the PCCS is as a condenser. If it's a 100 percent efficient --

MR. MARQUINO: Yes.

MEMBER BANERJEE: That is a question I ask you.

MR. MARQUINO: I think that's basically the answer is that the PCC performance, which we have test results on, will establish how concentrated noncondensibles can be in that heat exchanger at any decay heat level. And that noncondensible fraction, it is going to be mostly hydrogen and oxygen in the later phases of the three day period.

CONSULTANT WALLIS: Well, Wayne, this is a difficult question, but I think noncondensible behavior of hydrogen in a condenser is different than the noncondensible behavior of air because you're dealing with diffusion through a thin boundary layer where the steam and the condensation is occurring and you're building up noncondensibles. And the diffusion coefficient of hydrogen is very different from what it is for air.

MR. MARQUINO: Yes.

CONSULTANT WALLIS: So the performance of the PCCS in a hydrogen/oxygen atmosphere is different than it is in air. And I don't think you've done tests with PCCS full scale with the hydrogen/oxygen --

MR. MARQUINO: Well, we've done helium tests.

MEMBER BANERJEE: Yes.

MR. MARQUINO: We do have helium steam tests.

CONSULTANT WALLIS: Well you've got helium. Well, maybe that's scalable somehow.

MEMBER BANERJEE: Yes, that's scalable.

CONSULTANT WALLIS: Good thank you.

MEMBER BANERJEE: That's a pretty good test.

CONSULTANT WALLIS: Yes, that's good.

MR. MARQUINO: Next slide, please.

The closest we can get to the staff's MELCOR calculation is by degrading the PCCS heat transfer. If we reduce the tube area in the PCC, we can get a drywell pressure trace that agrees better with the MELCOR trace.

MEMBER BANERJEE: Degrade by how much?

MR. MARQUINO: About half.

CHAIR CORRADINI: Yes, about half.

MR. MARQUINO: The exact number is on the proprietary.

CONSULTANT WALLIS: How much does it change the efficiency when you're doing it? What was efficiency before you changed it and what is it after you changed it? It's in the 90s, isn't it, at both times, or is it proprietary?

MEMBER BANERJEE: Look in the slides. It's there.

CONSULTANT WALLIS: Well, I don't have any slides for this.

MEMBER BANERJEE: We have this curious situation that we have some proprietary and some nonproprietary.

CHAIR CORRADINI: But I think Wayne's point -- so let's just repeat Graham's question a different way so we get to some acceptable qualitative.

So Graham's point is if you're reducing the efficiency by about half --

CONSULTANT WALLIS: No, you're not. He's

reducing the area. But I think the efficiency hasn't changed much.

MEMBER BANERJEE: Well, it's the same thing.

CHAIR CORRADINI: It's the same thing.

CONSULTANT WALLIS: No, it's not.

CHAIR CORRADINI: Yes, it is.

MEMBER BANERJEE: It's area.

CHAIR CORRADINI: It's area.

CONSULTANT WALLIS: It's how much of the steam you condense --

MEMBER BANERJEE: It's the same thing.

CONSULTANT WALLIS: Aren't you condensing 95 percent. Just give you half the area doesn't mean you condense half the steam.

MEMBER BANERJEE: That's true. That's true.

CONSULTANT WALLIS: Come on.

MR. MARQUINO: So in all of these you're always condensing all of the decay heat generated steam. It just what noncondensible fraction --

CONSULTANT WALLIS: All of them? No, the PCCS --

MR. MARQUINO: Yes.

CONSULTANT WALLIS: -- emits some steam

with the noncondensibles. Nine percent or ten percent?

MEMBER BANERJEE: He wants to know what is the faction -- the difference in the fraction of the steam --

CONSULTANT WALLIS: What we call efficiency. What we've been calling efficiency is how much of the steam.

MEMBER BANERJEE: Give a straight answer, or get somebody --

MR. MARQUINO: But I don't know --

CONSULTANT WALLIS: You see the thing that Jack Till's --

CHAIR CORRADINI: You've got to let him answer the question before you ask him another question. That's not fair.

CONSULTANT WALLIS: I am trying to explain the questions. He doesn't even understand the question.

MR. MARQUINO: I don't have the exit steam flow rate from the PCC from the sensitivity calculations. We'd have to look that information up and get that to you.

CONSULTANT WALLIS: Jack Tills had a curved graph where he showed percent of steam that goes in that's condensed That's what I'm looking for. And he had them up in the 90s and he was saying well if it's 95 rather than 98 makes a big difference. That's what I'm looking for.

MR. MARQUINO: We'll have to look that up and get back to you.

CHAIR CORRADINI: So let me broaden the question and then we put it on this list. I think there's two questions here that are related.

One is: As Graham calls it, what is the amount of steam coming out relative to how much is going in? A ratio, whatever.

And secondly, Sanjoy brought it up but I think it got lost in the discussion, which is Now with that difference, what is the ratioing of that exiting steam to the noncondensibles coming out? And I think that leads us to other downstream questions. But it's that mixture of what's coming out under various performance modes that is essentially what Graham and Sanjoy are after. Is that correct, gentlemen?

MEMBER BANERJEE: Yes.

CHAIR CORRADINI: Okay.

MEMBER BANERJEE: Graham has an interesting point that probably it doesn't matter because, you know it's a self-adjusting system. You've probably condensed all the steam anyway in the drain pan in reality if you model it correctly.

CHAIR CORRADINI: So I've got it written down, Wayne. Wayne, we can move on.

MR. MARQUINO: Okay. We did sensitivities to the fan head and flow. The head, reducing the fan rate at head slows the pressure reduction in the drywell.

CONSULTANT WALLIS: Do you reduce it by ten percent?

MR. MARQUINO: Yes. Reducing the fan rated flow had a less significant effect.

CONSULTANT WALLIS: What is the typical cfm going through the fan?

MR. MARQUINO: Early in the event it's about 300 cfm.

CONSULTANT WALLIS: This is perhaps where my flat characteristic comes in if you change the head by 10 percent -- 300. If you increase it--

MEMBER BANERJEE: It's very sensitive.

CONSULTANT WALLIS: And you change the cfm immensely, yes.

MEMBER BANERJEE: Yes, it's very sensitive.

CONSULTANT WALLIS: You might actually shut it off.

MR. MARQUINO: Now we had some discussion in June about the wetwell heat loss. And--

CONSULTANT WALLIS: I'm sorry, I don't want to interrupt you. But if you just give us -- TRAC says something when you decrease something by 10 percent.

MR. MARQUINO: Yes.

CONSULTANT WALLIS: That doesn't help me because when I look at the fan curve it says well it's going to shut the fan off completely. And that doesn't make sense. So there's got to be some physical explanation, not rather than just "TRAC says."

MR. MARQUINO: Well, it makes sense that if you change the rated head of the fan in the early part of when its trying to draw from the heat exchanger and the heat exchanger has mostly steam in it and there's a low suction pressure, that that's going to degrade the ability of the fan to produce flow.

CONSULTANT WALLIS: Well, I understand that. It's just when I look at your fan characteristic, it looks as if 10 percent is going to shut it down to essentially zero flow. It doesn't seem compatible; that's what I'm saying. Something is off.

MEMBER BANERJEE: Yes. What you have shown here in the fan characteristics is let's say you had 300 cfm. That would be 2380 meters squared per second square. If you increase that by 10 percent, you shut off the fan the way your characteristic is there.

I mean if your characteristic, this is just yours.

MR. MARQUINO: Yes. So when you say "shut off the fan." In the early portion of the event we can have the fan go to very flow when its pulled steam in, the fan flow can be low. And later on in the event when we've got noncondensible and the suction pressure is higher, the upstream pressure on the fan is higher, then it's able to flow through the heat exchanger. And we showed some results in the last meeting where it's about the first 15 minutes of the 30 days where it's in this low flow mode.

MEMBER BANERJEE: That's going to be a strong pressure reduction, is that it?

MR. MARQUINO: Yes. A strong reduction in the upstream pressure on the fan.

The last point on this slide is the wetwell heat loss to the reactor building. We actually have a similar net heat loss to the reactor building between TRAC and MELCOR --

CHAIR CORRADINI: So, I've got to just interrupt you there.

MR. MARQUINO: Okay.

CHAIR CORRADINI: I thought in June, at least I remember writing down a substantial difference. Did I misunderstand at that time?

MR. MARQUINO: I think we were talking sensible heat versus latent heat. I don't want to speak for the staff.

CHAIR CORRADINI: Fine. But you guys have resolved it now?

MR. MARQUINO: But I think the bottom line is neither one of us think that that is an explanation of the TRAC-MELCOR differences.

CHAIR CORRADINI: Okay. So you have similar heat losses when you looked at it consistently?

MR. MARQUINO: Yes.

CHAIR CORRADINI: Outside, from the drywell to outside the building?

MR. MARQUINO: Yes.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: That was pretty different in June. It's been resolved?

MEMBER BANERJEE: This is the wetwell. This is to wetwell heat loss?

CONSULTANT WALLIS: It's been resolved now?

MR. MARQUINO: Yes, wetwell to reactor building.

CONSULTANT WALLIS: That's been resolved?

MR. MARQUINO: So we're looking at the wetwell as a box. In the TRAC model it's the only thing that communicates to the environment and what's the net loss from the wetwell. I think that's the figure of merit.

CHAIR CORRADINI: Fine.

MR. MARQUINO: Next side.

MEMBER BANERJEE: Was it wrong then that, at least we got the wrong idea at the last meeting that these were very different between TRAC and MELCOR?

MR. MARQUINO: Well, I'm not sure that we had -- in terms of the overall, I don't think we were talking different numbers. In terms of the breakdown by levels and that that may be where there was some difference in what GEH and the staff was reported. But I think we're converged on the overall loss from the wetwell to the environment.

CONSULTANT WALLIS: Because the numbers you showed in June were very different from Jack Tills' numbers.

CHAIR CORRADINI: They have resolved it. I'm going to leave it at that.

MS. CUBBAGE: Let's defer that to the staff's presentation?

CHAIR CORRADINI: Fine. Okay. Go ahead then.

MR. MARQUINO: All right. So I tried to address all the staff and ACRS observations from the June meeting. We still have a difference between the TRACG and MELCOR results, but they both predict that the containment pressure is reduced by the fan operation and it stays reduced. We don't have the situation where one is predicting an increase in containment pressure at the 30 day point and the other is predicting a decreasing trend.

MEMBER BANERJEE: You were showing a decrease, right?

MR. MARQUINO: Yes.

CHAIR CORRADINI: I think the fair thing

to say is there was a stabilization and there was an increase, and we'll see the staff's presentation next.

MR. MARQUINO: Yes.

CONSULTANT WALLIS: Because at no time did you reduce the pressure rapidly.

CHAIR CORRADINI: They reduce it rapidly at 72 hours with the turning on of the fans, and then it stabilizes.

CONSULTANT WALLIS: And that meets the GDC -- there was an RAI about reducing the pressure rapidly and all the response was to reiterate description of what happens. It doesn't address the question.

MR. MARQUINO: Okay. Our definition of rapid is to reduce the pressure to 350 kilopascals at 144 hours. So we're --

CONSULTANT WALLIS: So 144 hours is rapid?

MR. MARQUINO: Yes.

MS. CUBBAGE: That was discussed in the June meeting. And the staff was done with that topic, and I don't believe the Committee had any comments at that time.

CHAIR CORRADINI: Now you're going to go

on to vacuum breakers, I assume?

MR. MARQUINO: Yes. Next slide, please.

CHAIR CORRADINI: We want to hear about that.

CONSULTANT KRESS: There was a question about that, and that was whether or not the operation made that particular piece of equipment a safety component and it had to be treated as such.

MS. CUBBAGE: No, there wasn't an issue on that in June.

CHAIR CORRADINI: I'm not remembering that. Can you repeat what you're concerned with?

CONSULTANT KRESS: Well, it's a nonpassive piece of equipment. And I don't think it was designated as a safety systeming component.

MS. CUBBAGE: Oh, yes. I understand what you're saying. The discussion was that the rapid reduction happens at 72 hours when the RTNSS systems are credited.

CONSULTANT KRESS: Right.

MS. CUBBAGE: Right. But that was --

CHAIR CORRADINI: So it's the RTNSS that's not -

CONSULTANT KRESS: Yes. The question was whether it shouldn't some more than just RTNSS.

Because it has to be invoked to meet this rapid reduction.

CHAIR CORRADINI: So that's probably you're saying. My thought there at the time, and I thought the Committee was satisfied with the answer, which it's one of the RTNSS system. It's not safety grid, but it's one of the RTNSS system.

CONSULTANT KRESS: Well, the Committee might have been, but my question is it should have been safety grade.

CHAIR CORRADINI: Okay. I got it.

CONSULTANT KRESS: Okay.

CHAIR CORRADINI: So I guess I'm not personally understanding the difference in terms if it fits within a RTNSS framework, I would think that it has certain maintenance requirements and certain inspection requirements such that it will have reliability of operation under accident conditions. That's my interpretation.

CONSULTANT KRESS: Well, there are differences between the treatment. If it's required to meet a GDC, it seems to me like it ought to be a safety system. But that was the issue.

MS. CUBBAGE: If it was required before 72 hours, then it would need to be safety-related.

CONSULTANT KRESS: I see, it's the timing?

MS. CUBBAGE: It's the timing.

CHAIR CORRADINI: Okay. Any other questions over here?

Wayne, do you want to go on to the vacuum breakers?

MR. MARQUINO: Yes. In June we also presented information on the logic for detecting vacuum breaker leakage. And the staff followed up with an RAI 6.2-148, which we've recently responded to.

CHAIR CORRADINI: And just to be sure, what is that response number?

MR. MARQUINO: 6.2-148.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: This is another thing we haven't seen, is it?

MR. MARQUINO: It was very recent, so you may not have seen it.

CONSULTANT WALLIS: So I would like to know the process here. Are we supposed to review these things that we haven't seen yet and then write a separate report to this Committee about them, or what?

MS. CUBBAGE: By "recent," I just want to clarify. The staff sent this RAI to GE. You have the RAI. We have not received a response.

CONSULTANT WALLIS: You have not received a response?

MR. MARQUINO: But in any case, I'll present the information in the RAI to you.

So the question was whether the -- we provided a TRAC analysis previously that was proof of concept of the temperature detection --

CONSULTANT WALLIS: So, Wayne, you've showed us a TRAC plot in June and it didn't make sense. It had a temperature going down as the steam came in. And it had a temperature of the stream coming in of 160 -- wait a minute. A 166 C. Whereas, the drywell is 140 C. So it seemed to have the wrong boundary condition and a nonphysical answer from the TRAC analysis.

MR. MARQUINO: The boundary conditions were from the TRAC model at 50 seconds into the event.

CONSULTANT WALLIS: Was the temperature 166 C?

MR. MARQUINO: Yes. And --

CONSULTANT WALLIS: Right at the

beginning of the transient you're doing that? You are interested in what's the leakage, it's what's driving this 72 hour thing over three days; the leakage is driving all this pressure rise?

MR. MARQUINO: Right.

CONSULTANT WALLIS: That's what you need to detect during that period when the drywell temperature never goes 140 C.

MR. MARQUINO: Yes. So that as the crux of your question was that we provided a calculation. And the purpose of the calculation was to show that we can differentiate high leakage from low leakage with this temperature difference logic.

CONSULTANT WALLIS: You had a temperature which was so much bigger than you're ever going to get when you're interested in detecting this.

MR. MARQUINO: So under those conditions we were able to differentiate a leak at the analytical limit used in the three day containment analysis from a lower value, that would be the surveillance/acceptance criteria for the vacuum breaker.

CONSULTANT WALLIS: But this was based on the TRAC analysis?

MR. MARQUINO: It was based on the TRAC

analysis. Now we're not trying to claim that that analysis covers all possible conditions that happen over the three days. We --

CONSULTANT WALLIS: But you had a temperature difference between the drywell and the wetwell which was far bigger than you show in any of your plots. And so you're giving yourself an advantage of a huge temperature difference which you then say you can detect. It doesn't seem to make sense to me.

MR. MARQUINO: But the --

MR. DIAZ-QUIROZ: Wayne, this is Jesus Diaz-Quiroz, GEH.

And I'm just looking at the 72 hour plots in the DCD. And initially there is a large temperature difference between the drywell and the wetwell. As the event progresses through the analysis it does decrease. What we're looking at, say, in the 6th hour after the event we're looking at 80 degrees in the wetwell and about 140 still in the drywell. And the vacuum breakers cycle in the first hour within the first 72 hours. So there is a large difference and it does last quite a lot. Of course, at the end of 72 hours the wetwell temperature the wetwell temperature does lag, and that temperature started to decrease as you stated.

CONSULTANT WALLIS: So you can detect this early on, in the six hours? When it's cycling you can detect leakage. What do you do about the leakage over that long period of three days where the pressure is slowing going up and its being driven by the leakage, if there is?

MR. DIAZ-QUIROZ: Can you restate your question, please?

CONSULTANT WALLIS: The interesting period is after the first opening/closing of the vacuum breakers things go very slowly up over three days.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: Long drawn out agonizing slow increase in pressure driven entirely by the leakage to the vacuum breaker. That's when you should be detecting it, it seems to me. You shouldn't be saying we can detect it in the first six hours. You want to know is it happening later on.

CHAIR CORRADINI: I think Dr. Wallis' question is if you were doing a limiting analysis, you would do the limiting analysis at the delta T at the end of the of the 72 hours, not at the beginning of the 72 hours. That's kind of what I think you're asking.

CONSULTANT WALLIS: During most of the 72 hours. Yes.

CHAIR CORRADINI: Yes. Do you understand, Jesus?

MR. DIAZ-QUIROZ: Yes, I understand. Right. And as Wayne explained it initially, this was because during the first hour is when you do have vacuum breaker cycling and that's when you would expect if a failure were to occur in sealing, it would happen then when they do cycle. Those are the conditions we chose at the time.

We're not trying to cherry-pick, if that's what you're saying.

CONSULTANT WALLIS: And then you have a TRAC response which had the temperature falling at the sensor as the steam was coming in. And that didn't make sense to me.

MR. DIAZ-QUIROZ: No.

MR. MARQUINO: I think that may have to do with the extension pipe on the vacuum breaker inlet. The purpose of that extension is to cool the leakage flow and allow us to differentiate high leakage from a low leakage flow.

CONSULTANT WALLIS: And how does it cool

the sensor? Okay. And the other problem is that you've got a very slow leakage rate. This stuff is oozing in. It's really producing a layer of steam which is much lighter than the gas below it, which simply acts as a piston and drives out the nitrogen, which is cold and heavy. And so it should be very insensitive to flow rate. It just means the piston goes slower if there's less team. It doesn't mix. TRAC says it mixes, but it doesn't mix.

MR. MARQUINO: TRAC isn't mixing. The calculation we did was a 1D pipe calculation in TRAC.

CONSULTANT WALLIS: But you've got to test it anyway, is that right?

MR. MARQUINO: And we're going to test it.

CONSULTANT WALLIS: Okay. Well, there were several I had about TRAC, the TRAC calculation didn't make sense to me.

And another thing that bothered me was that you seem to have a step change. You said doesn't leak, then all of a sudden it leaks whereas I think it's more likely that it's been leaking for some time and that this team has driven out the nitrogen. And then you've already heated up your sensor, how you going to detect an increased link?

Anyway, I don't want to prolong this. But I had several questions about this which bothered me. And you're going to est it, so then we're getting the real scoop. And I think you've got to test it with just not a step change in leak break, which is what you analyzed.

CHAIR CORRADINI: I think I'm not completely appreciating your question, Graham. Your point is that you want to have a pre-exiting leak over a long time?

CONSULTANT WALLIS: We did an analysis. Say we can detect it if it doesn't leak at all and then it suddenly spills above the limit. I was saying that's okay, that's interesting analysis if TRAC does it right, but it's more likely that it mixed for a long period of time.

CHAIR CORRADINI: And degrades?

CONSULTANT WALLIS: And degrades. And then you have to say well what would we measure then, you know, because our temperature has already changed because of this long period of leaking.

Well, anyway, you're going to look into that?

MR. MARQUINO: Yes.

CONSULTANT WALLIS: Thank you.

MR. MARQUINO: Next slide please.

So we were asked to talk about radiolytic hydrogen accumulation.

CONSULTANT WALLIS: And oxygen.

MR. MARQUINO: And oxygen. And we are committed to address Generic Issue 195. And we've considered this in our review of operating experience, which is an integral part of the ESBWR design process.

We've started system-by-system reviews and we're tracking the findings and the recommendations of these review to assure that they're dispositioned in detailed design.

CONSULTANT WALLIS: But the existing plants don't have a PCCS, so I don't see how existing experience which has had ruptures due to explosion, why would that have anything to do with ESBWR PCCS behavior?

MR. MARQUINO: Well, the fact that existing plants have had hydrogen combustion problems was flagged in this operating experience review and it's caused us to put requirements to assure that our system lines are effectively arranged to prevent hydrogen buildup.

CONSULTANT WALLIS: This was because of poor venting that they had these events?

MR. MARQUINO: Yes. But the PCCS isn't a vent, it's a thing that creates a combustible gas as it works. It doesn't build up something which is vented.

MR. MARQUINO: Yes, but --

CONSULTANT WALLIS: But its very nature it creates this combustible gas.

MR. MARQUINO: But let me talk about the general case first, which is venting of -- making sure we don't have a deadend pipe that's not vented which will build up combustible hydrogen gas. And then if we look at the steam piping in the plant, we have the IC heat exchanger and the PCC heat exchanger. So the IC, which is connected to the main steam line, this has to be addressed during normal operations, And we have connected a vent line from the IC to a lower pressure portion of the steam line piping. So we'll always have a small flow out of the IC to remove any radiolytic gases that enter the IC.

Next slide, please.

For the PCC, as you --

CONSULTANT WALLIS: I see. Excuse me. We haven't talked about the IC before, have we?

MR. MARQUINO: No, I don't think so.

CONSULTANT WALLIS: But it does the same thing. It takes material from the reactor, condenses the steam --

CHAIR CORRADINI: Returns to the reactor.

CONSULTANT WALLIS: Returns to the reactor. It also has a vent pipe for noncondensibles. And I just ask myself what are those noncondensibles? The only gases that I know that is in the reactor system are hydrogen and oxygen and any leaking of radioactive gases. So you have the same sort of situation that you have in the PCCS if you have any noncondensibles. You have radiolytic gases in the IC, don't you?

MR. MARQUINO: Yes.

CONSULTANT WALLIS: So what do you do to control the flammability limit in the IC?

MR. MARQUINO: Well, there's no ignition source in the heat exchangers themself, there is no ignition source. And the IC is operating at a higher pressure. I believe we'll have a lower concentration of radiolytic gas in the IC relative to the PCC.

CONSULTANT WALLIS: Well, I think if you look at the past history of pipe end rupture causes by explosions of radiolytic gases, there was no ignition source there either. If you get the stuff at the right mix, it will go off spontaneously, apparently.

MEMBER BANERJEE: Where are your recombiners? Are they at that roof?

MR. MARQUINO: Yes. Our recombiners will be in the drywell and the wetwell and distributed so that we will be recombining and removing the radiolytic gas. Now that's going to reduce the overall concentration in the containment as a whole, but I don't think we can claim that it will present any radiolytic gases from being present in the PCC. Because we have a self-venting mechanism from the PCC. But there will be some residual hydrogen and oxygen in the PCC.

MEMBER BANERJEE: But from the break to the PCC, if you like, are there recombiners on the way?

MR. MARQUINO: Well, it depends on where the break is.

MEMBER BANERJEE: That's the problem, I guess.

MR. MARQUINO: It's sort of the situation where over a long duration we can expect that the gases find the PARS units, but we can't guarantee that they always go through a PARS unit on their way to the PCC inlet.

So we will apply appropriate industry codes to the PCC fans. We can make the fans out of brass or a nonsparking material. So we have API codes, Air Movement Control Association codes, NFPA codes that apply to fans or blowers in industrial applications similar to this?

CHAIR CORRADINI: So we're talking post-72 hours?

MR. MARQUINO: We're talking post-72 hours.

CHAIR CORRADINI: So let me make sure I understand this. Because Sanjoy asked it before. I wrote it down. I have two big action items that I want to repeat when you're done with your presentation, but one of them kind of comes to this. He asked, and I wrote it down that are you tracking a lower flammability limit, and in particular as you exit the PCCS that's the point where I think there's concern by some of us that you could get in a situation at long term that you would go above it. So is this being tracked in the analysis?

MR. MARQUINO: In the TRAC analysis it is not. But if the question is what's our evaluation of the concentrations in the heat exchanger --

CHAIR CORRADINI: Correct.

MR. MARQUINO: We can provide that information if that's an important question.

CHAIR CORRADINI: Well, it's kind of one of the subquestions that originated from Graham asking the questions about performance of the PCCS under your modeling conditions versus staff's modeling conditions and the drain pan, and what essentially is the overall efficiency. Because I think one of the outgrowths of that is are we getting the position in that local region where you could have some hydrogen burning.

Graham and Sanjoy, I think I've captured right, is that correct?

MEMBER BANERJEE: Yes. As long as you have lots of steam around, there's no issue because you're going to be a little --

CONSULTANT WALLIS: That's right. Now I have another question, though. You're saying this is when the fan's operating. Even before the fan operates the PCC has been sweeping out the nitrogen and -- I don't know if I recall. The residence time for nitrogen is less than a hour. So after days the nitrogen's gone from the containment. What goes down then from the PCCS to the wetwell, the noncondensibles going down that pipe are also radiolytic gases. So even before you turn the fans on during this long period of three days, you have to, it seems to me, monitor the flammability limit in that pipe because spontaneous combustion has been know to occur. I don't know. I'm not an expert on combustion. I just know that at least in the one Swedish reactor they had hydrogen/oxygen went off by itself in a pipe without any ignition source anywhere. And so I just don't know that.

MR. MARQUINO: I agree that the -- I would say once the fans are operating and stabilized, you're pumping this noncondensible around and high flow rates and you've drawn nitrogen back in from the wetwell.

CONSULTANT WALLIS: Yes. Yes.

MR. MARQUINO: Over about a half day you build nitrogen back --

CONSULTANT WALLIS: When you first turn the fans on you're concerned because there's no nitrogen there yet.

MR. MARQUINO: Yes. I think that's the--

CONSULTANT WALLIS: But what I said before was even before you turn the fans on you have this radiolytic gases and the noncondensible is going down the pipe to the wetwell, isn't that true?

MR. MARQUINO: That is true.

CONSULTANT WALLIS: And I think you need to resolve that somehow. It's not just what happens when you've turned the fans on.

MEMBER BANERJEE: Yes, I hadn't thought of that.

CONSULTANT WALLIS: These are specific to the ESBWR, aren't they? I mean, you don't have these features in other boiling water reactor systems.

MR. MARQUINO: We don't have a low pressure heat exchanger. We only have a high pressure heat exchanger.

CONSULTANT WALLIS: But you do have the intermediate condenser, or whatever you call it. Isolation condenser, you do have that?

MR. MARQUINO: Yes.

CONSULTANT WALLIS: So that, presumably, is being considered for the isolation condenser because it's the same problem but not quite so much because you haven't been producing -- well, maybe it is. I don't know. It is the same problem, isolation condenser.

MEMBER BANERJEE: Do you have a rough

number you can give me the rate of production of radiolysis in sort of the early stages and the late stages?

CONSULTANT WALLIS: He gave us some numbers the last time that seemed very high, 680 cubic feet or something humongous.

MEMBER BANERJEE: As large as that?

And what's the recombiner rate? Steady state it must be 600 cubic feet, right?

MR. MARQUINO: Yes. The recombiners will become effective at about four hours into the event. The bolt concentration has built up after four hours to the point that we'll start scavaging the --

MEMBER BANERJEE: And they're not sufficient capacity to recombine everything, right?

MR. MARQUINO: Yes.

MEMBER BANERJEE: That's easy to do.

MR. MARQUINO: And they're distributed.

MEMBER BANERJEE: Yes.

CHAIR CORRADINI: So it's more a matter that you've -- I guess I didn't understand answer. So just to make sure I get it right, so you're saying that after a few hours you've come to a point where the recombiners can more than accommodate what is the assumed decomposition rate?

MR. MARQUINO: Yes. And on a bulk basis.

CHAIR CORRADINI: On a bulk basis?

MR. MARQUINO: Okay. So we're not going to have a continually increasing radiolytic gas concentration in the containment.

CHAIR CORRADINI: But you'll have a continuing source?

MR. MARQUINO: We have a continuing source.

MEMBER BANERJEE: You may get some local areas, that's what he's saying. Yes.

CONSULTANT WALLIS: When we met in June you gave us a list of noncondensible gases at various times. And you said at 72 hours there were 689 kilogram of noncondensibles. And I said in the drywell. I said these have to be radiolytic, because the nitrogen's all gone. And then you gave a one percent fraction of noncondensible which seemed to be compatible with that. That's what I was going on.

MR. MARQUINO: Yes.

CONSULTANT WALLIS: Maybe this is a vastly overrated -- overestimated number, this 689 kilograms of radiolytic gas.

MR. MARQUINO: Well, I didn't get Professor Banerjee was asking me if I had the numbers and we have a derivation of the radiolytic gas production. So we can go back to that to get the hydrogen and oxygen production rate. It's proportionate to decay heat so we now how it varies over the three days.

CONSULTANT WALLIS: Was this 689 something that we had to assume because of some bounding analysis requirement and it's not realistic? Is that why it was so high? It's very high.

MR. MARQUINO: Well, the GE value that we use is from a Regulatory Guide and --

CHAIR CORRADINI: They are using the required value.

CONSULTANT WALLIS: Which is unrealistic by a large amount, is it?

MR. MARQUINO: I have no feel of whether it's unrealistic or in the ballpark.

CHAIR CORRADINI: I think that's going to have to be a side discussion. But the one thing I've written down that we're clear on is you're going to look at the inventory at some set amount of times to clarify the number that Graham has from the June meeting, is that correct? You've just said you can go back and give us an inventory at various times.

MR. MARQUINO: Yes. Now what we can do is we can provide the production rate --

CHAIR CORRADINI: Yes.

MR. MARQUINO: -- of hydrogen and oxygen in the core that's fed into the TRAC model.

CHAIR CORRADINI: Right.

MR. MARQUINO: Is that useful?

CHAIR CORRADINI: Yes, it helps.

MR. MARQUINO: Okay.

CONSULTANT WALLIS: Let me say something here, I think I ought to say it, really. This is an issue which came up this year. And personally, I'm not speaking for the Committee or anything, I think it's one of the more important issues of the ESBWR. Because this is a new feature of the design and it has to be very systematically worked on in terms of numbers like flammability limits and whatever, and predictions made. All the other things I think we've resolved. This one still seems to be up in the air. And to me personally it could be a major issue.

MEMBER BANERJEE: Can you take credit for recombiners? Are you allowed to?

MR. MARQUINO: Yes, we take credit recombiners at 72 hours and that allows us to classify them as a RTNSS system.

We don't credit them in the zero to 72

hour pressurization calculation.

CHAIR CORRADINI: That's why the pressure is rising?

MEMBER BANERJEE: Right.

CHAIR CORRADINI: Do you understand what he just said, Graham?

CONSULTANT WALLIS: While the pressure is rising?

CHAIR CORRADINI: The way the analysis is done pre-72 hours the combiners are not credited nor analyzed as part of the response of the containment.

CONSULTANT WALLIS: That's not why the pressure is rising. The pressure is rising because of leakage into the wetwell.

CHAIR CORRADINI: It's rising for two reasons.

CONSULTANT WALLIS: But the leakage is the dominant factor.

CHAIR CORRADINI: I think about a year and a half ago we unwrapped it and it does have a noticeable effect due to the radiolytic decomposition.

MEMBER BANERJEE: Right.

CHAIR CORRADINI: Because it's leaking noncondensible gas and because there's a continuing noncondensible gas source, the PCC has to vent all the time.

CONSULTANT WALLIS: That's true. That's true.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: That's true. But I think if you have no leakage through the vacuum breakers, the pressure just slowly goes up. I've seen that curve.

CHAIR CORRADINI: Yes, it would still increase.

CONSULTANT WALLIS: Right.

CHAIR CORRADINI: But at much slower rate.

CONSULTANT WALLIS: Correct. Okay.

MEMBER BANERJEE: So you're not allowed to take credit for the recombiners or you chose not to?

CHAIR CORRADINI: Well, that's a --

MR. MARQUINO: IF they are RTNSS system, we're not allowed to take credit for them. So in our licensing setup and the requirements we put on them, we're not allowed to credit for them.

MEMBER BANERJEE: So you will get a buildup of hydrogen and oxygen mixtures during this time then? At least in theory. In practice you may not.

MR. MARQUINO: Okay. The recombiners don't know what licensing requirements --

MEMBER BANERJEE: Right. I realize that. I'm trying to separate the two issues. I realize in reality they'll be operating for four hours.

CONSULTANT WALLIS: Well, maybe you'd better start taking credit for them.

MEMBER BANERJEE: You can't, right?

CHAIR CORRADINI: Well, wait. I think we're deviating. So I think your presentation is done. I want to see if the Committee has any other questions.

Okay.

MEMBER BANERJEE: Well I think I want to reiterate though that it would be interesting to know the LFLs.

CHAIR CORRADINI: I agree. I have it.

MEMBER BANERJEE: And where they are.

CHAIR CORRADINI: Okay. Why don't we take a break and come back at quarter of and have the staff give their updates analysis.

(Whereupon, at 10:30 p.m. off the record until 10:47 p.m.)

CHAIR CORRADINI: Okay.

MR. WAGAGE: Hello. My name is Hanry Wagage. I'm the Lead Reviewer for Containment Analysis for ESBWR.

I have here Jack Tills for consignment from Sandia National Laboratory. And both Jack and I will be making this presentation.

The next slide, please.

This is the Project Managers Technical Review Team. You have Ilka Berrios, who is Chapter 6 Project Manager. You know Amy Cubbage, who is Lead Project Manager.

I would like to recognize the excellent support we got from Office of Research staff members Allen Notafrancisco and Hossein Esmaili.

The purpose of this presentation is to present to the Committee comparison between TRACG and MELCOR ESBWR containment long term heat removal analysis.

During the discussion we will be telling about the open issues we have.

The current status of the analysis is that we have completed the MELCOR component of the analyses. And last time when we came to the Committee there was differences between the MELCOR and TRACG analyses. We understood the trend in TRACG and MELCOR long-term containment pressures.

Jack Tills will be going into more details on that.

Still we have the differences in immediate pressure drop at 72 hours. Jack will just explain the reason he think what causes that.

We have an open item RAI 6.2-140. Based upon our inquiry this RAI from GE. This is to ensure that design basis analyses is documented in the DCD. GE has responded yesterday and we are in receipt of it.

In addition, there are two other open items. Identification of -- breaker leakage and isolation of -- breaker isolation valves. It's an open item. We haven't received response to RAIs yet.

There is another emerging issue that hydrogen accumulation in PCC condensers will be another issue that goes to our open item.

I will hand over to Jack.

MR. TILLS: Yes. I'd kind of like to address just some of Dr. Wallis' questions that were left over from clarification items from last.

The first one was the issue of geometry, since I had brought these slides up at our last meeting, the differences in the geometry. And there was really two questions that we were asking General Electric to address.

The first one was our interpretation correct in terms of a misorientation of the TRACG to the actual containment design in that upper head region. And the issue was whether or not the GDCS, for instance, was connected to the upper drywell head or should it have been connected to the drywell that was where the PCCS take off was. So that was the action item.

And then the other action item, of course, was does it make a difference.

So I think from what we understand from General Electric's response and our discussion with them was that, yes, there was a difference in the TRACG versus the actual design of the plant. And instead of redoing the whole calculation, they started at 72 hours and did the sensitivity starting from that point and looked at what the impact was.

And as I think Wayne had indicated from General Electric, the impact looks small, but it was the nevertheless when they ran out to 144 hours it was about a tenth of bar difference, meaning that they were in the original calculation that was in the

CDC about a tenth of a bar lower than what they would have been if they made that correction. And that was at, you know, 144. And I think they later ran it out to 182 hours. But never ran it all the way out to 720 hours. So, you know, there was a difference with that. That's the first item.

CONSULTANT WALLIS: And so, Jack, I think that helps. It means that so the bottom line didn't change much. The problem that we have is when we look at the figures like the one you saw this morning, which has now been discarded and you see these bumps in noncondensibles --

MR. TILLS: Right.

CONSULTANT WALLIS: -- suddenly appearing somewhere, that that's the sort of thing which has to be related to the decals of the code.

MR. TILLS: Right.

CONSULTANT WALLIS: And those are more obvious things which don't seem to be quite consistent with physics or something.

MR. TILLS: Right.

CONSULTANT WALLIS: But the overall trend path doesn't change very much.

MR. TILLS: It doesn't change very much. But what seems to be what you would call insignificant from that standpoint is not insignificant when we're talking about four-tenths of a bar is over what they are. So when you're trying to do comparisons --

CHAIR CORRADINI: When you're unwrapping it, it --

MR. TILLS: When you're unwrapping it, it does become significant.

CHAIR CORRADINI: Okay.

MR. TILLS: The second point is in relationship to the heat transferring to wetwell. What I had showed last time here was sensible heat transfer into a gas volume, not total heat transfer on the walls of the wetwell, and Wayne was correct.

When we went back and compared apples to apples, so to speak, then the agreement was quite good. And so that's I call that energy transfer, not heat transfer. However, you know there is a difference. We're not exactly right on. The General Electric heat transfer is about half of what we predict. And the reason for that, and I gave them a paper on it, was again, because of the difference between Uchida correlation in the wetwell versus the MELCOR's more mechanistic treatment. The density in the wetwell is twice the atmospheric air density. And when that happens, Uchida will predict or under predict heat transfer by about a factor of two.

So the bottom line is is that we understand our differences between the two. They're not significant in light of what the total heat transfer out of the whole system is by the condensers.

Now, you know, before we had a slide that showed the difference as we were in the June presentation. And there was an issue with respect to MELCOR increasing in late time. There is also an issue with respect to the vary transient response that occurs when the fans are initially turned on.

So the next slide.

CHAIR CORRADINI: What I have is the June calculation.

MR. TILLS: It was the June that kind of promoted us to go back, look. See if we could converge a little bit better in terms of if we had the same things. There's a number of issues that were involved.

We didn't really understand the details of what General Electric was proposing for a fan, you know, in the post-3 day period.

And in addition, we also understood that there would be constant refill and, you know, evidently that was not actually being used in the General Electric. They were using some refill management of the PCCS pool. So we're talking about two different pools: The PCCS pool which is going to be refilled, and then we're talking about a GDCS which has a fan outlet and possibly varying submergents and varying fan flows.

And the next slide.

CONSULTANT WALLIS: Well, it was dramatic how rapidly they reduced the pressure. So rapid you can't even see the rate.

MR. TILLS: Right. And we'll talk a little bit about that as we go into it.

This is just an outline of the presentations. We'll start, again, the 0.72 hours just to kind of indicate to you as we redid these calculations that both General Electric and ourselves predicting the same 72 hour pressure.

CONSULTANT WALLIS: But when you presented it in June or it may be in your written text or in a slide or something that the PCCS noncondensible exhaust goes into the airspace.

MR. TILLS: Yes.

CONSULTANT WALLIS: And I think now it

goes into a drain tank or some drain core, or drain pan.

MR. TILLS: Drain pan.

CONSULTANT WALLIS: And then that probably makes a difference?

MR. TILLS: We did sensitivities in both cases. It makes a very small difference.

CONSULTANT WALLIS: Doesn't it have a potential to condense the steam, which --

MR. TILLS: Yes. Right.

CONSULTANT WALLIS: -- it didn't condense.

MR. TILLS: And so there'll be a small difference in the pressure.

CONSULTANT WALLIS: I thought the whole idea of your saying the difference between MELCOR and there was that MELCOR didn't condense all the steam.

MR. TILLS: Well, if you put it into the GDCS pool, it will condense the steam. There isn't that much steam that's coming out. When you have the condensers --

CONSULTANT WALLIS: Is that a difference?

MR. TILLS: --in front of it a good portion of the steam is in the condensers. So what is exhausted in a very low, you know, amount of steam coming out even though -- because the condensers are still very efficient. And so it's not like the whole steam is coming through.

CONSULTANT WALLIS: Well, I thought that was your point last time was that if you didn't get the coefficient right, you could make a very big difference to the depressurization?

MR. TILLS: Yes. Well, during the transient, we've got to be careful we're talking the same thing.

CONSULTANT WALLIS: Yes.

MR. TILLS: In the transient case you can have a sizeable difference in the initial drop of pressure. But in the longer term after the transient goes through, then you can to an equilibrium point, and that equilibrium point it's not much difference. That's the point I think I was making.

MEMBER BANERJEE: So I am not completely following this. So maybe you should tell us, are you going to tell us what the bottom line is here? Why TRACG is showing sort of a gradual decrease --

MR. TILLS: Yes.

MEMBER BANERJEE: -- and you're showing a gradual --

MR. TILLS: I'll try to do that.

MEMBER BANERJEE: Yes. But do we have to wait until to the end of the presentation or --

MR. TILLS: No, it's not. It's just not in the first one or two slides here.

MEMBER BANERJEE: Is it a simple thing or is it a complicated thing?

MR. TILLS: It's not a complicated thing. You know, for instance like the first three days period when we're talking about pressurized, that's a very simple thing. The PCCS is bound up with noncondensibles that are the radiolytic gases coming.

MEMBER BANERJEE: This is post-72 hours or pre-72 hours?

MR. TILLS: Pre-72 hours.

MEMBER BANERJEE: But there the difference is very small, right?

MR. TILLS: The difference between their analysis and us is very small. Okay. And that's due to the leakage that you have talked about.

CONSULTANT WALLIS: It's self-correcting essentially.

MR. TILLS: It's very self-correcting. And so if your PCCS model off one percent than the other, you will not see a difference because one will carry a little bit more gas in the condensers and the other one will not. And so that's not a problem.

The difficulty that we were having was during the transient when you first turn on the fans, okay, for the first maybe hour period and even during the first really half hour period where we see a larger drop in the GE versus our calculations is you notice that the fans are operating in a region that we normally wouldn't operate fans. They're operating in the flat region, which means that a small little difference in heads makes a big difference. That means that your model will have a feedback. So like a pumping action on the condensers.

And so when you originally turn the fans on, you might get a small increase in flow that wipes out or takes out nine condensers on the bottom of the condensers, but as soon as that happens, the fans also see a larger pressure drop and they start to shut down. And then it kind of goes back and forth.

In a very transient situation, and this is a very small volume in the condenser tubes. And the condensers are very sensitive to how much noncondensibles are in the tubes. About 40 percent of the tubes are uncovered during this period of time. So we're talking about the lower portions of the tubes.

So any types of instability that you get, you could get a large flow in either direction. So basically what we're saying is is that this region of operating with a fan with, in our case we put the fan in an explicit manner.

MEMBER BANERJEE: Yes.

MR. WAGAGE: 200 cfm.

MR. TILLS: And so it's an explicit add on to the MELCOR model.

MR. WAGAGE: Yes.

MR. TILLS: Which will give you even more feedback than you probably would normally expect. You're getting this kind of almost pumping action in here.

MEMBER BANERJEE: But didn't you see a much more rapid --

MR. TILLS: You see a rapid drop --

MEMBER BANERJEE: -- during this period?

MR. TILLS: Yes. About maybe -- you know, it's not as severe as it looks when we did this last calculation when we put the fan actually in there. But, you know, where they calculate maybe .6 bar drop, we calculate a .4 or .3

MEMBER BANERJEE: Okay. Sort of a transient deal?

MR. TILLS: You know, what we wanted to get a little idea also from both the Committee as well as the staff was is this important. Is this an issue that's important? You know, and I think Wayne had mentioned. You know, if you're dropping between the pressure at really four bars, say, at 72 hours and within a 100 hours you're dropping down it doesn't make any difference if you drop in 15 --

MEMBER BANERJEE: So you're attributing the early post-72 hour difference to putting in the fan. What is the reason that in the long term you show a pressure increase?

MR. TILLS: In the long term there's an offset and you'll see in our calculations we have one an offset of about .4 bars. In other words, at 30 days they're predicting approximately 265 kilopascals. We predict a little over 300 in the long --

MEMBER BANERJEE: There's more than that.

CHAIR CORRADINI: I think Sanjoy's question is --

MEMBER BANERJEE: Why is yours going up, theirs going down?

CHAIR CORRADINI: No, no, that's slide 11.

MR. TILLS: That's the old June calculation. Dr. Banerjee, this is not going up anymore.

MEMBER BANERJEE: What did you do? Just the fan curves --

MR. TILLS: Fan curves and also refill management. So both are in the slide packet that you've--

MR. SHUAIBI: And Dr. Banerjee, if I could interrupt. This is Mohammed Shuaibi from the staff. I guess --

CHAIR CORRADINI: Wait, wait, you're talking over each other. Go ahead.

MR. SHUAIBI: I guess what we would like to do if it's possible is if we can get through the presentation, or at least get to the slides that would address this. We were planning to address some of this information but we're still on the outlying slide in terms of what we want to cover.

MEMBER BANERJEE: Right. Right.

MR. SHUAIBI: So if it's acceptable to you all, I'd like to continue with the presentation.

MEMBER BANERJEE: I just get impatient.

CHAIR CORRADINI: Yes, we sense that. Right.

MR. TILLS: I mean I'll answer your questions, but it'll go -- all right.

So this the zero to 72 hour period, and you've already seen this. This is just reemphasizing again that with her recalculations both General Electric and MELCOR are the same.

Now let me make a point about the calculations. Throughout this presentation I used two different adjectives for what these calculations are.

In the first case when we have a calculations that's a DBA calculation, in others an audit or DBA calculation, that means that we tried to follow the design as well as we understand the design. We're not trying to match another code. Okay. But then in the interest of trying to determine the MELCOR versus TRAC calculation, in that calculation we call that confirmatory where we're trying to understand the comparison between two different models, okay?

So there's two different things I'm going to present here. One is the comparison as Dr. Banerjee wanted to see, between MELCOR and TRAC.

CHAIR CORRADINI: Which you call confirmatory?

MR. TILLS: Confirmatory. Confirming that we understand where we're at. And then the other calculation is a DBA calculation.

The reason they're two difference is because of what's modeled in the national containment, okay?

So in this case the confirmatory the DVA for the first passive period of time are the same. Okay. Both the design as well as operating and so forth are the same between the codes and the design.

CHAIR CORRADINI: Now, if I might just clarify one thing.

MR. TILLS: Yes.

CHAIR CORRADINI: At this point I seem to remember, but I could be wrong, you have much less nodalization with MELCOR in the drywell --

MR. TILLS: That's correct. That's correct.

CHAIR CORRADINI: -- compared to --

MR. TILLS: Our drywell is a single well mixed body.

CHAIR CORRADINI: Okay.

MR. TILLS: And we follow what we believe is the conservative, but probably not very much conservative because we believe that during the blowdown this thing is well mixed and even after the blowdown these are significant sources still coming in. And the volume is not big. We're not doing large PWR volume.

CHAIR CORRADINI: It involves Sanjoy, but I'll make you say that again eventually.

MR. TILLS: Okay. Well mixed.

CONSULTANT WALLIS: So if you are well mixed, that means that all the noncondensibles are always mixed with the steam?

MR. TILLS: That's right. And they go out into the wetwell.

CONSULTANT WALLIS: And since the, sort of, turnover time, whatever you want to call, is less than an hour for these things, in 20 hours everything is down to eight to the minus some enormous number?

MR. TILLS: That's right. That's right.

CONSULTANT WALLIS: So there's no noncondensibles left in terms of nitrogen?

MR. TILLS: That's right. That's right. And issues on hydrogen per our operations are kind of out in left field here. All right.

MEMBER ARMIJO: I want to make sure I understand. In your analysis do you include that volume above the vessel head? Is that connected in your analysis?

MR. TILLS: That's included in one large volume. In other words, that one mixes. In the General Electric case that volume even during the blowdown never gets cleared because it's a dead-ended cell. Okay. There's no way it's being forced up, compressed --

CHAIR CORRADINI: It does flow.

MS. CUBBAGE: Right, it doesn't flow in anyway.

MR. TILLS: And in the link time after three days they still have gas in there and that's where they do their adjustment. Wayne talked about a nonmechanistic deal. That means at three days any case that's in that region is soon to go over and we do a separate hand calculation to adjust the pressure. So, you know, it goes up a small amount. It's not a big amount. From maybe 300 in 95 or so to right around 400 kilopascals. So they add a small amount.

MEMBER ARMIJO: Okay.

MR. TILLS: Next slide.

I'm not going to belabor this one. This is just a better cartoon view of what the plant model is.

I will mention though that one of the adjustments that we had made for this long term calculation was to layer or nodalize the PCCS tank. And that's shown right here in this figuring, this layering that's going on here. And we did that in order to better model the saturation pool temperature in the PCCS tank.

CHAIR CORRADINI: So MELCOR, with this layering, because it's such a deep pool, the saturation temperature is different?

MR. TILLS: That's right. It varies by a few degrees.

CHAIR CORRADINI: Okay.

MR. TILLS: You know, not much but it does make a -- we saw a difference in terms of how fast we dropped the pressure when the fans came on.

The other thing is we put in the fan, you'll see a GDCS fan there. And this tray, I'll have another slide that has a little bit more detail on the tray, and that's showing where the fan and the condensate drain from the PCCS pools goes into.

CONSULTANT WALLIS: -- the condensate from the PCCS. Because it's less than saturation temperature because of the noncondensibles and the partial pressures and so on, and it's also less because it's colder on the wall and they get the subcooled variation of temperature through the film. And it's also cooled when we gets into that tank at the bottom, that plenum or whatever you want to call it, and gathers all the water, it's cooled in there.

MR. TILLS: Right,

CONSULTANT WALLIS: Do you have an estimate of the temperature of that water stream coming out into the drain pan?

MR. TILLS: I don't have that number exactly. It's going to be at the saturation -- you know, as you pointed out, there will be some sensible heat taken out of it, but basically its going to be at the saturation temperature of the drywell.

CONSULTANT WALLIS: I just wonder what it is. What it is. Because if you have noncondensibles influencing the condenser for about half its length, I think the partial pressures change that temperature significantly, but I'm not sure. I'm not sure.

MR. TILLS: That pressure in the condenser is basically the pressure in the drywell.

CONSULTANT WALLIS: Oh, but the pressure of the steam is that: (1) It's noncondensibles.

MR. TILLS: Right. Right. Right.

CONSULTANT WALLIS: So at the bottom you

have a much lower partial pressure of the steam and the water can get colder at the bottom of the condenser.

MR. TILLS: Yes. I mean, the pool temperature is at 373 at the bottom of the condenser.

CONSULTANT WALLIS: The pool temperature?

MR. TILLS: The pool --

CHAIR CORRADINI: The outside pool.

MR. TILLS: The outside pool.

CONSULTANT WALLIS: Say that again.

MR. TILLS: It's at around 373 --

MEMBER ABDEL-KHALIK: That is Kelvin.

MR. TILLS: Yes. Yes. Kelvin.

CONSULTANT WALLIS: Kelvin. Because it's the boiling point of water --

MR. TILLS: Yes, right.

CONSULTANT WALLIS: So it's colder than that?

MR. TILLS: Yes.

CONSULTANT WALLIS: So I just wonder how cold the water is that's going into that drain pan?

MR. TILLS: Yes, I don't have that.

CONSULTANT WALLIS: Because that mass flow is significantly more than the mass flow of steam going into that drain pan. Okay. Well, it's something to be looked into.

MR. TILLS: Yes. Next slide.

CHAIR CORRADINI: Let me just ask the question differently because it's going to come back up. So you have it somewhere, you just don't know it?

MR. TILLS: Yes.

CHAIR CORRADINI: Okay.

MR. TILLS: I just didn't bring it. Rather than saying what it is, I just can't remember.

CONSULTANT WALLIS: And you put in all these effects like the partial pressure and the heat transfer and so on?

MR. TILLS: Yes. Yes.

CONSULTANT WALLIS: And the subcooling of the film and everything?

MR. TILLS: Yes.

CONSULTANT WALLIS: Thank you.

MR. TILLS: The refill, and I make this distinguished in here between DBA and confirmatory. The DBA, as we understand it, has no refill management in he sense that when the injection comes in to fill the tanks, the PCCS tanks, comes into this region called the expansion tanks, the level will rise. The only refill management that we've been led to understand occurs is if the tanks overflow. Okay. To keep the tanks from overflowing. But if they don't overflow or up into the point where they tend to overflow, there is no refill management.

In other words, we don't tailor the refill to try and get better heat transfer in the tubes.

In the confirmatory calculation there is a refill management. In other words, the tubes are allowed to cover up as a result of the 200 gallons per minute flow. But then later when the level has reached the top of the tubes, the operation in this case would throttle back to keep the tubes just covered. So we call that refill management in a proper sense. And what we model, we do not model that.

CHAIR CORRADINI: That's fine. But just to say it differently: The difference in height between overflow and top of the tubes is what distance?

MR. TILLS: Well, when we don't do any refill management, it gets up maybe about a meter and a half above the top of the tubes. Its almost to where it was when it initially was drained down.

CHAIR CORRADINI: Okay. So it's about

.15 bars difference in terms of head --

MR. TILLS: Yes.

CHAIR CORRADINI: Okay.

MR. TILLS: This is a slide that just basically shows the difference about what we are modeling in the confirmatory and audit calculation with respect to the tray. The tray is in there to keep the fan vent covered for reasons other than what we're discussing here in terms of hydraulics. It's a matter of stopping flow from going back through the fan.

In this case our interest is how much static head is associated with having the tray modeled with a lip on there so that you have a constant submergence on the fan vent. And so the DBA audit from our understanding is that there will be a 10 inch -- if the trays are there, a 10 inch submergence because there's lips on the trays. So any condensate coming in will keep the fan covered approximately 10 inches.

The uncertainly there may be something like around a half an inch in terms of the design.

CONSULTANT WALLIS: So we don't know the design of the fan discharge line?

MR. TILLS: Pardon?

CONSULTANT WALLIS: We don't the design of the end of the fan discharge line? If it had a big sparger in there --

MR. TILLS: No, we don't know that detail. It's just a matter of static head at this point.

CONSULTANT WALLIS: But the tray has to be big enough that what you've been saying is correct?

MR. TILLS: That's right. That's right.

CONSULTANT WALLIS: And we don't know anything about the details. And if it were small and were bubbling through it, it would bubble up and overflow and all that.

MR. TILLS: That's right. That's right. It's not designed.

CONSULTANT WALLIS: So in order to say this will work, we need to know perhaps something more about the details of that tray?

MR. TILLS: That's right. And you'd probably need some tests.

CHAIR CORRADINI: I guess I understand. I guess I should know this, but I don't remember.

The purpose is that when after post-72 hours the fans come on they take their suction from the gas side of the bond with the PCCS. So instead of the gas is going down to the wetwell, they get blown through this and through this submerged about a foot of water?

MR. TILLS: Right.

CHAIR CORRADINI: And the only reason to have this pan is to essentially check any back flow into the fan?

MR. TILLS: That's correct.

CHAIR CORRADINI: Okay.

MR. TILLS: That's correct.

CHAIR CORRADINI: And the assumption in both set of models right now is if the water in the tray were subcooled, it would do some condensing. I have that right. But I'm curious about what the calculations -- Wayne indicated, maybe he'll correct me if I'm wrong, but right now TRAC does not model it. And the reason being its saturated, the pool is saturated, everything is saturated. And that's where we are.

What does MELCOR do in this case now?

MR. TILLS: MELCOR for the DBA calculation it imposes a fixed 10 inch head on the outlet of the fan. And because we don't know the details of how large the tray was, and like Dr.

Wallis was saying about the sparger effects, we put all of the fan exhaust into the gas space.

In other words, we assume that there's a small enough tray here that we don't get significant condensation. So that's our model.

The confirmatory model tries to mimic what they did in TRAC was they have fan submergence, outlet submergence, but its variable. As the GDCS pool level drops, their static head will drop whereas ours for the DBA is fixed.

They do not uncover. I think theirs is something like 14 inches below the initial level of the GDCS pool at 72 hours. So they barely almost uncover, but not quite uncover at the end of 30 days. But the change in the static head is effecting the fan performance in how what the fan is doing.

CHAIR CORRADINI: And how much the fan is pulling through the --

MR. TILLS: That's right.

CHAIR CORRADINI: Okay.

MR. TILLS: So they have a slightly higher late time fan flow than what we do because of the static head.

CHAIR CORRADINI: Okay. But from the standpoint of an energy transfer --

MR. TILLS: And the energy transfer is different because I think they inject their steam outlet into the GDCS pool, whereas as we, seeing that the tray is small, and ours goes into the gas space. So --

CHAIR CORRADINI: So if there heat transfer, you skip it.

MR. TILLS: That's right. Which would mean that ours would generally be conservative, whereas ours would not.

CHAIR CORRADINI: Okay.

MEMBER ABDEL-KHALIK: What's the shutoff head of the fans?

MR. TILLS: Well, I think it's around 24, maybe 2450 you know --

MEMBER ABDEL-KHALIK: Is the shutoff head in inches of water or psi, whatever power units you want to use?

MR. TILLS: I think it's a little over f kilopascals, as I remember. Maybe Wayne would have a better number on what that number is.

MR. MARQUINO: We provide the table --

MEMBER ABDEL-KHALIK: Well, the table just goes down to 150 cfm. It doesn't go to the shutoff point.

MR. MARQUINO: Let me look at the plot of head versus --

MR. TILLS: I think we have a figure in kPascals later in the presentation. In fact, I think if you look at slide 18 you'll see it in kPascals.

The point is it does shutoff. Because we're on the -- you normally would operate on near the rates point of the curve or slightly above the rated point. You wouldn't operate way in the flat field. But, you know, General Electric is comfortable I think with that. But it does create some analytical --

CONSULTANT WALLIS: Yes, I was surprised that they choose to operate in the flat region of the fan.

MR. TILLS: Yes. Yes.

CONSULTANT WALLIS: I mean that gives rise to instabilities and all kinds of things.

MR. TILLS: We did, too. And we had a conference with them. And I think they brought in a person that indicated that they've had experience operating in this regime from an equipment standpoint.

MR. MARQUINO: I want to agree with what was said about the steam condensation in the tray or the GDCS pool. That there was a question about the design features of the tray. And if there's time and you wish, I have a backup slide on the design features that we consider to address I think your point about the entrainment from the tray.

CHAIR CORRADINI: Well, let's hold that and --

CONSULTANT WALLIS: Well, can I ask then do you have from your tests of the PCCS, you did full scale tests under realistic conditions with noncondensible, you should have a figure of the subcooling of the water that came out due to the noncondensible and other effects. You should have actually numbers from tests.

MR. MARQUINO: Yes, we have information from the tests on subcool.

CONSULTANT WALLIS: And that would be the best evidence, I think.

MR. WACHOWIAK: This is Rick Wachowiak from GEH.

So we've been talking a lot about this tray and its heat transfer contribution a lot this morning. And I'm wondering why we go down that path. Because the function of the tray is to provide a water seal so we don't get backflow and have a containment bypass. And the heat transfer characteristics of the tray are not part of the design basis for it.

CONSULTANT WALLIS: Well, the reason we emphasized this was because Jack told us last time that the difference between a rate of depressurization at 72 hours between him and you was the efficiency of the PCCS. And we said if this tray is cold, it condenses the steam anyway and you don't care about efficiency of the PCCS because all the steam gets condensed anyway. That was the fact.

CHAIR CORRADINI: But I think, and I thought I heard Rick to say and I think we need to move on is, i's a water seal. They're taking it it has no effect in this because they're saying whatever goes in, bubbles out.

MR. WACHOWIAK: Right.

CHAIR CORRADINI: And it's only there as a check valve to stop back flow. Am I misunderstanding?

MR. WACHOWIAK: That's what I was trying to say, yes.

CONSULTANT WALLIS: Is that conservative? And this is a conservative idea, isn't it?

MR. TILLS: Why don't we go on.

CHAIR CORRADINI: Okay.

MR. TILLS: Okay. So this calculation is a confirmatory calculation. And this is our calculation on the top. The dashed calculation is the MELCOR calculation where we simulate pool level control. We simulate the fan vent with varying submergence similar to TRAC.

And you can initially there's a very rapid drop in pressure in the first few tens of minutes and then we go towards an equilibrium. And that equilibrium at the end of 30 days is roughly an offset of a little over .4 bars.

So the conclusion from this was is that if we model as best as we can the TRAC simulation, we get the similar trends long term. In other words, we're not going up when they're going down. We still have an offset for the early time period and we have an offset for the late time period.

Now the early time period has not phenomena, as I mentioned, than the late time. So you can't expect by just shifting things, like increasing the efficiency of the model, that you'll capture the transient better and then that will translate to what's going on --

CONSULTANT WALLIS: Let me ask you

another something. You assume a perfectly mixed containment.

MR. TILLS: Yes.

CONSULTANT WALLIS: So the nitrogen that comes out of the vacuum breakers is immediately available, does not cause condensation in the PCCS.

MR. TILLS: That's right.

CONSULTANT WALLIS: In reality my view is that the cold nitrogen moves along the floor and goes to the bottom of the containment and doesn't go up to the PCCS at all. In which case, the pressure would drop far further, wouldn't it?

MR. TILLS: Right.

CONSULTANT WALLIS: And more rapidly than you show here?

MR. TILLS: Right. And the next slide shows that sensitivity.

CONSULTANT WALLIS: Okay. So this is, perhaps, a very conservative assessment?

MR. TILLS: Yes.

CONSULTANT WALLIS: Yes.

MR. TILLS: Okay. So we have two things we wanted to try and investigate: (1) was why the transient might be higher and why the late time may be higher in MELCOR.

So the next slide --

CHAIR CORRADINI: You do have two effects here, I want to make sure. The stabilization of the pressure is really the fan curve?

MR. TILLS: Yes.

CHAIR CORRADINI: The, I think you called pool level control, will effect some Delta P in the performance of the PCCS, but that doesn't effect the stable, the positive slope versus what I'll stable stabilized slope?

MR. TILLS: Right. Right.

CHAIR CORRADINI: Okay.

MR. TILLS: Right.

MEMBER ARMIJO: You told us once before I think that what is the main reason for the .4 bar offset at late -- with the long-term offset?

MR. TILLS: From what we've been able to tell it's the difference between the two PCCS models. Their model predicts a slightly higher energy removal rate than we do. And when we did our calculation, that in this case is somewhere around 10 to 15 percent difference. In other words, they predict a little bit higher than we do for the same concentration of inlet gas than we do. And so we do that analysis later.

MEMBER BANERJEE: Both of --

CHAIR CORRADINI: Sorry. You go ahead.

MEMBER BANERJEE: Both of your models have been tuned to the same experiments, I take it?

MR. TILLS: I wouldn't call them tuned.

MEMBER BANERJEE: They're not tuned?

MR. TILLS: I would say that they're calculated the same experiments. When we were originally doing the modeling of the condenser with MELCOR, I mean we started not with MELCOR but with CONTAIN code back in the mid-'90s. And we were doing both analytical analysis of single tube tests and also numerical with the actual codes.

And so at that point in time the main interest of looking at this condenser was to turn around the pressure after the GDCS had stopped draining down and the RPV started to steam again, and so you wanted to see where it turned around. That was only a few hours in the accident.

Now we're talking about 30 days into the accident. The decay heat is much less. The flow going into the condensers is much less. And good portion of those early experiments that were done with single tube at UCB as well as the stuff that was done at MIT, now we're in a much lower flow condition. We're not in forced flow, we're in a mix transition region, quite different. So we extended some of our comparisons.

We were doing very good in terms of just a few percent off where we were in a forced flow high--

MEMBER BANERJEE: Are you saying that now you have mixed convection? But this is facing downwards --

MR. TILLS: Right. But the flow is in the -- forced to natural flow as you're going low in the tube as the flow going down --

MEMBER BANERJEE: What's the Reynolds number?

MR. TILLS: The Reynolds coming in is in a few -- you know, tens of thousands coming in, probably 20,000. But as you're going through the tubes, it's dropping.

MEMBER BANERJEE: But on a tube-wise basis it is a few thousand coming in, even in this regime?

MR. TILLS: Oh yes.

MEMBER BANERJEE: So eventually if there were no noncondensibles, it would become all water, right? So the gas Reynolds number would go to zero.

MR. TILLS: Would go to zero.

MEMBER BANERJEE: Liquid Reynolds number because --

MR. TILLS: The liquid, it stays within the laminar flow. It's only a few, you know, less than a thousand.

MEMBER BANERJEE: So experimental data ranges, which I said you tuned your codes to, were not in this low range?

MR. TILLS: Inlet was not. But outlet was not. I mean, it had gone to very low. And when we done analytical analysis of keeping forced flow we got very good results as long as kept forced flow correlations.

MEMBER BANERJEE: But the film is always laminar, right?

MR. TILLS: The film goes laminar. I'm talking about the boundary layer for noncondensibles.

MEMBER BANERJEE: Right. So you're going through a transitional region, and there are no experiments in this region?

MR. TILLS: Well, I think the experiments are single tube experiments.

MEMBER BANERJEE: Right.

MR. TILLS: Okay.

CHAIR CORRADINI: Those are the Berkeley experiments, right?

MR. TILLS: These are the Berkeley experiments. But the PANTHERS experiments do not have the details of what the heat flow is critically on the tube.

MEMBER BANERJEE: Right. But did they go down to these low slopes?

MR. TILLS: Yes.

MEMBER BANERJEE: So effectively you both compared against whatever correlations you used. I don't know. But you compared against the PANTHERS experiments, right?

MR. TILLS: Yes.

MEMBER BANERJEE: So did you come to the same sort of agreement with these experiments, or did you --

MR. TILLS: Yes.

MEMBER BANERJEE: Did you adjust correlations?

MR. TILLS: No. We adjust our correlations only to do sensitivity calculations. But the correlations are the actual --

MEMBER BANERJEE: So you were able to correlate the PANTHERS data using the original UC

Berkeley correlations?

MR. TILLS: We do not use the UC Berkeley correlations.

CHAIR CORRADINI: No. They have a model. I guess I wanted to get to this. They have a model in MELCOR which they consistently use, and it did a reasonably good job of the Berkeley single tube in the PANTHER. And now they take the same model and they apply it here, and it's different at these sets of conditions. That's what I hear Jack saying.

MR. TILLS: That's right. That's right.

MEMBER BANERJEE: The model is the same or different?

CHAIR CORRADINI: Same model.

MEMBER BANERJEE: Okay. But you get equally good agreement as GE gets, or no?

MR. TILLS: No. No.

MEMBER BANERJEE: Ah. Who is more accurate?

MR. TILLS: Well --

CHAIR CORRADINI: I don't know if we want to clarify --

MR. TILLS: -- we have backup --

MEMBER BANERJEE: Well, I want to know the reason for the difference.

MR. TILLS: Let me go to a backup. Not this one, this is hydrogen. The other one. And we go to -- let's see here.

MEMBER BANERJEE: Wayne, you wanted to say something?

MR. MARQUINO: We don't have any backup material, but we did provide information to the staff on comparisons of TRACG against the PANTHERS test, which are very representative of this fan operation mode. I think we could get Dr. Shiralkar who made the comparisons available after lunch --

MEMBER BANERJEE: No, that's not necessary. But you got good agreement, right?

MR. MARQUINO: Yes. And I think basically what someone said that if this .4R difference is a life-or-death situation, then we would drive to determine exactly what the difference is and basically we agreed to disagree. And we don't consider that these differences which are not affecting the conclusion that the pressure is coming down are worth further work at this time.

MEMBER BANERJEE: Yes, I agree with you. I just wanted to make sure that you agreed with the PANTHER experiments. And yours, I imagine, agrees better than them if they did not tune their correlations. But I would like to eventually see your agreement with the PANTHERS data to see how far off you were.

CHAIR CORRADINI: I think Jack, not in June but a previous --

MR. TILLS: This is a comparison that was made on the single tube back in the mid-'90s. And what's called here a film model that goes through, in this case it's going right through one of the UCB tests, is essentially the same model that's in MELCOR. It's the heat and mass transfer analogy model.

The higher curve here was an early curve. There's a Vierow/Shrock curve that was an empirical model. And then that model, this is an updated correlation. And this is just showing, the green line up there is not old model in the mid-'90s and he web and the blue dash line here are the updated, what's called the KSP model to the flow. It's an improvement, but for the single tubes its showing a little bit higher.

The reason I'm showing the single tube because this is tube-side and we've got good data on the tube-side deal.

When we go to PANTHERS, then we involve

not only the tube-side, but there's about 25 percent of the resistance that's in the pool-side. And we actually are using a slightly different correlation. We're using the Rosenhaur, and I think they're using Frost or Zuber correlation for nuclear boiling. So we have a slight difference in that. I don't think it's a really major deal. But the difference that we're talking about between PANTHERS calculations for low flow cases is like around 10 to 15 percent, okay. So where they seem to calculate those tests better than we do.

CHAIR CORRADINI: Okay.

MR. TILLS: We're like about 10 to 15 percent lower than they do in terms of heat removal. And that has been translated then to a calculation for the plant to see what this 10 or 15 percent in PCCS difference in heat removal make for long-term equilibrium. And it makes about a four-tenths bar.

MEMBER BANERJEE: So let me reconstruct what you told me so I make sure I understand it.

You use some version of a correlation you have in there which corresponds either to that red line or the blue line?

MR. TILLS: No. No. That's theirs. That's their calculation.

MEMBER BANERJEE: What are you using?

CHAIR CORRADINI: They're using mass transfer analogy

MR. TILLS: Heat and mass transfer analogy.

MEMBER BANERJEE: Reynolds analogy?

MR. TILLS: Right. We're using Reynolds analogy, diffusion layer deal. And, you know --

MEMBER BANERJEE: How does that analogy include in laminar flow? I thought it was a turbulent flow analogy.

MR. TILLS: From the gas.

MEMBER BANERJEE: Yes. Is the gas always in turbulent flow?

MR. TILLS: It goes into a laminar flow later, and what we use is the maximum of laminar and--

MEMBER BANERJEE: How is the Reynolds analogy for laminar flow?

MR. TILLS: Well, we're not going into laminar flow. We don't use the laminar flow --

MEMBER BANERJEE: I thought you said it went to laminar flow.

MR. TILLS: At the end of the tube we could go to zero flow.

MEMBER BANERJEE: So at what point in the tube does the gas flow become laminar?

MR. TILLS: Well, it just depends on what inlets -- what inlet.

CHAIR CORRADINI: So, I'm going to stop this here and ask e can pursue this, but they've got a few other things they need to get through. But I--

MEMBER BANERJEE: I am just trying to determine the accuracy of the calculation.

CHAIR CORRADINI: I don't think Jack is -- I won't speak for Jack. But what I hear him saying is that both sides think the .3 to .4 bars is not crucial. So we can investigate this further, but I'd like to at least get through all this stuff first.

MEMBER ABDEL-KHALIK: I would like to ask about the operation of the fans, if I may?

MR. TILLS: Yes.

MEMBER ABDEL-KHALIK: In just looking at the numbers in the table, the shut off head of the fans is about a third of the psi. And the question in my mind is there any situation in which you would have enough water in that pan that if the operator were to start that fan early, it would never come on?

MR. TILLS: If the GDCS pool level is above -- I mean, this has been an issue. When we start the calculation at 72 hours, General Electric has said that the lip of the tray would be right at the water level of the GDCS at 72 hours. And I think that's my understanding.

Okay. If the tray would be, say, a foot below, okay, then you would have much more static head in the -- and you could get a much less -- you know, less flow of the fan definitely. Whether or not it would not come at all is a question.

MR. MARQUINO: If the fan was turned before the GDCS pool drained, it wouldn't produce any flow or any significant flow, it's set up that way to take advantage of the condensate coming from the PCC to provide a loop seal. So to do that, we had to put it in the GDCS pool. We had to put the tray in the pool. It is above the elevation of the main steam line. So in any conceivable break when the DPV is open, the pool is going to drain below the tray. And then when you turn the fan on we'll get flow through because we only have ten inches of submergence on the discharge.

MEMBER ABDEL-KHALIK: I guess I'm just trying to imagine if there was any scenario in which the inlet pressure to the fan is low enough and the line is voided completely so that just having 8 inches of water in that pan would completely disable the fan.

MR. MARQUINO: No.

MEMBER ABDEL-KHALIK: But there is no way that this could happen?

MR. MARQUINO: No. The discharge pressure is limited by the 10 inches of submergence.

MEMBER ABDEL-KHALIK: Right.

MR. MARQUINO: Once the pool's drained, it can't be any higher than that.

MEMBER ABDEL-KHALIK: Right.

MR. MARQUINO: And then on the upstream side when we've turned the fan on when there's basically a pure steam environment in the drywell and evaluated that steam going in and the fan is still able to function and start up in that condition.

MEMBER ABDEL-KHALIK: I just can't see that because the shutoff is so low that only 10 inches of water in that tray will stop the fan.

CONSULTANT WALLIS: So it will never work at all.

MEMBER ABDEL-KHALIK: Right.

CHAIR CORRADINI: I don't think you guys are communicating. I hear one thing from one side.

MEMBER ABDEL-KHALIK: Maybe I am

misinformed, so please let me know how to view this.

MR. MARQUINO: Okay. Let me go back to the -- I have the flow versus line and flow versus DP that's part of the RAI 140 data. And I will look at the shutoff head on that, compare it to the table to address your --

CONSULTANT WALLIS: Well, I have the same problem. If I look at this table here, this shutoff head seems to be remarkably low.

MEMBER ABDEL-KHALIK: Right.

CONSULTANT WALLIS: Less than the 10 inches it's got to produce to blow into the pool.

MEMBER ABDEL-KHALIK: Correct.

CONSULTANT WALLIS: So it'll never work. Something doesn't seem right.

MEMBER ABDEL-KHALIK: That's is my question.

CONSULTANT WALLIS: Absolutely. Yes, I did the same calculation.

MEMBER ABDEL-KHALIK: Something seems to be odd.

CONSULTANT WALLIS: Maybe we're wrong.

MR. TILLS: The shutoff depends on two things. It depends on submergence, but it also depends on the pressure loss coming into the condenser tube.

MEMBER ABDEL-KHALIK: Right. But the lowest -- you know, you have to cross the system curve with the characteristic curve of the fan.

MR. TILLS: Right.

MEMBER ABDEL-KHALIK: And what I'm saying is the static part of that system curve may be above the shutoff head, so they'll never cross.

MR. WAGAGE: You actually take that, the static head is about a little bit half the shutoff head. And the static head of -- so water cannot --

MEMBER ABDEL-KHALIK: Not according to this.

CONSULTANT WALLIS: Not according to this table. That's the problem.

MR. TILLS: I'm sorry. Wayne, did you say that you were going to go back and look something up and bring back to the Committee for clarification?

MR. MARQUINO: That would be fine. Okay.

MEMBER ABDEL-KHALIK: Okay.

MR. TILLS: Okay. Next slide.

To answer Dr. Wallis' question in terms of the rapid response if you did not have vacuum breaker opening or they opened and the gases did not get up to the PCCS, we ran a case which is in this pink line here of the transient response if we isolated the vacuum breakers. In other words, we didn't allow the vacuum breakers to turn on.

The vacuum breakers do not put in a lot of gas compared to the late time behavior. So it's only a small transient case that come on at about 8 minutes or so in the actual baseline calculation.

So you can see that the pink line just shows you the sensitivity of this condenser to inlet flow. You know, whether or not the vacuum breakers are allowed to put gas into the PCCS or not. You can avoid rapid drop off and then later there's a rebound effect. And the rebound effect is because now you're pulling in gas from leakage going back into the system. And that we didn't fool with.

So that was just here in the sensitivity.

CONSULTANT WALLIS: So you can never get as far as the GE cliff or the beginning?

MR. TILLS: No. No.

CONSULTANT WALLIS: That seems rather mysterious.

MR. TILLS: No. But, you know, but we're basically just going after that in terms of trying to identify. That drops very, very rapidly.

CHAIR CORRADINI: But the cliff has something to do with the heat transfer model. But the heat transfer model for the PCCS. That's the only place it can come in.

MR. TILLS: Right. And the interaction with the fan with that whole system, I mean to drop that fast.

CHAIR CORRADINI: Okay.

MR. TILLS: So the blue line here, though, is a blue line where we looked at PANTHERS test in this low flow regime and looked at the MELCOR, and we were about 10 to 15 percent lower than PANTHERS. And so we jumped up the multiplier to raise up that agreement another 10 or 15 percent to see if just raising that up would make this difference. And it does not. It does not make that difference. But it does effect the offset on the late time.

So basically what we were just saying is that, hey, if you want to go after this transient deal, you're going to need a much more sophisticated model of fan interaction with PCCS. It's not even clear that additional tests would help this situation, you know because it's a very difficult situation to try and model transiently the flow of gases in tube. We can barely do a reasonable job in a steady state, let alone trying to track it down transient-wise.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: What did you use for your found bed characteristic? You use this one?

MR. TILLS: Yes. I just don't have that one in front of me.

CONSULTANT WALLIS: What is the rho here? Is the rho density to steam, or noncondensibles.

MR. WAGAGE: On page 19 of the presentation.

CONSULTANT WALLIS: This is your presentation?

MR. WAGAGE: That one show curve.

CONSULTANT WALLIS: You haven't got to it? Okay. We'll get to it.

MR. WAGAGE: I just had a table.

CONSULTANT WALLIS: When we get to it, we can talk about it.

MR. TILLS: Okay. Next line slide is really not -- it's just showing the final equilibrium. When we isolate the vacuum breaker.

Next one. The long term offsets -- again, these are the steps that we run through. We reviewed all of the heat and mass transfer modeling from single tube tests to confirm are actually on the tube-side. This is coming in as well as going out the head transfer coefficient along the tube.

We reviewed the independent reports on MELCOR modeling. Both single tube tests has been in the open literature just fairly recently.

And we also viewed some PUMA test results that used the MELCOR model.

Third, we performed additional PANTHERS tests at these low flow conditions to confirm that we were under predicting compared to the data by about 15 percent. We applied then that 10 or 15 percent conservatism on the modeling to show that that translates into about .4 to .5 bar difference in late time pressure.

So our understanding is that, yes, we're a little bit more conservative in terms of PANTHERS comparisons than they are and that translates into this offset. But I would remind you, you're dealing with proprietary tests, not open literature investigation. You're in a region in which there is no viable tests. In other words, these are partially flooded tubes. They're not fully flooded tubes. You know, so there's a number of reasons that we would still want to have some conservatism, and we're going with the 10 or 15 percent.

MEMBER BANERJEE: What is the percentage of noncondensibles particularly coming in in these tests?

MR. TILLS: Coming in? This is going from -- our calculations at 30 days is somewhere between .15 to .2 Mole.

MEMBER BANERJEE: Mole fraction?

MR. TILLS: Mole fraction. Not Mole, mass fraction. And the --

MEMBER BANERJEE: I have trouble with that because the difference in molecular --

MR. TILLS: Not much difference --

MEMBER BANERJEE: Oh, okay. Because it's hydrogen --

MR. TILLS: Right, this isn't hydrogen.

MEMBER BANERJEE: Not an oxygen mixture.

MR. TILLS: This is nitrogen. Yes. This is nitrogen. I'm giving you nitrogen.

MEMBER BANERJEE: With steam.

CHAIR CORRADINI: Wait, wait, wait. You guys are conversing, so you lost me. So stop conversing.

So he asked you at some point in time--

MR. TILLS: Right.

CHAIR CORRADINI: -- what the inlet noncondensible is. So the answer is at what time and --

MR. TILLS: At the time of 30 days we're calculating somewhere between .15 to .2.

MEMBER BANERJEE: And this is in mass fraction.

MR. TILLS: Mass fraction of nitrogen.

CHAIR CORRADINI: Of nitrogen? Okay. And this is when again? I'm sorry, you said and I didn't catch it. When?

MR. TILLS: Thirty days. And I think from what I remember from the TRAC, I think their like .25. They're a little bit higher than we are.

CHAIR CORRADINI: So the nitrogen now at 30 days is coming from the fact that we've had leakage from what?

MR. TILLS: Back leakage, coming back from wetwell to drywell.

CHAIR CORRADINI: Okay. So essentially the fact there is leakage gives us a noncondensible fraction.

MR. TILLS: That's right. And it's almost like you have a reservoir of noncondensibles that can self-regulate, again these condensers. Because you remember the decay heat for both codes is removing almost exactly at 30 days the actual decay heat.

CHAIR CORRADINI: Right.

MR. TILLS: So these condensers will always seek the decay heat removal.

CHAIR CORRADINI: Right. But so now so you've answered at 30 days and the inlet gas is nitrogen. So now let's back us up just prior to 72 hours before I turned on the fans, right?

MR. TILLS: Yes.

CHAIR CORRADINI: And let me ask, what is the inlet --

MR. TILLS: Hydrogen. The inlet hydrogen is almost, you know, you can't hardly determine what it is. I mean it's still very low. It's almost pure steam coming in. Because the radiolytic gases are very, very small --

CHAIR CORRADINI: So Mole fraction-wise, we're talking ten to the minus something?

MR. TILLS: Less than a tenth of a percent, probably.

CHAIR CORRADINI: Okay.

MR. TILLS: You know, very low.

CHAIR CORRADINI: Graham, did you hear that?

CONSULTANT WALLIS: I am working on something else.

CHAIR CORRADINI: But you got to listen to this so that you're not going to ask the question later. So he's saying coming into 72 hours the hydrogen concentration coming in is less than a tenth of a percent.

MR. TILLS: It is practically pure steam coming in from the drywell into the condenser.

CONSULTANT WALLIS: What GEH told us in June was one percent.

CHAIR CORRADINI: What who?

CONSULTANT WALLIS: GEH told us that a concentration in the drywell at 72 hours was .01 no units. I thought that meant one percent. That's all the 689 kilograms of whatever.

MR. TILLS: It's very, very small. I mean, I don't have an actual --

CONSULTANT WALLIS: It probably is very small. The numbers that we got in June seemed to be much higher.

MR. TILLS: I do have the number on the plot.

CHAIR CORRADINI: The reason we're asking -- we can belay this, Jack, if you need to look it up. But I think the reason we're asking this goes back to the the other question that we had come to.

CONSULTANT WALLIS: Right.

CHAIR CORRADINI: I just want to make sure -- when you were just quoting for Sanjoy at various times.

CONSULTANT WALLIS: So you're saying it's --

MR. TILLS: This is the plot of hydrogen Mole fraction in the drywell and wetwell. The green is in the --

CONSULTANT WALLIS: So point -- point --

MR. TILLS: And the red is in the drywell.

MEMBER BANERJEE: Did you have this slide or --

MR. QUEEN: I don't have any of that, no.

CHAIR CORRADINI: This is a backup.

MR. TILLS: This is a backup slide.

CONSULTANT WALLIS: That's because its all be swept down into the wetwell?

CHAIR CORRADINI: Post-72 hours that's where it goes.

CONSULTANT WALLIS: That's right. It's been swept down, just like the nitrogen, it's swept down into the wetwell.

MR. TILLS: Right.

CONSULTANT WALLIS: So when GEH said in June that the concentration in the drywell was .01, that must have been a mistake.

CHAIR CORRADINI: It's got to be a mistake. Because these are very small concentration. I wanted to make sure we're clear on this.

CONSULTANT WALLIS: It was a handout.

MEMBER BANERJEE: That's why I wanted the LFLs.

CONSULTANT WALLIS: I've got hard copy of a handout that says its .01 in the drywell.

MR. WACHOWIAK: This is Rick Wachowiak from GEH.

The amount in the drywell includes the area that's in the drywell head, right? And so that isn't participating in any of this steam --

CHAIR CORRADINI: That's the dead area, Graham. That's why the one percent --

MR. WACHOWIAK: -- that's the dead area that we moved into the wetwell at the end of that calculation. So you're talking about applies and bananas here. It's not what's mixed in. No.

CONSULTANT WALLIS: When you made that comment, when you're talking about the concentration of the drywell, you add the stuff which is not in the drywell somewhere else?

CHAIR CORRADINI: They purposely do it to bump the pressure.

CONSULTANT WALLIS: Well, okay.

MEMBER BANERJEE: Well, that's what he said, right?

CHAIR CORRADINI: Yes. Thank you.

MR. TILLS: Okay. This is just showing steam Mole fraction in the drywell.

CONSULTANT WALLIS: Right.

MR. TILLS: And you can see basically--

CONSULTANT WALLIS: Well, what's important to know is how much of the steam is condensed and if all of it's condensed, you still have the problem. But a tiny bit is not -- some of it is not condensed, you're probably all right.

MR. TILLS: It's a very high concentration and a lower condenser of hydrogen.

CONSULTANT WALLIS: What is the concentration when it comes out of the condenser?

MEMBER BANERJEE: That is the local issue that -- that's why you need a map of LFL.

CONSULTANT WALLIS: Right.

CHAIR CORRADINI: You can go back to your normal presentation. We just wanted to get clear coming in.

MEMBER BANERJEE: Excuse me. That's an interesting plot. Can you go back to it? What is that now?

MR. TILLS: That's a steam Mole fraction in the condenser that the fans are tied to. And this is just showing the lower plenum in the lower region of the condenser's steam Mole fraction. And this is what happens when you turn the fans on, it jumps up.

CONSULTANT WALLIS: So what is the hydrogen Mole fraction?

MR. TILLS: The ---

MR. McKIRGAN: I'm sorry, this is John McKirgan.

Jack, before we get into too many details on this point, I mean we're very early in this review and I'm a little sensitive to these slides. This is an issue, the staff's captured it and we're going to take this back and look at this very seriously.

CHAIR CORRADINI: Okay. So now that we've gone blue, go back to your normal presentation.

CONSULTANT WALLIS: So we're not supposed to see that?

CHAIR CORRADINI: This is proprietary to the members.

CONSULTANT WALLIS: It does show that you have these figures. Can we see that or not? Are we allowed to take that away with us or not?

MS. BERRIOS: No, you can see these ones.

CHAIR CORRADINI: We're joking. I was just saying that I want to go back. I think what staff is saying they're early in the evaluation --

CONSULTANT WALLIS: I understand that.

CHAIR CORRADINI: -- of hydrogen. So I'd rather at least we get through their presentation and bring up the hydrogen part.

CONSULTANT WALLIS: Okay. What I would like to know is are we going to have a meeting on this hydrogen/oxygen issue and is it going to be comprehensive? If it is, and this is so preliminary, we probably don't need to discuss it today at all as long as we know it's really being worked on.

CHAIR CORRADINI: There's uniform nodding behind you.

MR. McKIRGAN: The staff is going to take this back and we're going to look at this very seriously.

CONSULTANT WALLIS: Okay. Because until today I had no idea that anybody was working on the issue.

CHAIR CORRADINI: They are.

MR. McKIRGAN: They are.

MEMBER BANERJEE: Neither did I, actually.

CONSULTANT WALLIS: No. Not better informed.

MEMBER BANERJEE: Not than you.

MEMBER ABDEL-KHALIK: Okay. Back to the question about the fans. If you look at this diagram and trace the flow path of the fans where the suction is coming in and where the discharge is leaving can this fan ever operate if you have ten inches of water in the pan? Ever?

MR. TILLS: Yes. It is operating. You know we model with it operating. You know --

CONSULTANT WALLIS: Because the rho that you have to put in this diagram is the density of steam at three bars. If you put in something lower than that, you find it never works at all.

MR. MARQUINO: That's right. The rho is representative of the containment conditions at 72 hours and its an input to the code. And it's used by both GEH and the staff.

CONSULTANT WALLIS: Because it could mean something like 14 inches instead of eight.

MEMBER ABDEL-KHALIK: So when you buy this fan the manufacturer gives you a characteristic curve, what did you do to that characteristic curve to get these numbers in the table?

MR. MARQUINO: We took that data out of the TRAC output, that specific table, and that implies a rho value. I also have the data in kilopsacals versus cubic meters per second. That I can bring over and show you. Maybe at a break we can do that.

MEMBER ABDEL-KHALIK: I think it would be a very good idea to do that. Because there might be an issue with this characteristic curve. All along I assumed that this is what the manufacturer would give you, which you know if the manufacturer has no idea that you're going to use this for steam at three bars, they may give you --

MR. MARQUINO: They need to know the rho value.

MEMBER ABDEL-KHALIK: -- a different characteristic curve depending on whatever density is it; air at standard temperature and pressure, most likely. So we need to get the details, the raw data of what the characteristic curve of the fan is to show whether or not this would actually work at all.

CHAIR CORRADINI: But you see where Dr. Abdel-Khalik's question is? Ten inches of water is 2400 so you're always in shutoff mode.

MEMBER ABDEL-KHALIK: Right.

CHAIR CORRADINI: That's what's bothering him. You're on the same page now, right?

MR. MARQUINO: yes.

CONSULTANT WALLIS: IT is 2400 pascals, but it's actually now this 2400 times the density of steam at three bars, which gives you I think about 14 or 15 inches of water. It's still not very much.

Anybody, this is all going to be cleared up?

CHAIR CORRADINI: Yes, it will.

MEMBER BANERJEE: Well, I think you said that you guys did the calculations, right, and you found that --

MEMBER ABDEL-KHALIK: But they did the calculations using the wrong density.

MR. TILLS: What may be the wrong density.

MEMBER BANERJEE: In the characteristic curve.

MR. TILLS: We used what General Electric gave us as what their characteristic fan curve is. I mean there's been a considerable amount of back and forth on this. But that's what we were using.

MR. MARQUINO: So the flow goes to zero when the head is about 0.9 psi, and that's consistent with what Henry said relative to the 10 inches of submergence.

CONSULTANT WALLIS: Yes. Yes. I think that this is probably okay. I just when I looked at one of your RAIs it says 2400 pascals at 300 cfm. Well what you really meant was 2400 delta P over rho.

MR. MARQUINO: Right.

CONSULTANT WALLIS: And I think there was a mistake, and there's a mistake in that RAI. A typo.

MEMBER BANERJEE: Now they put the right units.

CONSULTANT WALLIS: Now I think we got the right units and it probably it work.

MEMBER ABDEL-KHALIK: But I think it would be a good idea to confirm that this is indeed what the manufacturer's characteristic curve would be.

CONSULTANT WALLIS: Or they can --

MEMBER ABDEL-KHALIK: It depends on what kind of fan.

CHAIR CORRADINI: So just for the sake of SI units, that's 6,000 pascals?

CONSULTANT WALLIS: Rho is hydrogen.

MEMBER BANERJEE: I mean, I'm still puzzling about what Graham is. Why operate a fan in this regime? I mean it seems -- with a tiny redesign of the fan, you have a completely flat regime the other way. You know, initially when we talked about this I thought it was flat the other way. This is flat this way, right? I mean you change a little bit of the -- you got a huge change in your flow. Whereas normally you change the delta P a little bit, you know the flow stays, more or less, the same.

MR. MARQUINO: We are using the default homologous curves in the code. So we have not adjusted those head flow characteristic particular to the fan that we might procure. And as I said, that is kind of putting a penalty on us because it'll be over capacity at some performance points.

MEMBER BANERJEE: So what you're saying is this is not a real fan?

MR. MARQUINO: No. This is an analytical fan.

MEMBER BANERJEE: This is an analytical fan?

CHAIR CORRADINI: This is what they need, now they're going to buy it.

MEMBER BANERJEE: All right. Okay. Got it.

MR. TILLS: And this is just showing the fan curve as we're calculating it along with -- and you can see the issues that you've been raising on the figure here shows shutting off early time.

MEMBER BANERJEE: Right.

MR. TILLS: And that's why we didn't want to spend a whole lot of time on this transient response at the time when you first turn the fans on. Because this thing is going to zero flow and then it hits and goes back. You know, we're just really not tracking that.

CONSULTANT WALLIS: The thing that we would like to see, I think, is it self-correcting? That it doesn't sort of go to zero and bounce around all over the place, but it tends to when you get to any noncondensibles it tends to clear them out.

MR. TILLS: Right. Right. And that would

be very difficult to zero in on.

CHAIR CORRADINI: You're not going to buy anything like this, I hope.

MEMBER BANERJEE: Would you really need the fan if it's doing that?

MR. TILLS: Yes.

MEMBER BANERJEE: That's the issue. I mean, what's the fan doing?

MR. TILLS: Okay. So let me see, let's back up just a little bit. Yes. We had already covered the issue of comparing MELCOR and TRAC. This is going on to DBA. Again, this was showing the three areas that we understand is DBA fan with this type of characteristic. They're using the semiscale pump model in TRAC, but we're putting in that same model via a fan characteristics in MELCOR.

The tray, we understand, has a ten inch submergence fixed through the period of intervention. And the fill flow has got no level management.

I just wanted to go down here. This is, for instance, the intervention period with the flow. And I'm showing here just the PCCS tank level, both TRAC and MELCOR. And you can see this is level control in TRAC, the dots. And then MELCOR, this was the comparison, confirmatory. And this is DBA.

Okay.

This is the initial flood level at times zero. And you can see we're not really overflowing. It's going back into the storage tank. So there really isn't any intervention required here from what we understand.

CHAIR CORRADINI: But just so I'm clear of the effect of all of this. The effect of all this one and a half meters is they're essentially in a large amount of their pool -- a large amount of their rod bundle or their heat exchanger bundle surface is boiling which gives them a bigger -- which gives them a better performance which takes on the pressure a little bit?

MR. TILLS: Right. You could also say, you know, their saturation temperature is slightly than hours.

CHAIR CORRADINI: Slightly, right.

MR. TILLS: A few degrees different than ours at some level of the PCCS.

CHAIR CORRADINI: Yes. Okay. Okay. Thank you very much. And this is just showing that. Here's a saturation temperature with time as you're going, you know, through this different level pool.

Okay. So now we're in the DBA.

CONSULTANT WALLIS: So this is the anomaly that you put more water in and it actually cools worse?

MR. TILLS: Yes, that's it.

CONSULTANT WALLIS: Yes, right.

MR. TILLS: So now we're in the DBA regime here mode. And now instead of tracking going down in time because our fan flow is slightly less, and also our refill is a little bit different. Instead of going and tracking the trend, we're back again to a flat, basically a flat curve. Okay. With these assumptions.

So what does this mean in terms of what General Electric has said? I think their conclusion was is that we both show a constant trend going down, confirmatory, okay. But if we go back to DBA calculation, that's not necessarily the conclusion here. The conclusion is that we'll be a little bit higher. And in this case we're back to a fairly flat profile. Okay.

Now this calculation, admittedly, is somewhat conservative. The ten percent conservative model, the PCCS was the ten percent.

Also mention that single tube tests on the heat transfer is typically admitted to be, you know, in the 10 or 20 percent accuracy. It's almost like wall heat transfer. How accurate can you model that or measure that? You know, 10 or 15 percent is probably about it on measurement.

So, we believe that this is a reasonable approach to take a conservative model for the PCCS.

CONSULTANT WALLIS: But it looks as if it never comes down.

MR. TILLS: No, it does not.

CONSULTANT WALLIS: That's rather far from reducing rapidly or reducing it.

MR. TILLS: It does not. Well, initially it reduces it rapidly.

CONSULTANT WALLIS: Yes.

MR. TILLS: And I think what General Electric's conclusion was is that, hey, you know even MELCOR will reduce the pressure from around 400 kilopascals to something less than 350 in a few 100 hours, or in a 100 hours. That was I think their statement here today. And I think that's confirmed by this calculation.

CONSULTANT WALLIS: That is an effect on leakage from the containment because the pressure's up high for longer.

MR. TILLS: Right. And I think that goes

to the staff's reason why you want to reduce pressure fast.

MS. CUBBAGE: There's no credit for pressure reduction in the dose calculations.

CONSULTANT WALLIS: No. I'm just saying they're leaking stuff from the containment, you have to put this into our dose calculations or something?

MS. CUBBAGE: Right. They did not take any credit for reduction in pressure in their dose calculations.

CHAIR CORRADINI: For both the control room and the external release, Amy?

MS. CUBBAGE: That's right.

CHAIR CORRADINI: Okay. So can I just get back to that, because I want to make sure I'm clear?

So two things. One is both stabilize, they just stabilize at different values?

MR. TILLS: Yes.

CHAIR CORRADINI: And in terms of the assumed, and I'll use your black line, they assumed you as they, uses this radiolytic decomposition which nothing turns on because it's a RTNSS system until 72 hours?

MR. TILLS: That's correct.

CHAIR CORRADINI: And then once the system turns on, is it overwhelming the production, matching the production or not keeping up with the production of radiolytic gases that are assumed to be produced? I'm trying to decide am I taking noncondensible out of the atmosphere because of --

MR. TILLS: There is no PARS, no assumed PARS to be operated for first --

CHAIR CORRADINI: 72 hours?

MR. TILLS: -- three days.

CHAIR CORRADINI: Right.

MR. TILLS: Then miraculously at this point, in reality all of a sudden the PARS start working.

CHAIR CORRADINI: Right.

MR. TILLS: Okay. And so the PARS would be both in the wetwell as in the drywell.

CHAIR CORRADINI: Right.

MR. TILLS: And at this point it's an interesting deal because what happens is in this calculation those are going to be shutoff generation rate.

CHAIR CORRADINI: Right. But you do not catch up? Because what I heard was the PARS capability is such that it's going to remove the amount of noncondensible. But in your audit calculation the black line you simply kill it?

MR. TILLS: That's right. You kill the generation.

CHAIR CORRADINI: Okay. Thank you.

MR. MARQUINO: So it matches production at 72 hours and there's no net additional noncondensibles added.

CONSULTANT WALLIS: Well since you're pumping noncondensibles into the GDCS pool region all the time from the PCCS, then there's no pause in there, is there? You're --

MR. MARQUINO: In the PCCS? That's outside of the primary containment. So there's no hydrogen --

MS. CUBBAGE: It's in the GDCS.

CONSULTANT WALLIS: The exhaust from the PCCS goes into the GDCS pool area, which just has a little bit of a grid at the ceiling. And so you're pumping noncondensibles, which are hydrogen and oxygen this time, into that GDCS pool volume --

CHAIR CORRADINI: You're still assuming a 100 percent behavior of the PCCS. I don't know --

CONSULTANT WALLIS: I know. Anything that comes in that's a noncondensible goes out.

CHAIR CORRADINI: Right.

CONSULTANT WALLIS: So you're pumping them into that region?

CHAIR CORRADINI: No. But you're not hearing me. I'm saying steam, hydrogen and oxygen are coming out of the PCCS and they're bubbling out of the GDCS pool.

CONSULTANT WALLIS: Yes.

CHAIR CORRADINI: And steam is. So it's not just hydrogen and oxygen that's coming out of the pool.

CONSULTANT WALLIS: Well someone's going to tell us about condensation --

CHAIR CORRADINI: But I wanted to correct what you're saying.

CONSULTANT WALLIS: So you're saying that the steam then sweeps and goes back into the containment again?

CHAIR CORRADINI: Well, whatever's coming out of the PCCS isn't going to get trapped there. It's going to go out to maintain pressure equilibrium.

CONSULTANT WALLIS: That's right. So you're going to say it's going to come out with enough steam in it, but it's okay.

CHAIR CORRADINI: I don't know. I'm just saying there's some steam there. That's all i'm saving.

MEMBER ABDEL-KHALIK: Aside from whether these fans are safety grade or not, what guidance would you give the operator in terms of when they should start these fans based on these results?

MR. McKIRGAN: I think that question is probably more for GE to answer.

CHAIR CORRADINI: You're asking GE.

Back to Wayne.

MR. MARQUINO: We haven't finalized the emergency procedures for ESBWR, but we don't intend to restrict the time that the operator could turn the fans on to 72 hours. The pool drain would be a factor, so we wouldn't direct the operator to turn the fans on unless the GDCS head is initiated and drained the pool.

MEMBER ABDEL-KHALIK: I guess we'll have to wait then until we can see what the PORVs look like.

MR. MARQUINO: Yes.

MS. CUBBAGE: Well we're not going to see those as part of the certification. I just wanted to make sure that they're conservatively not crediting them or based on the design basis not crediting them until 72 hours. But what we're hearing is nothing would prevent them if they were available from turning them on early.

MEMBER ABDEL-KHALIK: Well, that's my concern also that if they were to attempt -- unless we see what the characteristics that those fans are, they may not get --

MR. TILLS: And I'll just give you the summary here. It just says basically, you know for the intervention period we did go back to General Electric for clarification and design and operation. We've had those discussions with them.

We did confirmatory calculations to match, to try and match what they were modeling in their TRAC code. And we got reasonable agreement in terms of trends.

We also looked at the transient deal and with the exception of the transient deal, you know our calculation has shown an offset of about .4 which we understand at the late time equilibrium.

The added calculation if we follow design in operation, we're not decreasing with time, but we're essentially flat with about a 24 percent margin at 30 days.

So, you know, we've tried to follow the guidance of the Committee to go back and look and see where the differences are. We did find some differences in PCCS modeling that seemed to explain these offsets. And yet we do see a difference between confirmatory and DBA calculations at this point.

CHAIR CORRADINI: Questions by the Committee.

CONSULTANT WALLIS: Well that was very helpful. Thank you.

CHAIR CORRADINI: I think it was.

MEMBER BANERJEE: Yes, just a question. The fact that you have a one dimensional model with a lot of mixing, is it likely -- I know this is loaded; to give you a conservative answer or a nonconservative answer in terms of pressure?

MR. TILLS: We believe its conservative.

MEMBER BANERJEE: Why?

MR. TILLS: Because what drives this system is how much gas goes into the wetwell. And if you are well mixed, we've looked at integral tests, PANDA -- or not PANDA. Yes, PANDA tests. Not PANTHERS, but PANDA tests. We always were well mixed. We modeled those experiments. Always get a higher pressure when we well mixed.

MEMBER BANERJEE: Okay.

MR. TILLS: In fact, in the Standard Review Procedures for the NRC for BWR, drywells are always indicated to be modeled as a single cell well mixed.

MEMBER BANERJEE: And is there a physical reason for it?

MR. TILLS: Well, there's no trapping when you have well mixed. So there's no trapping volumes. And in fact, when we look at the comparison between TRACG and MELCOR for blowdown when it was MELCOR mixed, we see that we're about half -- or even greater higher pressure than they are in TRACG because they have trapping. The trap in the lower regions of the drywell below the source injection.

So like anytime you have a -- you know, 80 percent of the volume in this drywell is in the upper drywell region. A very small amount in the lower drywell. So unless you're trapping all of that noncondensibles is going get blown to the wetwell. And that's where the pressure increases is going to occur.

So, you know, everything that we have that we looked at indicates we're conservative by doing well mixed.

And these sources, blowdown is more obvious it's going to be well mixed. But the injections late time, okay, for the first days is still significant. You're boiling this RPV. It's not like a quiescent, you know, plume-type environment. That's not the environment here.

MEMBER BANERJEE: So do you have an estimate of the velocities?

CHAIR CORRADINI: You used the words he doesn't want you to use.

MR. TILLS: Yes, I don't have. But we'll back to you and tell you what they are.

MEMBER BANERJEE: Okay.

MR. TILLS: The injection rate coming out of the break pipe is somewhere around ten, a little bit less than ten kilograms per seconds coming out of the break pipe.

CHAIR CORRADINI: Yes, that would make sense. Because you got essentially two megajoules per kilogram for boiling --

MR. TILLS: That's right.

CHAIR CORRADINI: -- delay heat. And that's about 20 megawatts of decay heat.

MR. TILLS: Basically the boiling source.

CHAIR CORRADINI: So you can calculate

based on the break size what the velocity. It's a pretty substantial velocity even just to get the decay coming out.

MR. TILLS: Right.

MEMBER BANERJEE: Well, the densities were about three kilograms per meter cubed? So it's about three meters cubed per second.

CHAIR CORRADINI: I don't know how big the pipe is. I think Jack's point about on the order of ten kilograms per second sounds about right.

MR. TILLS: Right.

MEMBER BANERJEE: Yes.

MR. TILLS: And of course it isn't coming as a non-interacting plume. It's coming out hitting other parts, hitting other structures which the CFD code probably was going to have just as much trouble modeling as any other code.

MEMBER BANERJEE: Right. Okay.

CHAIR CORRADINI: Any other questions from the Committee?

Shall we have lunch. Okay. Let's recess until 1:15.

(Whereupon, at 12:20 p.m. the hearing was adjourned, to reconvene at 1:16 p.m. this same day.)

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

1:20 p.m.

CHAIR CORRADINI: Why don't we get started?

I think the staff will begin this afternoon's discussion. Is Bruce or Jay going to lead us off?

MR. BAVOL: I'll start things off. My name is Bruce Bavol. I'm the Chapter 15 Project Manager for radiological analysis. And we'll get right to. I'm going to turn this over to Jay Lee and we'll star moving through the presentation.

MR. LEE: Okay. Good afternoon. I'm Jay Lee. I'm with NRO and I do the radiological analysis.

The purpose for today's presentation is to brief you all, Subcommittee, on completion of fission transport and the removal evaluation done by Sandia National Laboratory.

We feel that the ESBWR containment has a unique design. It has passive containment cooling water system and its heat exchanger also create the drain cooling system. So how this effect the fission product removal and ESBWR is uniquely different from current operating BWR or even somewhat different from

AP1000 as well. So we will be presenting the work completed by Sandia on the fission product removal and transport inside the ESBWR containment.

We did brief you last year, I believe, it was January. So it was like a year and a half ago about this issue. And at that time Sandia did not complete some of the study they were doing. At that time we presented preliminary result and the preliminary evaluation. So we are back here today to present you the work completed by Sandia regarding the fission product behavior and the removal inside the ESBWR containment through this PCCS and gravity-driven cooling system. And then, of course, we're going to answer your questions.

The three issues we like to discuss or we like to present today is:

(1) Natural fission product deposition in the main steam line and the main condenser. This is really the aerosol fission product, fission product in aerosol form. We present aerosol behavior and it producing inside containment last year. So today's presentation is aerosol deposition in the main steam line and in the main condenser.

The second bullet item here we like to present to you today is iodine removal by passive containment cooling water system, in other words iodine behavior in containment and the reactor pressure vessel. That's the second item.

The third item we'd like to present to you is control of pH of water in containment and reactor pressure vessel pools to prevent iodine re-evolution.

Now bullet item number two and number three was also, I believe, Dr. Kress raised this issue during last meeting. Also in his report he pointed out that we should complete this study and present at a later time, which is today. So we are responding to your concern, Dr. Kress, by presenting this bullet item number two and number three.

With that, then I'm going to let Sandia start their work they have done for us. Don Kalinich is Sandia National Lab. And he did most of our study, along with Randy. So, Don, would you please go ahead and start?

MR. KALINICH: Sure. My name's Don Kalinich. I'm with Sandia National Laboratories. And I'm going to walk you through details on those three bullets that Jay just discussed. The first one is going to be concerning the fission product deposition in the main steam lines and the main condenser, specifically here aerosol deposition.

The main steam lines and the condenser are designed to meet the SSE criteria. There's a 200 cfm leakage rate that's specified in the tech spec for the valves. That leakage rate is assumed to be there for the entire duration of the accident, 30 days. And there was an independent RADTRAD confirmatory calculation that's been performed by the staff using information that I'm going to present here in order to compare with the GEH results in their Chapter 15 analysis.

Next slide.

So the way that analysis was done was results the ESBWR MELCOR model were used to establish thermal-hydraulic boundary conditions so that we could estimate aerosol removal coefficients. This is equivalent to what we presented last year when we were looking at just the containment removal coefficients. Subsequent to doing that work, the request came in to look at the main steam lines. So we extended the model to consider that part of the system and reran it so we could get main steam line results.

For that part of the model we have a containment main steam line only ESBWR MELCOR model.

And we used that to perform quantitative analysis of uncertainties and aerosol physic parameters and their influence on the aerosol removal coefficient. We do a Monte Carlo analysis here. We define, we sample them and then statistically present the results. In this particular case we're using a 150 realizations in the statistical analysis.

CHAIR CORRADINI: So just to refresh my memory.

MR. KALINICH: Yes, sir.

CHAIR CORRADINI: This is using essentially the DBA source term specified as the source that's going to be leaking through the value, the closed main steam isolation valve, is that correct?

MR. KALINICH: We used the NUREG-1465--

CHAIR CORRADINI: I should have said the alternate source term.

MR. KALINICH: Yes, we used that.

CHAIR CORRADINI: But essentially that timing source term for DBA application?

MR. KALINICH: Yes.

CHAIR CORRADINI: Okay.

MR. KALINICH: That's correct.

CHAIR CORRADINI: Thank you.

MR. KALINICH: And that's the same thing that was done for the containment, just to be no worries.

CHAIR CORRADINI: Thank you.

MR. KALINICH: Next slide, please.

So these are results. What we're looking at here is a 150 realizations on each graph, and there are four graphs. If you follow along from left to right and then top to bottom, you've got the in-board main steam line piping, the piping between the two valves, the piping out-board of the second valve, and then the condenser. And what we're looking at here is time on the X-axis 24 hours. And then you've got the removal coefficient in units of inverse hour. And so what you've got here each of the multi-colored lines, there's a 150 on there.

The black lines, the top one represents the 95th percentile. The bottom one represents the fifth percentile. And then the red line in the red line in the middle represents the 50th percentile, the median value.

CHAIR CORRADINI: And so just again to refresh my memory, so you used a sampling technique and you used a normal distribution on the removal rate and sampled within that or were there more parameters than just that?

MR. KALINICH: I'd have to pull the report up. But we looked at things like particle slip coefficient --

CHAIR CORRADINI: Okay. So a whole range of things?

MR. KALINICH: A whole range of aerosol physics parameters, and I can provide that list and the distributions.

CHAIR CORRADINI: That's fine. That's fine.

MR. KALINICH: They're in the documentation.

CHAIR CORRADINI: But so the ranges, they're all normal distributions or --

MR. KALINICH: No, sir.

CHAIR CORRADINI: They're all various distributions and --

MR. KALINICH: It depends on the parameter that you're looking. Some would be uniform, some would be -- I can tell you that they all fixed upper and lower bounds because you want to do that for this type of analysis. But depending on what the parameter is and what the dataset are that support the definition of the distribution, and there's an explanation for each one in the report.

MEMBER STETKAR: And it's pretty clear that they are not all normal distributions?

MR. KALINICH: No, sir. They're not.

CONSULTANT KRESS: What did you do about the particle size?

MR. KALINICH: Particles? I'd have to look at that. I know we look at variation on the aerosol mass median diameter and on it's on the geometric standard deviation. And I'd have to go pull the report, which I have sitting in my backpack if you're interested, even an hour later and I can tell you specifically what we did.

I know that Dana has looked at it because I know that in the early analysis we were using old information and we were corrected and we reran our work. I think we chose -- we ran into a triangular distribution from -- but that's too much detail for right now, I can give you the specifics offline. But they're not all normals and there is a basis. I just didn't think that you all wanted to go through a dozen different parameters in great detail.

MEMBER POWERS: Maybe I can help. We used a triangular distribution for the mean of the particle sized distribution. That triangular came from our results of the PHEBUS FPT 1 and FPT 2 tests. And we used a uniformed distribution per the geometric standard deviation of the distribution. Again, we looked at the range that was plausible down to about 1.6 for the geometric standard deviation and up to about 3.2. That upper bound was again based on things that have been observed in the PHEBUS FPT 1 and 2 tests.

CONSULTANT KRESS: That's about as good as you can do.

MEMBER POWERS: That's a fair way to think of doing --

CONSULTANT KRESS: What was the physical size of this, Dana? I mean submicrons?

MEMBER POWERS: The physical size? Well, there are, of course, the particle distribution in principle goes up to the size of boulders because its live normal, but in fact the mean is down around, a little better than a micron.

CONSULTANT KRESS: Okay.

MEMBER POWERS: And that's probably been the most important evolution of our understanding coming out of the PHEBUS tests is the radionuclide particles in the piping system are relatively small. And that once they go into the containment you get growth up to the 2 and 3 microns. We never get up into the 10 and 25 micron sizes that have been hypothesized back in the NUREG-1150 days.

MEMBER BANERJEE: Now are these dendritic particles or --

MEMBER POWERS: Not typically. The problem is that by the time you actually sample them on a stage, any of the details of the structure. Our current understanding of how particles grow in these environments is they initially form chains, branch chains and once they've reached critical limit they fold over into something I call a dust bunny. It's highly porous material that has a roughly spherical envelop, but a relatively large shaped factor because of the high pilosity. Once you take it into the containment, you then get what amounts to a centering not really there's so much centering as water condensing in the crevices and them pulling them together a little tightly. By the time you put them on a stage that you can look at, they look more compact than they probably are when they're suspended but they're still manifestly high porosity to them.

CONSULTANT KRESS: You took care of those shape factor variation?

MEMBER POWERS: Yes. Shape factor, I

believe, is -- and we're relatively generous on that because as you go from chains down to dust bunnies, you go over a fairly large range. The upper bounds on that range were actually fixed by some experiments in which exploding wires were used to form the primary particles and those used uranium dioxide, iron oxide and things like that. A fairly consistent pattern. And in those experiments they observed shaped factors up as high as 18.

CONSULTANT KRESS: Eighteen? Wow.

MEMBER POWERS: And, of course, more typically you drop down to 2 and 3s, especially after you get this collapsed to my dust bunny. And that's really what it very much looks like, is the dust bunnies that collect under furniture and things like that.

MEMBER BANERJEE: The shape factor being defined as surface area per volume ratio?

CONSULTANT KRESS: You count them, they're two spheres with the density of the material shaped like-- aerosol models think they're still spheres.

MEMBER POWERS: Our aerosol models think they're spheres with unit density.

CONSULTANT KRESS: Yes.

MEMBER POWERS: And there are two ways to handle the shape factor. One is based on the envelop and the other one is both the envelop and the porosity effect on density.

MEMBER BANERJEE: So to follow this do you normally use some form of Boltzmann equation probably with the density function --

MEMBER POWERS: You're looking at integrating the evolution of the aerosol dynamic equation, which is a distribution. And what we do--

MEMBER BANERJEE: A density function.

MEMBER POWERS: What we do is we break that up into size bins. Because these distributions are not unimodal, typically. Because you have a source coming in to an aging aerosol, so you typically get multimodal. So rather than prescribing a distribution, you're integrating over a size bin. What we feed into it is this distribution we've been discussing with Tom where we have an uncertainty and its mean and an uncertainty and its geometric standard deviation.

MEMBER BANERJEE: It has to two log-normal shapes?

MEMBER POWERS: But we assume the input, aerosol, the source of aerosol is coming in as a log-normal and then the integration is done by setting up size bands so we don't prescribe the evolved distribution. But in truth, by the time they get to the containment and things like that, they look like log-normals.

MEMBER BANERJEE: Do you have collision events and coalescents so there is actually a change?

MR. KALINICH: Yes. But I think the short answer would be is MELCOR uses MAEROS as is kernel for its aerosol physics. So if that means anything, the MAEROS can. So I don't generally describe what's in that, but I was hoping that that would be sufficient to -- because there's many pieces of physics in there.

MEMBER POWERS: MAEROS is a reasonably sophisticated aerosol code. What do I say? It's been validated for containment aerosols against a huge number of experiments. It seems to be fairly reliability. That's not to say there aren't still issues that we wrestle with. And when I was especially going to piping systems, some of these subtleties of shape factors as a function of size and things like that, are areas of ongoing research. But for routine analysis, MAEROS is probably the standard of the state-of-the-art.

MEMBER BANERJEE: But from a physical point of view these are so small that they would be basically be carried by the fluid.

MEMBER POWERS: Absolutely. There is no backward coupling, that is the fluid effects the aerosol, the aerosol does not effect the fluid at these concentrations.

MEMBER BANERJEE: So the primary unknowns are the coalescents of the breakup rates.

CHAIR CORRADINI: And the deposition.

MEMBER BANERJEE: And the deposition.

MR. KALINICH: I guess, going ahead back to that one just so -- what we provide after we provide the 150 realizations is we provide numeric values for the median which is what is then put into the RADTRAD code in order for it to do its calculation that's then compared to the Chapter 15 results. So that's what you get out of all this here on this figure.

Next slide.

So this basically is going to try to lay out in very short form what was done by GEH and what was done by the staff so you can kind of have an idea of how they got what they got and we got what we got.

GEH calculated containment removal

coefficients. They calculated removal coefficients for an elemental iodine based on SRP 6.5.2.

CONSULTANT KRESS: Is that what's normally called a lambda?

MR. KALINICH: Yes, sir. Lambda.

CHAIR CORRADINI: Normally what, Tom? I'm sorry.

CONSULTANT KRESS: It's called a lambda in the vernacular.

MR. KALINICH: Yes. In the parlance you would see that as a lambda because most of the time that's put into an exponential decay equation for deposition. That's basically what you're doing is you're fitting all the physics into some simple model that you can do quick and fast calculations on.

MEMBER BANERJEE: So these particles don't pick up a charge?

MR. KALINICH: Physically, yes, but in the models --

MEMBER POWERS: They definitely give inherent assumption here is Boltzmann distribution of charge that there's a unipolar bias. Now whether that's true or not is another question.

What I can say is that the only time that you can test whether they get charging is when you have a radiation field is the charging is not due to decay, it's due to the differential bombardment of atmospheric ions. In general, negatively charged ions have a higher mobility than positively charged ions and so you could develop a unimodel and charge distribution.

What I can say is that we're able to model experiments like the PHEBUS experiments without invoking charge. And what we think is happening is structures and discharging events are vast enough that we're not seeing big deviations from this Boltzmann charged distribution.

CHAIR CORRADINI: So you get charge exchange?

MEMBER POWERS: Yes, you get a charge exchange and we're just not seeing this huge differential mobility. But if I had a radiation field in this room and put aerosol particles up here, they would develop a negative charge because the oxygen ions would just be much more mobile, the anions would be much more mobile than the cations and you would see distortion especially for particles that are larger than about two microns. Small ones would be more like Boltzmann distribution. I can say we're not seeing that effect in the experiments and we can model those experiments quite well without invoking charge. They're always charged, but not invoking a bias charge one direction or another.

CONSULTANT KRESS: I'm not even sure how you would do that in the models anyway.

MEMBER POWERS: We have actually tried to set up models on that. And it's doable at the expense of an enormous amount of --

CONSULTANT KRESS: Yes.

MR. KALINICH: Okay. No credit was taken for removal in the main steam lines. Credit was taken for deposition, aerosols and elemental iodine, in the main condenser based on BWROG methodology. And this is consistent with the ABWR DCD.

No credit is taken for removal of iodine.

For the staff calculation. Containment aerosol removal coefficients were also calculated, albeit in a different fashion.

We also calculated main steam line and main condenser aerosol removal coefficients. In the staff calculation no credit was taken for removal of elemental or organic iodine.

And then the results of the staff calculation independently confirm that -- let me rephrase this. The staff calculation binds the GEH calculation in the sense that the GEH calculation has a higher -- right, Jay?

MR. LEE: Yes, compared to our lambda calculation. In other words, GEH lambda was somewhat higher than our lambda. In that sense it is bounded.

CONSULTANT KRESS: That is nonconservative, though, isn't it?

MR. LEE: No. GEH is more conservative in terms of lambda calculation.

MR. KALINICH: No, you mean it the other way around, Jay.

CONSULTANT KRESS: The other way around.

MR. KALINICH: Our lambdas were bigger than their lambdas.

MR. LEE: Okay. That's right.

CHAIR CORRADINI: Whose lambdas were bigger than whose lambdas?

MR. KALINICH: The staff's lambdas were bigger and no deposition.

MEMBER ARMIJO: Which is less conservative.

CONSULTANT KRESS: Yes, now I'm with you.

MR. KALINICH: Next slide, please.

Okay. The next topic I'm going to talk about is fission product removal, and here in this case we're talking about iodine vapor specifically. And the question is: Does iodine vapor removed by the PCCS stay removed? The idea being that if you do remove it, that vapor goes into a liquid phase that then goes into pools and other parts of the system. And the question is: Well, does that iodine then come back out? And if you're in your steady state for your system, maybe all you're doing is you're just moving iodine out of the vapor, into pools, back into the vapor and it doesn't provide any sort of sequestering of the material.

So there was a rate analysis of iodine transport between the PCCS, the GDCS, the RPV, the drywell and the wetwell to confirm what GEH has done on this topic.

Next slide, please.

So here's a picture of the ESBWR containment. I'm just going to talk real quick about this.

Basically, we looked at a bottom drain line accident so you can imagine that there's a pool down there underneath the RPV where the systems drain when the line is broke and then aerosol or vapor is taken in through the PCCS. What gets pulled out, then gets put into the GDCS pool, which once that system is brought on line goes into the RPV where the liquid there is boiled and there's a potential for iodine vapor to come back into the drywell through the DPVs that have opened as part of the accident sequence.

CHAIR CORRADINI: I just want to make sure I understand.

MR. KALINICH: Yes, sir.

CHAIR CORRADINI: So you're looking at what would be the equilibrium concentration reached after we get to some point in time? Is that the point of this?

MR. KALINICH: Actually, what I choose to look at was the mass of iodine vapor in the drywell. Because that's really the -- but you could look at it either way you want.

Next slide, please.

And this is just another figure that have some mechanisms on it. We can go on ahead and move on through this though due to the interest of time unless someone has questions.

So what we did, is we did a calculation performed with a simplified MELCOR ESBWR model. The iodine pool model was implemented in three places; in the RPV, in the drywell and in the wetwell.

There's actually no model currently available either in MELCOR that I'm aware of from talking with Dana that's going to model the diffusiopheric deposition of iodine vapor in the PCCS. So what we did instead is we said well what if we specify it. We'll just make a parametric model and we're say well if it occurs at a certain rate, what response do we get in the MELCOR model? That would at least give us an idea of how that effects it parametrically.

So the next slide.

CONSULTANT KRESS: Couldn't you just tie it to the condensation rate?

MR. KALINICH: I suppose you could, but given that this model already takes a long time to run, I thought it was just cleaner to just do something simple than try to do something complicated for something I really didn't know. You know, in theory once you go down that primrose path if you're going to spend the time, you might as well actually get someone who knows what they're doing to actually build you a real model. From what I understand, there's just not information available. And given the time constraints, it wasn't an tractable thing to do. So this was our best foot forward, if you will, to try to at least get a handle on the problem.

So just to give you sign of what the iodine pool model is. It's in the MELCOR code it's based on work that was done by Dana. Basically it looks at acid generation and transfer to walls and pools. You're looking at radiolysis of air which produces nitric acid. And you have radiolysis of cable insulation that produces hydrochloric acid.

There's a pool pH calculation that's performed and we account it for the fact that you do have sodium pentaborate buffering in the pools. It accounts for iodine aqueous pool chemistry, pool-atmosphere mass transfer, iodine atmosphere radiolysis and recombination and iodine atmosphere to wall deposition.

MEMBER BANERJEE: Is for PWIs, right?

MR. KALINICH: The sodium pentaborate is for ESBWR.

MEMBER ARMIJO: That's typical BWR.

MEMBER BANERJEE: I see.

MS. CUBBAGE: In this situation they inject a slick on every LOCA signal.

MEMBER BANERJEE: Okay. Right. Got it. It's really meant to serve as a buffer then, is it?

MS. CUBBAGE: No.

MEMBER POWERS: It was an accident that the neutronics coincided with chemistry here. Of course the really important thing is that the buffering capacity, the neutronics business is very obscure. We don't understand it.

MR. KALINICH: So this function is the result of four calculations times on the x-axis after seven days and on the y-axis you have the drywall airborne iodine vapor mass in kilograms. And what you're seeing here is the black curve is you have -- basically what we did is we put on a lambda. We said it removes material at a particular rate per hour. The black -- and the PCCS. It's MELCOR so we put in there a set of control functions that said based the math we're going to remove a certain amount of it per hour using a lambda coefficient.

Yes, sir?

CHAIR CORRADINI: Maybe you said it and I didn't catch it. So it's being removed by essentially going into solution of the condensate and then drained --

MR. KALINICH: That's right. And we're forcing it to do that. There's no First Principle physics. We're just saying here's a rate that we're going to take out iodine out of the vapor as it comes through the PCCS. And we're going to put it into the liquid phase. And then liquid would drain into the GDCS and then on into the RPV and into the drywell because we've got a bottom drain line break.

MEMBER ARMIJO: You don't have any experimental basis --

CHAIR CORRADINI: Right, that's what I was going --

MEMBER ARMIJO: -- to say that this sort of makes sense or --

MR. KALINICH: Dana?

MEMBER POWERS: It fits. I mean, yes, we know that this is exactly what happens that it does go into solution readily. Again, I harken to the PHEBUS experiments where we have a wetwell condenser and we put -- the gaseous iodine comes from the RCS. Of course it does defuse over. And dffusiopherically condenses on the condenser and it does stop. Okay. To come to the end of that gets me into details that are the product of research right now.

What Don's described is he needs to do a calculation before, and we've completed our research, and so he's taken a fairly ad hoc but it serves his purposes here. The physics he's doing is well established.

CONSULTANT KRESS: These lambdas come from a very small value to a very high value. They fall somewhere in the middle.

MR. KALINICH: Right. By accident if there was something out there that we could get our hands on that would work, and we start talking about, you know, primary and odd diffusion equations and all that interesting stuff, but nothing that was going to help even quickly or-- remember, this work was being done a year and a half ago. And so PHEBUS was even further back than it was now.

Basically what I did is I said well I've got the base case where we don't have any removal, which is the black line. And then I started saying well let me just start putting in lambdas and see where you get so at least you can have an idea. Well, yes, if you have a really high lambda, you're going to basically knock all the -- which makes physical sense. But where do you need to be? Is it a lambda of one? Is it a lambda of ten? Lambda of 100? A lot of it depends on long you're going.

Obviously, the red line is not going to get you to nothing anytime soon.

The blue line, which is a lambda of ten, if you're going out for another factor of four, out to 28 days, you've got a good trend there. And if it turns out that you have a very aggressive system in terms of the physics here, you're going to get the stuff out in about four or five days.

I just don't have an idea of where the actual system would truly lie until we get data in a model that we can put together and then run --

MEMBER BANERJEE: This is a point of reference: If you made the assumptions and still wrong that it was lambda that corresponded to some sort of condensation rate and made it the same, what lambda would that be?

MR. KALINICH: I don't have an answer. I could go back and look at something, but I don't have the results.

MEMBER BANERJEE: But you have MELCOR calculated some condensation rates?

MR. KALINICH: Yes, we have. Yes.

MEMBER BANERJEE: I'm not saying its going to be that, but it will at least give you a reference line of some sort.

MR. LEE: You know, of course the condensation rate is one of input in MELCOR code.

MEMBER BANERJEE: You have a longer rate-

-

MR. KALINICH: I think the key thing that we get from this, and let me go to the next bullet to explain why this -- what we think we're getting out of this slide.

MEMBER BANERJEE: It doesn't matter.

MR. KALINICH: So the first thing that you see is that higher removal rates result in lower iodine vapor mass in the drywell which would seem to be obvious but what really is important is the second bullet. And this results are indicative of that we're removing iodine vapor and its remaining in pools rather than being re-evolved. Because if it was re-evolving, then I would expect to see that, you know if that lambda of 100, that green curve looked like a black curve, then what that would tell you is that the stuff's staying in the pool. So I really don't care at that point what's going on with the PCCS. In the large, it's not being effective in removing iodine vapor.

CONSULTANT KRESS: Does the code calculate the pH --

MR. KALINICH: Yes, it does. And that probably -- hit the third bullet that we'll talk about.

CONSULTANT KRESS: Okay.

MR. KALINICH: Yes. Obviously if the pool -- that's the other half of the story is that if you're doing this calculation, you have to make sure why are the pools sequestering. And there's sequestering because they remain basic.

CONSULTANT KRESS: That was the question.

MR. KALINICH: That's the quick and dirty.

And so the third bullet on this is, is that this supports the staff's assumption that iodine in elemental form remains in the water pools.

Yes, sir.

CHAIR CORRADINI: So if I might just back up. These are all calculations that again are looking at where reality might sit based on the DBA. For the DBA analysis specifies a rate of removal or assumes there is no removal? That's what I don't remember, or don't know.

MR. KALINICH: The analysis that was done by the staff RADTRAD assumes no removal of iodine vapor from the system.

CHAIR CORRADINI: So this is looking, if I might say, margin based away from the DBA requirement? I'm trying to understand that.

MEMBER ARMIJO: Yes. Yes. Yes, you are right.

CHAIR CORRADINI: Okay. Okay.

MR. KALINICH: It also confirms what was being reported by GEH in their calculations.

CHAIR CORRADINI: Okay. Thank you.

MR. LEE: You know, you also clarify whenever we say "iodine vapor," we meant the iodine in elemental form.

CHAIR CORRADINI: Yes, I understood that.

MEMBER ARMIJO: Okay.

CONSULTANT KRESS: But you did end up with a steady state level of iodine in the drywell? I mean, it didn't go to zero?

MR. KALINICH: No. No.

MEMBER ARMIJO: No.

MR. KALINICH: Especially if you're not removing any of the vapor through the PCCS. You can see that black line. It just kind of sits there.

CHAIR CORRADINI: Well, that was the source of his original question, is your concern, wasn't it?

CONSULTANT KRESS: Right. Even if you got some removal, you could end up with a steady state?

CHAIR CORRADINI: Correct.

MR. KALINICH: Right.

CONSULTANT KRESS: Because it doesn't remove all of it?

CHAIR CORRADINI: Right.

MR. KALINICH: And you can see the left curve which was a lambda of one per hour. Its steam doesn't really go down all that, we're just not removing all that much.

CONSULTANT KRESS: Yes.

MR. KALINICH: Next slide.

So now we're getting onto the follow line here, which is control the pH and not only the containment pools, but also the RVP pool to prevent iodine re-evolution.

So iodine in the pool will not significantly partition to the atmosphere if the pool pH is greater than 7, roughly.

Formation of cesium hydroxide and the addition of buffer, sodium pentaborate, results in an initial pool pHs between 8 to 8.5.

Acid formation in the system will eventually result in a reduction of the pool pH. And once again, we're accounting for radiolysis of air producing nitric acid and radiolysis of cable insulation producing hydrochloric acid.

CONSULTANT KRESS: Now where does the radioactive elements come from when the radiolysis are there?

MR. KALINICH: It would be --

CONSULTANT KRESS: In the pool?

MR. KALINICH: They form in the atmosphere.

CONSULTANT KRESS: So you did cap the atmosphere?

MR. KALINICH: Yes, sir.

CONSULTANT KRESS: Okay. That was my question.

MR. KALINICH: So in this model basically we've introduced the NUREG-1465 source term for the ESBWR into the system, and it done goes to where it wants to go based on the intercell deposition physics. So it all starts in the atmosphere and it'll deposit on heat structures and in the pools and the like.

CONSULTANT KRESS: So this is creating nitric acid in the air?

MR. KALINICH: Yes, sir.

CONSULTANT KRESS: And then that's going into the pools?

MR. KALINICH: Yes, sir.

CONSULTANT KRESS: You have a mass transfer coefficient for that? And how does it get into the pool?

MR. KALINICH: Well, it can be -- I'd have to actually look at the -- I know that we use the -- let me see if I can try another shorthand here.

The pool model that's in MELCOR is the end spec model with modifications that were made by Dana. So I would have to actually go back and look at that model to see exactly what the mass transfers are. Maybe Dana can help me out here. I know there's a figure and about 13 pages in the reference model, I just don't have them all committed to memory. I apologize. There is a mechanism for moving the materials from vapors to pools.

MEMBER POWERS: The mass transport is based on the model described in the document by Kress and others. And in that --

CHAIR CORRADINI: Oh God.

MEMBER POWERS: -- document they describe the class of model, one in the liquid phase, one in the gas phase. To calculate the boundary distances that have to have diffusion across we use MAckey and

Ewing, and they're experimental studies of the transport of organic pollutants from water.

We have the model for -- if the pool is evaporating, you have a resistance to the things going into solution. If it's condensing, you get an augmentation. So we do -- gaseous diffusion across the gas phase. In the liquid phase we just use molecular diffusion, which isn't quite right for iodine but it's what we can do right now.

CONSULTANT KRESS: But you did not find the cause of that vapor?

MEMBER POWERS: That's right. It does account for the effects of pool evaporation or condensation due to augment. And it's kind of interesting because as you condense -- evaporate, you still get some iodine transport across that evaporation front until you get to very close to boiling, actually, before you stop it completely.

But, yes, you have to do it in a -- sense where you've got a flux of water vapor and whatever is going into solution plus a stagnant gas that's in the background.

CONSULTANT KRESS: My concern was that you always keep the nitric acid from actually going into the pool.

MEMBER POWERS: Yes, it does not resist it if the pool is boiling completely. It interferes, but it doesn't stop it.

Where the dominant resistance to mass transport is depends a little bit on how fast your conductive currents are over the top. The pool itself is assumed to be relatively well mixed, but it can become right limiting for the diffusion of irons across --

MEMBER BANERJEE: So how do you estimate the --

MEMBER POWERS: We use the correlation from Mackey and Ewing. They did experiments on water pools. And they were looking at organics, partitioning out of water. And they looked at them in, you know, a classic wind tunnel experiment where they get flow over the top. The reason you have to do this is there's a tendency to want to do these as a flat plate. But in fact, you get these capillary effects that ping your mass transport across both the gas phase and the liquid phase. As you go to higher flow rates, then you get actual gravity waves forming that effect it.

So they give you correlations for both the gas phase mass transport which we turn into a boundary layer effect -- because we had a different diffusion coefficient as a function of Reynolds and Schmidt numbers. And they're kind of predictable form --

MEMBER BANERJEE: This is on the liquid side it's a very high Schmidt number, right?

MEMBER POWERS: Yes. Yes.

MEMBER BANERJEE: So is the primary resistance on he liquid side or --

MEMBER POWERS: It depends on the Henry's Law coefficient

MEMBER BANERJEE: Okay.

MEMBER POWERS: If you have relatively large Henry's Laws everything's on the liquid side and relatively low, then you'd get into --

MEMBER BANERJEE: It depends on the solubility?

MEMBER POWERS: Yes. Exactly. Yes. It just depends where you are --

MEMBER BANERJEE: It's comparing the solubility to be on the liquid side.

MEMBER POWERS: And we don't want to make the judgment. We let the computer make that judgment. Do them both using the brilliantly deduced model from the esteemed Kress and colleagues.

CHAIR CORRADINI: Let's move on.

CONSULTANT KRESS: I have a question, though.

CHAIR CORRADINI: You are in conflict. I'm sorry.

CONSULTANT KRESS: Where did you come up with the amount of cable insulation?

MR. KALINICH: It's from the GEH -- I believe it's both in the DCD and the licensing topical report.

MR. LEE: GE has a DCD type of a cable insulation as well as the amount of a cable insulation used. And that is classified as proprietary information.

CONSULTANT KRESS: Does the blowdown have any effect on that?

MR. KALINICH: On the amount of cable?

CONSULTANT KRESS: Yes, or the amount of acid producing material?

MR. LEE: It so happened that amount and the type of cables that the applicant used, GE used, is pretty same as amount used in ABWR design.

MEMBER ARMIJO: What fraction of this insulation gets turned into hydrochloric acid? All of it?

MEMBER POWERS: No. It is a function of the dose rate and time. And we use for that -- ladle of hydrochloric acid production we use a recommendation from Beahm and coworkers at the exalted Oak Ridge National Laboratory in their studies.

There's been some subsequent work done on that at BTT in Finland where they say it's not a constant rate that we assume that in fact there's an exponential rate. It depends a little bit on the loading of the insulation, loading of additives, magnesium oxide, iron oxide into the insulation you're doing. But the number we use is one recommended by Beahm, et. al, for unloaded insulation. And, quite frankly, I can't remember what it is. It's so many kilograms per megarad of dose. And we just use that. Remember, the code calculate how much gets turned in. So it's a function of what your atmospheric dose rate is and the amount of insulation that you have exposed to that dose rate. If you don't, it does not require that that insulation be swept into the sump. Everything's getting that dose.

MR. LEE: Yes. I think that Oak Ridge developed the G factor.

MR. MARQUINO: Wayne Marquino at GE.

There was a question about whether the blowdown effects the mass of insulation. We spec any unprotected insulation that's not within conduit is that mass value. So it's all participating.

MR. KALINICH: So there's a slide question comes when does the pool pH drop below 7 is what you'd like to know. And the GEH calculation predicts that the drywell pool pH goes below 7 between 20 to 29 days in a normal scenario they were looking at and how much credit they took for cesium hydroxide formation.

The staff calculation confirms the GEH results out to 7 days.

Next slide.

MEMBER ARMIJO: I want to make sure I understand what that means. Does that mean after 7 days its below 7?

MR. KALINICH: No. It means that we ran our calculation out to seven days and we still have pH between 8 and 8.5.

MEMBER ARMIJO: So you don't actually have a time at which it actually goes below pH 7?

MR. KALINICH: We don't. We don't.

Just to give you an idea, this

calculation took about two to three weeks to run.

MEMBER ABDEL-KHALIK: Why?

MR. KALINICH: The iodine model is very CPU intensive.

CHAIR CORRADINI: Clearly an appropriate modeler didn't do it.

MR. KALINICH: There's a lot of chemistry being calculated. I took a look at it when I started running it to try to figure out if there was something I could do -- I mean, and we went through and simplified the model in a number of places to try to speed it up. But ultimately, you know, there's --

MEMBER BANERJEE: These are ODEs.

MEMBER POWERS: Yes, the model actually takes the in spec set of equations which are about, I would -- as I recall, 212 rate equation. But we take the steady state limits on those because it gets ready state pretty quickly. And its looking at both the radiolysis of water as well as these iodine reactions as well as the effect of iron impurities as well as the effect of CO_2 and hangs like that going into solution. Calculates the aqueous iodine concentration and the calculates the partitioning of that iodine across.

And the model developer is not what I

would call computationally adept and I wouldn't vouchsafe the speed with which the calculation.

It hones finely, it may not hone fastly.

MEMBER BANERJEE: You didn't try a reduced order model?

MEMBER POWERS: We have a variety of ways to reduced the order of the model, but they've never been implemented in the MELCOR.

CHAIR CORRADINI: Okay. Moving.

MEMBER BANERJEE: It's interesting.

MR. KALINICH: Sorry to interrupt you, Dana.

Just to give you an idea of the differences between the GEH calculation and the staff calculation, the GEH calculation is based on a MELCOR ESBWR model that's run out for 24 hours to provide 24 hours to provide thermal-hydraulic information and the cesium hydroxide and cesium iodine formation rates.

A code called ChemSheet is then used to take that output, extrapolated out to 30 days, in conjunction with acid generation rates to calculate the evolution of the pool chemistry for those 30 days. So that's how the GEH calculation was done.

The staff calculation is a simplified

MELCOR ESBWR model with Iodine Pool Model implemented in the RPV, drywell and wetwell. And we ran ours out seven days.

And our conclusion after looking at these is that iodine trapped in pools doesn't re-evolve all but it confirms what GEH has.

And I thought I actually had a plot, but there's a nice plot that shows that the pHs are constant for seven days. Imagine that, if you will.

So I believe the next slide, that's it.

MR. LEE: After seven days we expect iodine to decay, Iodine-131 decays almost half. And also chi over q factors by then is fairly low. So the dose will be less significant.

MR. KALINICH: So seven days was a sufficient of time to run to provide confidence that we can confirm what GEH does.

MR. LEE: So the regulatory review issues becomes really does ESBWR design provide adequate mitigation of radiological consequences in an event of a major reactor accident to protect public health and safety, meeting the dose acceptance criteria specified in 10 CFR 100, which is a citing criteria and also 10 CFR 52.47? Mainly 24 rem -- 24 rem at the LPG and five rem in the control. That's really the question.

So staff's final conclusion after reviewing all this lambdas we've been calculating inside the containment and main steam line and the condenser, the pH and all that, we conclude that an independent confirmatory calculation by the staff confirmed GEH calculations or GEH analysis as we've shown in the previous slides. Therefore, staff concludes that ESBWR design meets relevant dose acceptance criteria.

We do not have any open issues or open items. And this closes our Chapter 15 radiological analyses review.

CHAIR CORRADINI: Questions by the members?

CONSULTANT KRESS: This conclusion is kind of dependent on your assumed lambda values for the --

MR. LEE: Yes. Certainly we used the lambda value, with the GE lambda, also our GE lambdas.

CONSULTANT KRESS: I mean the lambda value for the PCCS.

MR. KALINICH: No. We took no credit for iodine removal in the calculations.

CONSULTANT KRESS: Okay.

MR. KALINICH: So the real purpose of that was to see if you put iodine in the pools, does it stay there, does it come back out.

MEMBER ARMIJO: So you used a lambda zero, is that --

MR. KALINICH: That's right. Yes. For the RADTRAD calculations that were done by the staff there was no credit taken for iodine removal in the system.

CONSULTANT KRESS: Yes. I guess I missed that.

MR. KALINICH: It was in one of the comparative cites between the GEH calculation and the staff calculation.

CHAIR CORRADINI: So I guess to follow on Tom's question just for my understanding, is that required by the DBA assumptions that you take no credit for that? That's what I didn't understand.

MR. LEE: No, there's no requirement or anywhere in the SRP that we have to give a credit or not give a credit for such --

CHAIR CORRADINI: But historically no credit is taken?

CONSULTANT KRESS: Oh no. All it says is

if you take credit, you have to justify that.

CHAIR CORRADINI: Okay. Fine. That's fine. I understand. Thank you.

MR. LEE: If you have any questions?

CHAIR CORRADINI: Other questions?

Thank you.

We'll move onto the GEH, who is going to give us a presentation, is that correct?

MR. BARRETT: All right. So in order to make the day flow a little bit better, I think I can bond two presentations in one, but the RB mixing holdup just moved ahead of the control room stuff. So we're going to be starting on page 16

CHAIR CORRADINI: Mr. Barrett, are you going to lead us off?

MR. BARRETT: I am.

CHAIR CORRADINI: Okay.

MR. BARRETT: And we're going to cover the reactor building mixing holdup.

CHAIR CORRADINI: Page 16.

MR. BARRETT: Yes, there should be a nice little --

CHAIR CORRADINI: Yep. Go ahead.

MR. BARRETT: Okay. The ESBWR reactor building provides a holdup volume and delays the transport of radionuclides from the containment to the environment. That's the overall concept of our secondary confinement, which is our reactor building.

And we did a detailed the holdup/transport analysis of the ESBWR reactor building using the code GOTHIC 7.2a.

And the purpose of this analysis is to show that we confirmed that the reactor building is a conservative characterization of what was used in the dose consequence model for the holdup and transport of delay of radionuclides.

You guys want to go to the next slide.

And so what we modeled is the whole entire reactor building. The clean ventilation system areas and the contaminated area ventilation system area. And the contaminated ventilation system area completely encompasses the entire containment and the clean area is around that. We didn't, however, do the -- model. And our reactor building is a highly compartmentalized building where the radionuclides would have to disperse to many different rooms through doors, HVAC duct, et cetera. And the model is based off of the General Arrangements drawings located in the DCD which where we include all HVAC and door pathways that connect all the different areas in between each other.

CHAIR CORRADINI: So I have a question just out of curiosity?

MR. BARRETT: Yes.

CHAIR CORRADINI: So you switched to GOTHIC instead of MELCOR. I'm sorry TRACG, I'm sorry. I've had everything all screwed up. And the logic being that this essentially you're modeling this as essentially a series of air volumes connected by orifices?

MR. BARRETT: Yes, more or less. Yes.

CHAIR CORRADINI: Okay.

MR. BARRETT: And we've always used GOTHIC. We didn't use MELCOR or TRACG. This is basically -- well, I'll get into it a little bit more.

CHAIR CORRADINI: That's fine. I just wanted to make sure I understood. That's fine.

MR. BARRETT: Okay. So right now --

CHAIR CORRADINI: On page?

MR. BARRETT: -- we're the model description page, I apologize.

CHAIR CORRADINI: So you're on page 20?

MS. CUBBAGE: Slide 18.

MR. BARRETT: Unfortunately, the copy I

have is not numbered th same as yours. I apologize for that.

MR. BARRETT: We're on Major Assumptions?

MR. BARRETT: So for the major assumptions of the analysis, it's LOCA concurrent with fuel damage, loss of offsite power and HVAC systems are not available. The leakage from the reactor building occurs at the closest point to the control building, which is the most conservative from a dose standpoint to the operators and the control room.

The reactor building is pressurized through a quarter inch water gauge on the windward and leeward sides of the building. And the reactor exfiltration rate was tuned to be 300 cfm.

CONSULTANT WALLIS: Now that corresponds to what kind of wind speed?

MR. BARRETT: Well, a quarter inch -- it'll be somewhere in the 20s you'll around a quarter inch, I believe. Somewhere in the --

CONSULTANT WALLIS: That's right. That's what I have. Twenty miles per hour or something like that?

MR. BARRETT: Yes, somewhere in the 20s.

CONSULTANT WALLIS: Why is that good

enough?

MR. BARRETT: Well, a dose analysis was done at calm wind speeds. So at higher wind speeds the dose would be lot less. So that's why we used the quarter inch.

CONSULTANT WALLIS: Well why not less?

MR. BARRETT: Well, I guess for conservatism.

So our dose was done considering low -- like a high exfiltration or wind loading, but still it was done at --

CONSULTANT WALLIS: It seems there's sort of of an optimum place where it's worse. I mean, there's no wind then nothing happens. If it's too high a wind, it just blows everything away.

MR. BARRETT: Right.

CONSULTANT WALLIS: Somewhere in between in the worst condition. IS this the worst condition or --

MR. BARRETT: Well, the dose analysis was done at two things that can't happen at the same time: At calm conditions and high exfiltration rate. So both of those can't happen at the same time, but the dose analysis was done both together concurrently.

Okay. If you go down to the next slide "Containment Release," most of the mass inside the containment during an accident is nitrogen and steam, any of which can carry the radioactive releases out to the environment assuming that those radionuclides would be attached to either steam or nitrogen to traverse to the reactor building. And the ESBWR containment is noted with nitrogen gas. And the steam that comes from the pipe break is where the steam would come from.

And the radioactive releases reach the environment through either the nitrogen and steam.

And for the GOTHIC model that we used in order to track these radionuclides is we used nothing but nitrogen because it won't condense, unlike the steam will. So we only tracked the nitrogen and assumed that all of it is traversing to the reactor building on nitrogen.

And comparing the releases of --

CONSULTANT WALLIS: This is radioactive nitrogen?

MR. BARRETT: Well, it's not radioactive nitrogen, but what we're saying is is in the model we're going to release nitrogen into the reactor building --

CONSULTANT WALLIS: That carries the radioactivity?

MR. BARRETT: Right, right. Which could carry it.

CONSULTANT WALLIS: Yes.

MR. BARRETT: Okay. And comparing the releases is how we're going to do a comparison between the GOTHIC analysis and the dose calculation, which I'll get into in in a minute.

Go to the next slide.

CONSULTANT KRESS: Now in addressing the NUREG-1465 source term --

MR. BARRETT: Yes. In dose calculation that was used for the source term.

CONSULTANT KRESS: That has a time associated with it. Now GOTHIC's going to calculate flow rates which have a time associated with it due to the blowdown and stuff. How do you put those two times together?

MR. BARRETT: So the nitrogen is not going to carry or anything, so it would have flow rate in and it's going to come out. So what we did was in the dose calculation we tracked a -- we used an isotope that -- long-lived isotopes so that it will be basically constant throughout the whole entire period. And we tracked that.

And what we do is a --

CONSULTANT KRESS: I guess my question is you have the blowdown is driving the GOTHIC behavior, which is of course the time from start of load in.

CONSULTANT KRESS: And you have a source term which starts when?

MR. BARRETT: Okay.

CONSULTANT KRESS: That's my question.

MR. MARQUINO: In a GOTHIC analysis we don't have varying pressure in the containment versus time. We have a constant rate out of the containment inside the reactor building that's based on the primary containment design pressure.

In the dose analysis we capture time released from the 1565 source term and time varying chi over q values. The match up is in the dose calculation we also don't change the primary containment release. So that allows us to compare the dose calculation to this GOTHIC analysis where nitrogen is like a tracer gas.

MR. BARRETT: Going onto slide 21. Here I talk more about what the quarter inch pressure, water gauge pressure that was assumed on the windward side and the leeward side and that how what we did to model it, one of the modeling assumptions we did is we had 300 cfm coming into one side and 300 cfm coming out of the other side. And we used a conservative containment release locations closest to areas where it can get out to the environment, or closest to the control building. And we funneled it out towards that area so that it can get out to the control building with the least path of resistance.

Go to the next slide.

All right. For the results what we did is after 72 hours we took the ratio of the amount of nitrogen that reaches in the environment and put that ratio over what was getting into the reactor building from containment. And that value is approximately 48 percent.

In the dose calculation, as Wayne was discussing earlier, we did the same type of ratio. And we got a ratio of approximately 70 percent when you assume a mixing volume in the dose calculation of 50 percent.

You can go to the next slide.

So as you can see, this a figure of merit. It just shows the different ratios.

The top line is our dose calculation line, which has about approximately a 70 percent. And the bottom line is the GOTHIC line, which is about 48 percent. And the line that's right next to the GOTHIC line is the equivalent dose calculation line if you were to use a mixing volume of approximately 90 percent.

So, as you can see, the GOTHIC line i s always below what would be predicted to get out into the environment that was used in the dose calculation.

Go to the next slide.

All right. So we did several sets of sensitivity analyses requested by the staff in order to show that our model was to determine some of the uncertainties and to quantify some of those uncertainties. And so what we ended up doing is making a best estimate type leakage model where we used like multiple leakage points, varying temperatures and some of those things in order to just get like a best estimate model. And what we did then is then we perturbed a bunch of different parameters to see how it was going to behave after that. And we quantified all those. And what we found is that the CONAVS boundary or the tested boundary that we have right now is the most important parameter. And that that is what's going to really drive how much is being held up inside of the reactor building.

And so in order to qualify how conservative our referenced case was that I used earlier, we took that nominal best estimate case and matched the 300 cfm leakage when it leaked out of wherever it could, and that line is below the referenced case that I used earlier. So there's some conservativeness in how we distributed leakage and how we allowed it to get out into the environment.

Additionally, we did a 30 day calculation. We ran out both the RADTRAD or dose calculation model and the GOTHIC model after 30 days to show that the GOTHIC model is always below the dose calculation model or ratio.

And then the staff also asked us to put it in terms of dose consequence and consequences of additional holdup, and which we did an equivalent dose for what the operators would see from the different perturbations that we used in the nominal case.

And then we also did some dose analysis for what would happen during the holdup, if you got a lot of holdup. And, obviously, the dose to the outside public would be a let less. The dose to the operators would be a lot less. And the equipment inside is still within our EQ limits and we have ITAACs to confirm all that.

CONSULTANT WALLIS: With this constant leakage rate --

MR. BARRETT: Excuse me.

CONSULTANT WALLIS: With the constant leakage rate that you have, 300 cfm, I would think you could do a very simple hand calculation sort of an exponential approach to equilibrium which would come pretty close to some of these code.

MR. MARQUINO: For the RADTRAD calculation, yes, it has a pretty simple model. The GOTHIC model is a set of lumps and orifices. So it's a 1D model of --

CONSULTANT WALLIS: That they have combined into some pseudo lump and pseudo orifice.

CHAIR CORRADINI: There would be an array of exponentials?

CONSULTANT WALLIS: Yes.

CHAIR CORRADINI: Yes. Right.

MR. BARRETT: Go on to the next slide.

And these are just a summary of the ITAAC and surveillance requirements that we have in place right now that specifies when we're testing the reactor building and to ensure that the as built design will match what was done in the analyses.

Go on to the next slide. Okay.

This is the conclusions, and the basic conclusion is that the analyses of the reactor building confirms that the mixing volume assumed in the ESBWR dose analysis is a conservative characterization of the multi-volume reactor building that we have and provides the holdup and transport delay of the radionuclides.

CONSULTANT WALLIS: Where does this 300 cfm come from? Is there assumed that all the doors are closed or all the doors are open, or all the seals work, or whatever it is --

MR. BARRETT: Right. Right. What we have is a test on our reactor building contaminated area where we pressurize it and we don't allow it to go past a certain --

CONSULTANT WALLIS: It hasn't been built yet, so how do you know what 300 cfm -- is 300 cfm a specification?

MR. BARRETT: Yes. It's in ITAAC.

CONSULTANT WALLIS: Oh, it's an ITAAC. Okay.

MR. BARRETT: Yes. That's the conclusion

of the presentation. Do you have anymore questions?

CHAIR CORRADINI: Now we're going to go back in space, I'm not sure what, to another topic, is that correct?

MR. BARRETT: Yes. We're going to go to the control room habitability heat-up analysis

CHAIR CORRADINI: All right.

MR. BARRETT: We're going to skip the agenda slide. It kind of tells about, sort of things like -- we'll just start from the beginning of the control room heat-analysis.

So we did a detailed analysis using CONTAIN 2.0 of the entire control building, in particular --

CHAIR CORRADINI: So I have a question immediately.

MR. BARRETT: Yes, go ahead.

CHAIR CORRADINI: So we've now gone through MELCOR and now we've gone through GOTHIC and now we're at CONTAIN. Can you give me some insight? Do you just feel like you want to diverse in all your applications? What's going on here?

Wayne, I'll let you make that answer.

MR. MARQUINO: Is your only tool in your toolbox a home a hammer?

CHAIR CORRADINI: Well if I've got a red hammer and a green hammer and a blue hammer, unless I enjoy my color diversity, yes. I mean CONTAIN is no different, and MELCOR is no different than GOTHIC. Unless I misunderstand there's some feature. That's what I was trying to get at. Is there a feature you're trying to use here that --

MR. BARRETT: Well, for the reactor building mixing issue we used -- GOTHIC has the ability to do 3D modeling, 2D, 1D and multidimensional type. It has a more kind of mesh. And we used some of that for the larger volumes and for the traversing of the nitrogen throughout the reactor building.

And for this particular analysis when we first set out, it was an NRC code. We felt like it was a pretty good code. So we decide to go with it.

CHAIR CORRADINI: Okay.

MR. BARRETT: And so then we wanted to go with the simplicity model, so it allowed us to do that.

CHAIR CORRADINI: Okay. Fine.

MR. BARRETT: So like I was saying, these contain 2.0, it includes an entire control building with emphasis on the control and habitability area.

And so all the rooms are connected to each other. And so all the room-to-room interactions can be seen. And the considerations we used were a loss of off-site power where normal HVAC is unavailable for cooling. We have safety related heat loads are always going. Some of the nonsafety-related heat loads, most of the major ones, have been de-energized. There's people, lighting and there's an operation of an emergency filter unit which supplies unfiltered outside air -- I mean filtered outside air into the control room.

MEMBER STETKAR: What assumptions did you make on the nonsafety-related heat loads.

MR. BARRETT: Well, we basically came up with something we might like to have. Like nonsafety, we don't any unsafety-related.

MEMBER STETKAR: No, I understand that. But in the real world there will be a finite amount of nonsafety-related heat loads in that building. And the question I was getting to is are you assuming that the operators are going to actively shut off any nonsafety-related heat loads --

MR. BARRETT: No. They de-energize automatically once you get to a certain -- under certain conditions.

MR. ARCARO: Yes. There's a safety-related trip on the nonsafety-related heat loads that are in excess of what's in the heat up analysis.

MEMBER STETKAR: You took credit for that term probably, but you took credit for the full two hour duration of the nominal life of nonsafety-related batteries and equipment that will be powered from it?

MR. BARRETT: Yes.

MEMBER STETKAR: Okay.

MR. ARCARO: And then what's left was, you know what we need for alarm indication and running three or four via fuse

MR. BARRETT: Right.

MEMBER STETKAR: Yes, I just wanted to make sure you weren't shutting things off that actively --

MR. BARRETT: No. Further what we did also, like there's a nonsafety room above the control room habitability area. We actually took that up to like -- I can't -- something like 60 C and let that go throughout the entire duration assuming that it's going to be working some how in order to run those nonsafety screens in the control room. So that was an additional conservatism.

They probably -- for whatever reason it got that hot in those rooms it probably wouldn't work and we wouldn't have the additional heat load. But we included that in the model.

MEMBER STETKAR: It would be interesting to see what would happen when whatever is there doesn't work.

MR. MARQUINO: No. But we did make a revision about a year ago based I&C and Operations input to accommodate additional nonsafety heat loads so that they wouldn't have to be shed at times zero. And that's been factored into the analysis.

MEMBER STETKAR: That has? Okay. Good. Good. Than you.

CONSULTANT WALLIS: Now, you talk about heat loads and there's a lot about heat loads in the answers to the RAIs. How about water loads? I mean, you've got 11 people in there at 93 degrees Fahrenheit.

MR. BARRETT: Yes.

CONSULTANT WALLIS: Presumably producing quite a moisture to paper.

MR. BARRETT: That's in the analysis as well.

CONSULTANT WALLIS: I didn't see any kind of water balance in any of your RAI responses.

MR. BARRETT: They might not have been in the RAI responses. Maybe because they didn't request specifically for what the values were. But they in fact in the analysis to match up with what the ASHRAE Fundamentals has suggested for latent and sensible loads.

CONSULTANT WALLIS: And then the outside conditions, the air which is coming in.

MR. BARRETT: Yes.

CONSULTANT WALLIS: You seem to have very low humidity in that air?

MR. BARRETT: Right. The outside air temperature was based off of the worst temperature ever for all the potential ESBWR sites. And at that worst temperature --

CONSULTANT WALLIS: 117 degrees Fahrenheit?

MR. BARRETT: 117 degrees, we took the coincidence wet-bulb temperature and figured out what its corresponding humidity to be.

CONSULTANT WALLIS: You took it to be 20 percent humidity.

MR. BARRETT: Right.

CONSULTANT WALLIS: A wet-bulb

temperature of 63 degrees Fahrenheit. Now that seems to be awful low for the worst case.

MR. BARRETT: It's the worse case --

CONSULTANT WALLIS: When we're looking at cooling towers for another application, they're assuming the worst case is 86 degrees wet-bulb temperature. You know, 63 degrees Fahrenheit, 20 percent humidity seems to be very low for a worst condition, doesn't it?

MR. ARCARO: Well, there was some sensitivity runs, too.

MR. BARRETT: Right. We also did an additional sensitivity run where we did take --

CONSULTANT WALLIS: But why did you take such an optimistic initial case before you'd done any sensitivity at all?

MR. BARRETT: Because, well our acceptance criteria for heat up was 93 degrees Fahrenheit. A final temperature of 93 degrees Fahrenheit. And to get the worst case for getting to 93 degrees Fahrenheit is to have the highest dry-bulb temperature.

CONSULTANT WALLIS: 17 degrees Fahrenheit?

MR. BARRETT: Yes.

CONSULTANT WALLIS: But that has a relative humidity of 20 percent.

MR. BARRETT: Right. That's it's coincidence -- I mean it would be --

CONSULTANT WALLIS: A wet-bulb temperature of 63 degrees Fahrenheit. That seems to me to be much too low for a bad humid day in the worst parts of the nation.

MR. MARQUINO: Antonio explained one point, which it is a factual temperature, the highest temperature and a corresponding humidity. And --

CONSULTANT WALLIS: The humidity is just 20 percent?

MR. BARRETT: Yes. Well, as you get to higher and higher temperature it's harder and harder to get higher and higher humidity.

CONSULTANT WALLIS: I know. But that's a wet-bulb temperature of 63 degree Fahrenheit.

MR. BARRETT: Yes, that's based off of actual data.

CONSULTANT WALLIS: The highest recorded?

MR. BARRETT: Yes.

CONSULTANT WALLIS: It doesn't make sense.

MR. BARRETT: That's not the highest

recorded humidity or the highest recorded wet-bulb temperature, but that is the highest recorded temperature for all the sites, which is the most limiting for the highest temperature in the control room.

CONSULTANT WALLIS: Okay. Okay. So you were saying the temperature limits. I was worried about humidity limit. I think you want to look at the worst case where they're all evaporating and there's 90 degrees and they've uncomfortable, how humidity does it get. And I didn't see that in the--

CHAIR CORRADINI: So let me Dr. Wallis' question differently. So you didn't find it being limiting to have a lower temperature but a much higher humidity? That's what I think what he's asking in a reverse way.

MR. BARRETT: Okay. From a maximum temperature standpoint it's not more limiting. From a humidity standpoint, obviously to have higher humidities it would be more limiting. So what we did do was a sensitivity analysis where we used the zero percent exceedance wet-bulb temperature at a 100 percent humidity and we did a calculation. And the temperature was nowhere near as high, however it did have a high humidity, the temperature was nowhere near the 93 degree limit.

MEMBER STETKAR: How high was it?

MR. ARCARO: One of the earlier runs, 96 degree dry-bulb, 100 percent humidity gives 89 degrees at 72 hours.

CONSULTANT WALLIS: Well, I am still puzzled. I'm still puzzled. Because you said the limit is going to be comfortable is 86 degrees at wet-bulb temperature.

MR. BARRETT: Yes.

CONSULTANT WALLIS: Now that can happen outside.

CHAIR CORRADINI: But I think the answer to your question, his sensitivity they got within a few degrees of their limit on the same manner.

CONSULTANT WALLIS: Oh, you see, if their limit is 86 degrees Fahrenheit in the control room, it can be 86 degrees Fahrenheit wet-bulb outside. And then it comes in, and they evaporate into it, so it's got to go up. I don't see how you can ever get down to 86 if it's 786 outside.

MR. BARRETT: Get down to it?

CONSULTANT WALLIS: It comes in, and they evaporate into it.

MR. BARRETT: Get dow to 86, I'd not

following you.

CONSULTANT WALLIS: It doesn't make sense.

MR. McLAMB: I think to clarify here what you're asking is how can you take hotter air from outside and at 72 hours after forcing it through the control room, how is the temperature going to be any lower than --

CONSULTANT WALLIS: How can you take humidity air from outside and have it come into the control room and leave no more humidity than it was when it came in? That doesn't

MR. BARRETT: Well, first of all, the initial conditions of the control room is not going to be 86/86. It's going to be like 74 max 60 percent.

CONSULTANT WALLIS: But after a while --

MR. BARRETT: After a while it should start to come up. But at the end of it, you're not going to be high. It's not 86 already in the control room and you're adding more 86, or something like that.

CONSULTANT WALLIS: Well when we analyze cooling towers we assume it 86 degrees Fahrenheit wet-bulb temperature in the air outside.

MR. BARRETT: Yes.

CONSULTANT WALLIS: And if that comes into the control room --

MR. BARRETT: Yes.

CONSULTANT WALLIS: -- the humidity in there has got to be higher than that because people are evaporating.

MR. BARRETT: The humidity will start to rise.

CONSULTANT WALLIS: Well, it does rise. It's higher. I think a transient is less important, after while it's equilibrium. So I couldn't understand how you get the humidity down to the desired value. I still don't understand that. But anyway, go on.

CHAIR CORRADINI: But let's just make sure. You said something in your question that I want to make sure they agree with.

So do you reach an equilibrium quick enough or are you still coming up into a transient?

MR. BARRETT: We're still coming up. We're still coming up.

CHAIR CORRADINI: Anyway, Graham, I think that's what he's trying to tell you.

CONSULTANT WALLIS: Very close, doesn't

it?

MR. MARQUINO: Well, we've got a plat later that shows the daily cycles of temperatures and how the ---

CONSULTANT WALLIS: Like humidity? Humidity equalizes pretty quickly. Water comes in and water goes out. It doesn't build up. There's no walls soaking up humidity. Humidity happens very quickly.

MR. BARRETT: Yes, humidity will be going up. But it doesn't start -- humidity doesn't start at 86 percent, 100 percent. I mean, it's going to be somewhere around I think normal for a ESBWR is 20 to 60 percent. So it will be building up, but it's not going to get up that high.

CONSULTANT WALLIS: Yes. I didn't see a corresponding build up of humidity, which seemed to me would happen much quicker. Because the walls are a heat sink --

MR. BARRETT: There is a humidity plot in the -- well, that one is that the 20 to 40 percent so it's not going to show you what you want.

CONSULTANT WALLIS: Do you know much people give off in water vapor when they're as uncomfortable as this in a stress situation?

MR. BARRETT: Could you say that one more time?

MR. MARQUINO: What's the acceptance criteria --

CONSULTANT WALLIS: The heat source, what's the water source for 11 people in a stress situation at 93 degrees Fahrenheit? I'd made an estimate and it seemed to me that it was worth about 10 percent in humidity, but maybe I was wrong.

MR. BARRETT: What we use is what ASHRAE recommended us to use for people giving off moisture.

MR. ARCARO: Yes. So a sensible heat of 75 watts and latent heat of 55 watts per person.

CONSULTANT WALLIS: That's not water. Okay. So I won't ask any more questions. I just didn't see the answer to my question to what I read about how did they reach buildup, what were the sources and so on.

MR. BARRETT: All right. Go to the next slide.

All right. The rooms of the control building are modeled as single nodes connected by concrete. So all the interactions between all the different rooms can be seen from the nonsafety room above. Safety room below. All the different heat transferred.

MEMBER ABDEL-KHALIK: How many of these walls are below grade?

MR. BARRETT: The whole entire control room habitability area is actually below grade.

MEMBER ABDEL-KHALIK: How many of those walls are in contact with the outside world?

MR. BARRETT: The outside world, like the ground? The actual soil?

MEMBER ABDEL-KHALIK: Right.

MR. BARRETT: The whole back wall is contact and part of the side walls. So maybe half of the outside barrier, then we also have some walls inside as well.

MEMBER ABDEL-KHALIK: Is the condition at that boundary taken in the analysis at all as a boundary condition?

MR. BARRETT: It is. It is on the outside. But we took a conservative number. We estimate it to be 86 degrees, although it will be a lot less than that. The further down you get, the cooler the ground will be.

MEMBER ABDEL-KHALIK: Well, we'll listen to what you have to say.

MR. BARRETT: I see. Okay.

Our design goal for the summer conditions is a bulk average temperature of 93 degrees Fahrenheit at the end of 72 hours.

Go to the next slide.

For major assumptions:

The total heat load is 9630 watts which encompasses all of the heat loads, including a 15 percent margin;

The outside air supply -- the outside temperature is 117 degrees Fahrenheit with a day and night temperature profile.

CONSULTANT WALLIS: At 20 percent humidity?

MR. BARRETT: At 20 percent humidity at 117 degrees and at the lower end I think it's 40 -- 40 something percent.

CONSULTANT WALLIS: It's not a lot.

MR. BARRETT: Right. If the humidity is higher, the temperature will be lower. Like if you took the same amount of moisture --

CONSULTANT WALLIS: Well I couldn't find it, because I'm so stupid with a computer, I just try to see the records for Washington, D.C I think in Washington, D.C. you get temperatures in the 90s and wet-bulb temperatures well above what you say you have here.

MR. BARRETT: Right.

CONSULTANT WALLIS: So I'd like somebody to check that. And the staff check it, or somebody who is smart with a computer can get onto it and figure what the humidity records are for some humid places.

MEMBER BANERJEE: But what's the issue? I mean --

CONSULTANT WALLIS: My issue is that he's got a very low humidity air coming in and people are evaporating. I'm more concerned about the humidity in the control room. It seems to me --

MR. BARRETT: The real question is how much heat is being added to the overall calculation from the 117 degree air coming in versus the actual heat loads in the area.

MEMBER STETKAR: And he said well it's conservative to assume 117 degree dry air coming in from temperature. But they said it only really makes like three degrees temperature difference.

CONSULTANT WALLIS: But it's the humidity difference I'm worried about.

MEMBER STETKAR: And humidity is a real concern.

CONSULTANT WALLIS: It is, yes. So you're concerned, too?

MEMBER STETKAR: Oh, yes. Well, I'm not concerned not only for the human beings, but also the equipment in there that has to operate at a --

CHAIR CORRADINI: John doesn't care about the human beings. He cares about the equipment.

MEMBER STETKAR: No, I do. I do. Let them sweat in the dark for 72 hours.

MEMBER BANERJEE: But even in Karachi, isn't it warm --

CHAIR CORRADINI: Let's keep on going. I want to get through this. Let's go.

MR. BARRETT: All right. So the concrete thermal conductivity is listed here. So all the concrete thermal properties including the density, thermal conductivity, specific heat are lower than what the actual design values are.

For, for example, like the concrete density is about 1900 kilograms per meter cubed when it's really going to be around 2400 or so. The initial humidity is 60 percent max and the EFU flow rate is a flow rate of 508 cfm maximum. The lower end is 466 cfm.

CHAIR CORRADINI: And just to clarify,

just so that Professor Wallis hears it again, you suggested that there was another sensitivity you did which was -- and I don't remember. It was something 0100 percent humidity and an incoming temperature of what?

MR. BARRETT: 88 degrees.

CHAIR CORRADINI: Okay. So that's a sensitivity that essentially takes much lower temperature but a 100 percent humidity?

MR. BARRETT: Right.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: Well, how does it ever get to a lower humidity than 100 percent? Because -- how does it get to a lower wet-bulb temperature than 88 if it's a 100 percent humidity--

MR. BARRETT: It's 88 drywell and 100 percent humidity --

CONSULTANT WALLIS: How does it ever get down to 86?

MR. BARRETT: What was that?

CONSULTANT WALLIS: How was it a 100 percent humidity at 88 degrees and you want a wet-bulb temperature of 86 degrees for OSHA --

MR. BARRETT: When it starts --

CONSULTANT WALLIS: How do you ever get the water out to get it down to that lower humidity?

MR. BARRETT: Well, at the end of the 72 hour period it's not up to the 86.

CONSULTANT WALLIS: Humidity transient is very quick.

MR. MARQUINO: It's mixing in the control room habitability area.

CONSULTANT WALLIS: The transient is about the -- just with the air in the control room. There's no sink in the walls or anything. It's a very quick transient. And there's no --

MR. BARRETT: You're putting 509 cfm into a control room that is --

CONSULTANT WALLIS: I figured that out. Yes. And I figured out how much people would sweat. And it actually contributes a significant of moisture to that 500 cfm.

CHAIR CORRADINI: So let's hold the question. Let them go through the analysis. I just want to make sure that you have another analysis as a sensitivity that we can ask about. But let's let you at least let you go through your basic analysis.

MR. BARRETT: Okay.

MEMBER ABDEL-KHALIK: Now tell me about

the next to last bullet.

MR. BARRETT: Okay. The control room habitability area concrete has been exposed to an air temperature of 85 degrees F for 8 hours before the initiation of the transient.

MEMBER ABDEL-KHALIK: Now prior to that point what was the temperature of the concrete across the entire thickness?

MR. BARRETT: 74. It's 74 degrees at the wall at the surface in the control room habitability area. And depending upon the temperature on the opposite side, there's a linear temperature distribution. And --

MEMBER ABDEL-KHALIK: And what was that temperature?

MR. BARRETT: -- for example on the opposite side, in most cases I think it was 78 degrees.

MEMBER ABDEL-KHALIK: The one larger was, roughly, 74/75 degrees across the entire concrete wall thickness?

MR. BARRETT: Yes.

MEMBER ABDEL-KHALIK: Is that a reasonable thing to assume when there is direct contact with the outside?

MR. BARRETT: Okay. One other thing that we did is so we went and we actually set all of the initial temperatures so if a control room habitability area is 74 degrees, corridor and normal conditions are whatever to whatever. So we cited that one at 78 degrees. We cited it at 78 degrees. And then we ran the whole entire model for 72 hours, allowed everything to come into equilibrium including stuff that's in contact with the outside world, the outside world being 86 for the soil. So it came to same equilibrium. And then at that point we exposed the control room habitability area inside to an 85 degree -- we set all the air temperature to 85 degrees Fahrenheit, exposed it there for eight hours. And then whatever the resulting concrete temperatures were at that point, we then started our transient analysis.

MEMBER ABDEL-KHALIK: Well, what's the logic?

MR. MARQUINO: Going back to your question about the outside temperature and --

MEMBER ABDEL-KHALIK: Yes.

MR. MARQUINO: -- the ground temperature, we've also provided the technical specification on the average concrete temperature so that it will be monitored and that heat sink will be viable consistent with our analysis.

MR. BARRETT: Right. So if you go outside of that, you can go into like an LCO for an eight hour period, so you have eight hours to get the temperature down. But if you go over 85 degrees, then the nonsafety systems will start -- everything will start shutting down. So --

MEMBER ABDEL-KHALIK: There is actually a tech spec on the average concrete wall temperature for the --

MR. BARRETT: Well, it's on the temperature of the air. So --

MEMBER ABDEL-KHALIK: Well, you just said "the concrete temperature."

MR. BARRETT: Yes. It's on the temperature of the air first, and then once the temperature of the air -- if the temperature of the air goes above, say it goes to 75, you then in an action and then you must get the temperature down below. And then you must check the concrete barrier -- the concrete temperatures. Because what you want to make sure is that you're not over 74 degrees for the concrete.

MEMBER ABDEL-KHALIK: How do people

assure compliance with that tech spec on the concrete wall temperature? Do you have embedded thermal couples within the concrete walls to measure concrete temperature?

MR. MARQUINO: Well, there's multiple ways. We could provide embedded temperatures, as Antonio said. This is in response to the air temperature being out of spec. It usually would not have to be monitored. So it could be simply temperature -- local temperature measurements that an auxiliary operator takes in that tech spec condition.

MEMBER ABDEL-KHALIK: I'm sorry. How would an auxiliary operator measure the concrete wall temperature if part of it was below grade?

MR. MARQUINO: They can measure the interior wall temperature.

MEMBER ABDEL-KHALIK: Well, okay. But is that really our concern in terms of providing adequate heat sink?

MR. ARCARO: I guess that is one method you could do. But the tech spec basis talks about if the average of the control room habitability air temperature exceeds the specified limit, restoration of the heat sink is verified by administrative evaluation considering the length in time and extent of the heat sink average air temperature exclusion, or by direct measurement of the heat sink material, structural material temperatures.

So based on analysis, based on evaluation you know how long it takes for the heat sink to heat up. So that would be your operability. You know, if you exceed a certain time, then you're outside of that window.

You know, the option is you could actually go measure the structure and verify that the concrete temperature is a certain temperature.

CHAIR CORRADINI: But when you say measuring, just to make sure I understand. When you say measure the concrete temperature, you're implying measuring the inside temperature? You got a lot of feet of concrete. You're talking about the inside wall temperature?

MR. WACHOWIAK: This is Rick Wachowiak from GEH.

So your concern seems to be that we haven't assumed outside temperature of the wall that's in contact with the ground.

MEMBER ABDEL-KHALIK: Well, my concern is that you're assuming that you have a huge a huge sink.

MR. WACHOWIAK: Yes.

MEMBER ABDEL-KHALIK: And, you know if this thing is located at a hot location, the ground temperature may be very high. You have a long summer period that the below ground part of the concrete may actually be a lot higher than the assumed 74 to 78 degrees F that you're using in your analysis.

MR. WACHOWIAK: Right. So you understand the question. In our calculation we looked at what the ground temperature would be so many feet, meters below ground.

MEMBER ABDEL-KHALIK: Right.

MR. WACHOWIAK: And then assumed that that was the outside temperature of the wall. And I think what your question is, and not about the inside temperature and those things, is how robust is that calculation that we did to ensure that that's what the outside temperature is.

MEMBER ABDEL-KHALIK: It's been there for months.

MR. BARRETT: And I guess the -- I looked at the ASHRAE book for Phoenix at 22 feet, so that would be the underground portion, and you would be 73 degrees, so it's 86 degrees soil temperature. You know, the temperature kind of does a thing like that as you go down in depth. So I'm thinking you got margins on your 86 degrees.

MEMBER ABDEL-KHALIK: What is the ceiling of the control room relative to grade?

MR. ARCARO: It's about grade.

MR. BARRETT: Yes, it's about grade.

MEMBER ABDEL-KHALIK: Okay. So if you're taking the value at 22 feet --

MR. BARRETT: So you'd be somewhere less than that.

MR. BARRETT: Yes, but we've done 86 for the entire thing.

MEMBER ABDEL-KHALIK: I'm sorry?

MR. BARRETT: The soil temperature is assumed to be 86 degrees.

CONSULTANT WALLIS: That's very high for soil temperature.

MR. WACHOWIAK: This is Rick again.

So what you're saying is that the value that we used is robust for the sites that we're planning on using this plan. The average wall temperature over that control room habitability area should be less than what we assumed in the analysis?

CONSULTANT WALLIS: Could you clarify something about the walls? I thought I read in some of these RAIs that you made some assumption about half the walls cool down or something or heated up.

MR. BARRETT: I did a hand calculation--

CONSULTANT WALLIS: That's a hand calculation. But really it's a transient, isn't it. And your computer actually does a heat diffusion through the walls, does it? Does it do that calculation?

MR. BARRETT: Yes. There's like a really fine mesh. The mesh is finer closer towards the air.

CONSULTANT WALLIS: I thought it did, yes. And you just a check with this half of the wall thing?

MR. BARRETT: Yes, exactly.

CONSULTANT KRESS: What does the computer use for the outside surface of the concrete?

MR. WACHOWIAK: What we were just talking about. In contact with the ground. It's the boundary condition.

MR. BARRETT: We used a boundary condition that's 86 degrees. It's a huge boundary condition. It's 86. It's not going to change.

MEMBER STETKAR: Antonio, I was just searching through drawings and I'm coming up empty, and I have to admit ignorance. Is the control room habitability area itself in contact with the exterior soil or is surrounded by other areas of the control building that contains other equipment and spaces?

MR. BARRETT: Yes. Part of it --

MEMBER STETKAR: I'm talking laterally.

MR. BARRETT: Yes. Yes. So here's the hallway corridor. So there's no equipment or anything out there. So it's contained on that side. And the other side is a thick concrete with soil on the other side.

MEMBER STETKAR: Okay.

CHAIR CORRADINI: Okay. So that explains your answer when you said "half is and half isn't." So half of it is exposed to a hallway, the other half is directly onto the soil?

MR. BARRETT: Right.

CHAIR CORRADINI: Okay. Got it. Thank you.

MEMBER ABDEL-KHALIK: Now, at the end of that 72 hour when the temperature reaches -- or still hasn't reached the 93 degree F limit, what is the average temperature of the concrete?

MR. BARRETT: It's less than 93. I don'[t recall off the top of my head. I would have to get back to you on that. It's less than 93.

MEMBER ABDEL-KHALIK: I mean, it has to be. IT's still absorbing heat, I'm guessing that's what your question is?

MEMBER ABDEL-KHALIK: Well, I'm trying to find out what it is.

MR. BARRETT: Well, I would have to get back to you on that.

Next slide.

So this is a picture out of DCD. I didn't include the humidity chart on here. But this shows the heat up at the control room. The blue line is the outside air temperature and the red line going across is the acceptance criteria of 93 degrees Fahrenheit. And then the other line is the profile of the heat up of the control rooms.

The second note I have down here is that that corresponds to a maximum wet-bulb temperature of about 75 degrees Fahrenheit. And the NIOSH recommendation is about 86 degrees Fahrenheit. So it's quite lower than that.

CONSULTANT WALLIS: Now the external wet-bulb temperature is higher than that, as it can be. How can it possibly get down to 75?

MR. BARRETT: In this particular case the outside wet-bulb temperature is not. It's lower than what's already in the control room.

CHAIR CORRADINI: So the next logical question would be for the sensitivity you quoted, I guess we'd be interested to see a similar sort of plot.

CONSULTANT WALLIS: For the 88 --

CHAIR CORRADINI: For the low temperature but a 100 percent humidity case. I think that's where --

MR. BARRETT: Okay. So you want to see something like the wet-bulb temperature --

CONSULTANT WALLIS: So 88 degrees Fahrenheit, 100 percent humidity.

MR. BARRETT: That's what the sensitivity -- I'm not presenting -- that is not --

CHAIR CORRADINI: Yes, I understand. But you have that?

MR. BARRETT: We have done that analysis, yes.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: I would be very interested to see what you get for a humidity in the control room.

MEMBER ABDEL-KHALIK: Now this graph shows -- it is not very obvious, but it shows an initial reduction in the air temperature for a very short period of time.

MR. BARRETT: Yes.

MEMBER ABDEL-KHALIK: Where does that come from?

MR. BARRETT: That comes from earlier I mentioned how I artificially held the control room habitability area at 85 degrees Fahrenheit for a period of time, at which the corresponding temperature of the concrete was at 74 degrees and started to heat up slowly. So once I stopped artificially holding the temperature at 85 degrees, it had a dip of when it starting to absorb that heat, which is also I did a hand calculation which is also present in that hand calculation as well. So the concrete is still much lower.

MR. WACHOWIAK: And this is Rick.

So the physical phenomena that's happening there is that if we lose some sort of cooling in the control room, the temperature can go up and as we go past 72, that's when we go into the tech spec action. But the next automatic action that happens is later at what temperature?

MR. ARCARO: Eight-five degrees is where you trip it.

MR. WACHOWIAK: At 85 degrees we trip off nonessential or nonnecessary nonsafety-related loads. So the physical phenomena there that happens is we actually do lose load so that the artificial increase in temperature is no longer a valid assumption.

MR. BARRETT: Right.

MR. WACHOWIAK: So there is a physical meaning to that.

MR. ARCARO: At 74 you got a tech spec limit, 78 you got an alarm, 85 you trip off your MDCIS to stay within the heat loads of the calculation.

MEMBER STETKAR: So all the MDCIS goes away?

MR. ARCARO: Just your essential, nonessential MDCIS. You've still got enough to see your panels.

MR. WACHOWIAK: This is Rick again.

What we've done in that case is we've given the I&C system a budget of how many watts are allowed to be used in the control room following this limit. And between the I&C group and the HFE group they're going to decide best to use that budget of heat load for nonsafety-related equipment that stays on.

CONSULTANT WALLIS: These 11 people are in this room for three days?

MS. CUBBAGE: It's eight hours. They have shifts.

CONSULTANT WALLIS: They're coming out?

CHAIR CORRADINI: They're allowed to go out and get another group.

MS. CUBBAGE: Oh.

MR. BARRETT: Go to the next slide.

And the staff also requested that we did do a winter conditions analysis. So we did an evaluation of that analysis. And we used the code ECOSIM. And the ECOSIM --

CHAIR CORRADINI: I'm not going to ask that question.

MR. BARRETT: Yes.

CHAIR CORRADINI: Go ahead. I just think you guys are equal opportunity employers. Everybody's doing -- you're using everybody's tools.

MEMBER ARMIJO: Was there something special about ECOSIM compared to --

MR. BARRETT: Yes. The CONTAIN code had some limitations as far as going down to as low as we wanted to go, the negative 40 degrees. So we used ECOSIM. And in order to validate ECOSIM what we did is we reproduced the CONTAIN model and did the exact same model and got the same results, so we used --

MEMBER ABDEL-KHALIK: For the high temperature.

MR. BARRETT: Yes, for the high temperature.

CONSULTANT WALLIS: For the winter you have very cold air coming in?

MR. BARRETT: That's correct.

CONSULTANT WALLIS: How about snow and ice, doesn't that -- and ice formation would block off the air flow, or what happens to ice crystals that come in the filter and so on?

MR. ARCARO: For RTNSS and safety systems you have defectors and --

CONSULTANT WALLIS: But the filters, don't it just snow. The air intakes, don't it just snow?

MR. ARCARO: They're protected from snow.

CONSULTANT WALLIS: But the snow is in suspension. Small snow particles blow about and they're often -- you know, they get around obstacles.

MR. MARQUINO: So your concern is that the snow will come in and then melt and then --

CONSULTANT WALLIS: I don't know. It

might block up the filters at the inlet, don't you?

MR. ARCARO: Well, you have a fan and then you got a prefilter. You've got a stage of filters.

CONSULTANT WALLIS: I know that the Army put filters on people who were going out in the snow exercising. And some of them had very bad effects because filters clogged up with ice. And they couldn't breath.

MS. CUBBAGE: This issue wouldn't be unique to ESBWR, would it?

CONSULTANT WALLIS: No, it wouldn't be unique. But I just wondered what they do with the--

MS. CUBBAGE: So I think plants are out there operating with snow.

CONSULTANT WALLIS: Yes.

MR. BARRETT: Okay.

MEMBER ABDEL-KHALIK: If I may just go back to the summer analysis, if you don't mind?

MR. BARRETT: Yes.

MEMBER ABDEL-KHALIK: You have a heat load of roughly 9.6 kilowatts.

MR. BARRETT: Yes.

MEMBER ABDEL-KHALIK: And the temperature of the air is continually increasing over a 72 hour period. That sort of tells me that the heat transfer rate from the control room to the containment is less than 9.6 kilowatts. Is that true or is the increase primarily because of infiltration of hot air?

MR. BARRETT: It comes from both. So it's less than both combined.

MEMBER ABDEL-KHALIK: So roughly what is the heat transfer rate -- what is the relative contribution to this increase? Can you tell me what the heat transfer from the control room air to the containment is at the beginning and end of this period?

MR. BARRETT: I could tell you --

MEMBER ABDEL-KHALIK: Probably at the end of this period would be the highest value?

MR. BARRETT: I think the highest value would probably be at the beginning. Because well, number one, the outside air temperature difference between the outside air temperature and the control room temperature is the highest. And then you have the additional heat load.

MEMBER ABDEL-KHALIK: But if you're starting with room temperature roughly 74 and the wall temperature is roughly 74?

MR. BARRETT: Well, it's not. The air

temperature is starting at 84.

MEMBER ABDEL-KHALIK: Okay. Okay. So what is the highest heat transfer rate from the control room air to the containment wall?

MR. BARRETT: I'm not sure. I'll have to get back to you on that. I'd have to look it up in the analysis. But I could let you know later.

MEMBER ABDEL-KHALIK: All right. Thank you.

MR. BARRETT: Okay. Our design temperature for the bulk average air temperature if 55 degrees Fahrenheit for the winter conditions.

You can go to the next slide.

And the winter conditions model is similar to the summer conditions models except that it has much lower heat loads, much lower initial temperatures and a lower EFU air supply temperature, which is the negative 40 degrees. All the concrete dimensions and thermal properties are the same.

CONSULTANT WALLIS: And the initial temperature of the ground?

MR. BARRETT: In this particular model the initial temperature ground is much lower. We actually didn't use the ground as any sort of heat--

CONSULTANT WALLIS: And the initial

temperature of the concrete, though, is the -- something in between the temperature of the control room and the ground, isn't it? A gradient wind stay state?

MR. BARRETT: Yes, that's correct.

And for this analysis I'm trying -- yes, we used 65 degrees for the temperature of what the ground would be. But the ground is actually not going to provide any additional heating.

CONSULTANT WALLIS: The ground is a lot colder than that?

MR. BARRETT: Yes.

MR. ARCARO: Yes, 60 degrees.

MR. BARRETT: About 60 degrees. Thank you.

CONSULTANT WALLIS: In northern New England the ground temperature pretty well year round when you get down a few feet is around 45 degrees.

MR. BARRETT: Right. So, I mean, it would act as a heat source at 60.

CONSULTANT WALLIS: A cold source.

MR. BARRETT: Yes. A cold source. Yes.

So, at the end of the analysis it was above, it remained above 55 degrees.

Can we go to the next slide.

So we did several alternate calculations at the request of the staff for the containment analysis.

We used GOTHIC 7.2a to get a more detailed analysis, 3D modeling of the control room habitability area.

CHAIR CORRADINI: What do you mean by that? You used the lump parameter version of GOTHIC? You didn't use the distributive parameter version?

MR. BARRETT: We used the lump parameter version of CONTAIN for the heat up analysis.

CHAIR CORRADINI: Okay.

MR. BARRETT: And then we used the 3D modeling for an alternate calculation where we subdivided the control room into multiple nodes.

CHAIR CORRADINI: But when you say multiple nods, I'm just to make sure I understand. GOTHIC has two methods of application. One is to essentially solve the Navier-Stokes and one essentially just break up volumes into subvolumes but it's still lumps.

MR. BARRETT: Yes, it breaks up the volumes and the subvolumes.

CHAIR CORRADINI: Okay. Fine. All right. Thank you.

MR. BARRETT: So where you get to see all the different flows and all the different aspects that are going inside the model.

CHAIR CORRADINI: Okay.

MR. BARRETT: And we did this model, and it confirms the CONTAIN model that was done where the operators are in the subdivided nodes, where the operators were it remained below 93 degrees. I think below six foot six. But there is a temperature gradient within the main control room and the other rooms.

Second, as I mentioned earlier, we did the ECOSIM model where we took the exact same model, modeling it again in ECOSIM and the numbers were the same. So that gives us a higher confidence that the modeling was done correcting.

MEMBER ABDEL-KHALIK: So in this sort of 3D modeling do you know the locations of the heat sources within the control room?

MR. BARRETT: We didn't know the actual specific locations, but we made some assumptions based off of, like, where panels are, where panels are located and we used, like, okay this is particular position is where the wide display panel would be. So we're going to use that as a primary where most of it would come from. Then a BEU may be down in this particular part of the control room. So we'll use that particular node for additional heat loading.

MEMBER ABDEL-KHALIK: So this sort of just allows you to live with higher temperatures due to stratification?

MR. MARQUINO: The operators are assumed to be standing on the floor. So we established this two meter elevation as where we were monitoring the temperatures against the 93 F criteria. And we didn't look at temperatures in the false ceiling at the top, which would be higher.

MEMBER ABDEL-KHALIK: You did or did not?

MR. MARQUINO: Well, the code calculates those temperatures, but we don't have any acceptance criteria for them.

CHAIR CORRADINI: He's saying that --

MEMBER ABDEL-KHALIK: I mean, is it really reasonable to assume that the air in the control room will be stratified in these nice layers and you don't have to worry about anything above two meters?

MR. BARRETT: Well, yes. Well, there's a temperature gradient, but it's not like if you go up an extra foot it's going to be, you know, a 100 and some degrees. It's only going to be like 93.1 degrees or something like that.

MEMBER ABDEL-KHALIK: I mean, don't you think with people moving around that there's enough mixing that any assumptions you make about stratification would be sort of just assumptions?

MR. BARRETT: Yes. Well, I mean, we're going by what the code calculated as far as its temperature gradient. We didn't artificially make it have this stratification. So, I mean, if you have a room and you have stratification, there's going to be higher temperatures at the top and cooler temperatures at the bottom.

MEMBER ABDEL-KHALIK: Provided you don't have people walking around all over the place mixing it up.

MR. BARRETT: Right, right.

Our criteria is an average temperature. We're not -- it was not like a point temperature at this point or at that point. It's supposed to be an average temperature rise over the entire thermal area. So by that respect, I mean it seems to be well within what we've looked at.

MEMBER STETKAR: Antonio --

MR. BARRETT: Yes.

MEMBER STETKAR: -- on that point, eventually we're going to get to this picture, I hope.

But since you brought up the average temperature, did you do anything about trying to calculate temperatures inside those cabinets where equipment lives, specifically solid state electronic digital equipment that really doesn't like to get warm and not a primary heat source for this room?

MR. BARRETT: Right. We did not look for that specifically. And I think it's going to be handled separately from this particular evaluation.

MR. WACHOWIAK: This is Rick --

MEMBER STETKAR: How is it going to be handled separately from this particular evaluation?

MR. McLAMB: You're talking about equipment qualification. And this evaluation can be used to provide temperatures outside of the cabinets. The purpose was not to calculate temperatures inside the cabinets.

MEMBER STETKAR: This can be used to calculate a bulk fluid temperature in the room which doesn't necessarily even mean the temperature immediately outside the cabinets, does it?

CHAIR CORRADINI: No, I think that would be -- at least that's the way I interpreted what you just said, is you're going to use this as a boundary condition for the bulk, but you're going to do a separate analysis for the equipment qualification?

MR. McLAMB: Right. This goes beyond the level of detail that Antonio performed in his analysis. He's worried about people being overheated.

CHAIR CORRADINI: Okay.

MR. WACHOWIAK: This is Rick Wachowiak, GEH.

So just to be clear on this, our equipment is subject to -- digital equipment in a mild environment, it's subject to an EQ program. The components inside the cabinet will be tested as a unit as part of the EQ program with ambient temperatures outside the cabinet much higher than what we're allowing in the control room. So the equipment inside the cabinet will be tested as part of the -- qualified as part of the EQ program to much higher temperatures than what we'll see in the control room.

There are other rooms where we challenge that limit more closely. But the control room is not one of them.

CHAIR CORRADINI: Okay.

MR. McKIRGAN: I'm sorry, if I could just -- this is John McKirgan.

The staff has also issued an RAI on this. So I think we'll be seeing additional information on that.

CHAIR CORRADINI: Okay.

MR. BARRETT: And so additionally, our First Principles hand calculation was performed, as I mentioned earlier where we took into account heat transfer, heat transfer from the air, equipment and into the concrete walls. And it is relatively close to what was calculated in the CONTAIN analysis with being below 93 degrees.

Go to the next slide.

CONSULTANT KRESS: Is that a transient calculation?

MR. BARRETT: Yes. There was a --

CONSULTANT WALLIS: The hand calculation isn't a transient, is it?

MR. BARRETT: It is a transient calculation.

CONSULTANT WALLIS: And you have all sorts of little nodes in the wall?

MR. BARRETT: Yes. Well, no, no --

CONSULTANT WALLIS: To an average or--

MR. BARRETT: Yes. I think Thomas alluded to it earlier. I used like half the -- yes. Because that would have been a lot of --

CONSULTANT WALLIS: Just the same as the transient where the normal way it penetrates the wall.

MR. BARRETT: Okay. And some of the sensitivity analysis that we did were the zero percent Exceedance Wet-bulb, EFU outside air temperature. That was the 100 percent humidity case and where we do get a temperature, I think, around 89 degrees which is much lower than the 90 degree limit. Possibly higher humidity.

Lower EFU air temperature where we went out and ran case where one day at 117 degrees and the next day at the one percent exceedance, which I think was around 100 degrees. And we got like a two degree additional margin from doing that.

And we varied the EFU flow rate which we saw almost no sensitivity, a very, very small sensitivity.

We varied the heat load, and I think it was approximately 700 watts. We'll get an extra degree.

And then we varied the temperature profile where we saw a small sensitivity to that.

CHAIR CORRADINI: So all of these sensitivities, which one -- I'm trying to get a feeling for which one challenged the --

MR. BARRETT: The main ones, I would say, was like the heat load. So I mean if we put twice as much equipment in there, it's not going to be that great.

The outside air temperature if you increase it much past 117, if you put like 10 extra degrees, that's going to have a large effect.

Other than that, the rest of them didn't show too much sensitivity.

MR. ARCARO: Well, the other side of the outside air temperature, we assumed a continuous cycle at 117 degrees, whereas you know ultimate heat sink sort of calculations allows you to use that as a historic peak. So if you do one cycle at 117 and then you use your one percent exceedance for the other values, you get quite a reduction in temperature.

CHAIR CORRADINI: So I guess that was something -- right. I guess that was something I didn't understand when you did this. So in assuming the external value you are directed by ASHRAE to once you have that maximum, to continue the cycle at that maximum?

MR. BARRETT: No, no. We did that as a level of conservatism.

CHAIR CORRADINI: Okay. So the ASHRAE guidance would be to essentially look at one really bad day and other days around it closer to the average day in that location, in that geographic location? That's what I'm trying to understand?

MR. BARRETT: Yes. Well, yes, you would have the one peak. After that I'm not sure -- I don't think it says that you're supposed to use average for those days.

CHAIR CORRADINI: I understand. But you don't use the same cyclar peak?

MR. BARRETT: Right. You don't use that same peak.

MR. ARCARO: I think we're using the worst case, URD ASHRAE temperature that we'll find in combination of dry-bulb/wet-bulb and we're using it, you know, for three cycles. So there's certainly margin there.

CHAIR CORRADINI: Okay. Thank you.

CONSULTANT WALLIS: Now these air supplies produce a pressure of about an eighth of an inch of water or something like that?

MR. BARRETT: Yes.

CONSULTANT WALLIS: What happens if there's a strong wind blowing outside? I mean you had another analysis for another building. Does that affect the flow of the air that's ventilating this control room?

MR. BARRETT: Well, the EFU supplies a particular volumetric flow rate into the control room, so --

CONSULTANT WALLIS: But I'm saying if the wind is blowing so that it comes in on one side and goes out the other, or does it come in? Does it come in -- the wind is blowing in an adverse direction, does it change the flow rate through the ventilation system?

MR. BARRETT: The way that the analysis was done is that e did it at a constant flow rate in and a constant flow rate out.

CONSULTANT WALLIS: But then when you did a building in your previous talk you said that the wind wa causing a flow through the building. And I just wonder if --

MR. BARRETT: Yes, we have like a fan. We have a fan. In the building we don't have anything that's --

CONSULTANT WALLIS: Yes, but the wind's the fan in the building?

MR. BARRETT: Right.

CONSULTANT WALLIS: In this case there is not a fan.

MR. BARRETT: And so therefore it would be changing with the wind.

CONSULTANT WALLIS: The wind is not a fan?

MR. BARRETT: Right, it is a fan.

CHAIR CORRADINI: I think we're talking about two different buildings. Let's make sure we're clear.

CONSULTANT WALLIS: Yes, I know that.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: I'm just saying in one case you consider the wind to be a fan, and this case the wind oppose the fan if its blowing the wrong way, couldn't it?

MR. ARCARO: Well, I guess the basic model is you take outside air, it's got a deflector, a missile shield, it's going to take outside air.

It's going to run it through the control room using the EFUs. It's going to discharge through an orifice device inside the building. I guess you could get perturbations in pressure due to wind.

CONSULTANT WALLIS: If the wind is driving flow rate -- if the first building --

MR. BARRETT: I guess, what is your overall question?

CONSULTANT WALLIS: Well, when you did the first building, the reactor building, you said the wind creates flows through the rooms in the building, right, because it changed the pressure between the rooms and causes flow.

If the wind does the same thing with the control room, and that presumably is superimposed on whatever your fan is doing.

CHAIR CORRADINI: So to ask the question differently, is have you looked at a pressure variation about the supply of the fan and how that would change the flow? I think that's what Graham is asking.

MR. BARRETT: Yes, it has a very small impact on the analysis variation on the pressure.

CONSULTANT WALLIS: That is pretty weak. It's only an eighth of an inch water gauge that you were talking about. And in the case of -- that's only 20 feet a second. If you had a wind outside of 60 miles an hour.

MR. BARRETT: When we looked at varying the pressure in the control room, it had very little sensitivity on the heat up analysis.

MR. WACHOWIAK: This is Rick Wachowiak from GEH.

I had a talk with our HVAC engineer about this particular question. And he said that during the detailed design we can place the exhaust orifice and the intakes for the fans in such a way that it would minimize the effect of wind coming at the building from different directions deriving flow through that.

So for example if we had the exhaust and the fans both on the same side of the building, then effect cancels itself out. But that's a detail design consideration and he's already considering it.

CONSULTANT WALLIS: But then, as we have discussed many times, the devil is always in the details.

MR. WACHOWIAK: Right. And once again, we have to remember with this control room that the 500 or so cfm, it is the normal flow into the control room through the HVAC system. There's recirculation fans within the control room, but the normal supply and exhaust is still through this same orifice and it's still the same amount. So, if that was going to be a consideration, we would see it during normal operation too. So it's something that would be continuously monitored, if you will. But that's the intent is to minimize that effect.

CONSULTANT WALLIS: It's designed in a way so that the wind does not affect the ventilation?

MR. WACHOWIAK: That's correct.

MEMBER ABDEL-KHALIK: Now in this sensitivity analysis what was the parameter range for this flow rate?

MR. BARRETT: 466 to 509.

MEMBER ABDEL-KHALIK: 466 to 509?

MR. BARRETT: 466 being the minimum, 509 being the max.

MEMBER ABDEL-KHALIK: That's a very narrow range even for a sensitivity analysis.

MR. BARRETT: Well, that's the range of what we expect the fan to be.

CHAIR CORRADINI: Based on fan performance, is that what you're saying?

MR. BARRETT: I believe that's right.

MR. ARCARO: Yes, and nominal minimal value for the fan is 466. And the analysis was done higher than that because of the effects of, you know, the high temperature.

MR. BARRETT: Next slide.

All right. This shows some of ITAAC and surveillance requirements that we have in place right now.

CONSULTANT WALLIS: Excuse me. Cfm is a bit difficult for an air fan because the density of the air just for barometric pressure variation can vary, not in extreme cases, something like 10 percent. So the mass of air that's involved depends upon barometric pressures. Cfm is a funny variable. I mean, other than to do with maps or something like that.

This is a cfm at some condition. Some barometric condition which is unspecified.

MR. ARCARO: I think that there's an ITAAC for performance that talks about the flow rate at a pressure.

CONSULTANT WALLIS: A given barometric condition, yes. Must be.

MR. ARCARO: Yes, tested air and filtered air supply shall be reduced below the required 466 cfm when the control room habitability area is isolated and being maintained at a positive pressure of .125 inches water gauge with respect to the surrounding areas.

CONSULTANT WALLIS: Yes, but I'm saying 466 cfm if the air is at 40 degrees Fahrenheit and the barometric pressure is high, then you can get a ten percent difference in density than if it's a hot day with a low pressure.

So this difference between 466 and 500 is about in the uncertainty and what you mean by 1 cfm.

MR. ARCARO: And I think that the way the existing plants do surveillance is they normalize it. They do the standard cubic feet and they take into account the --

CONSULTANT WALLIS: The standard cubic feet or 20 degrees --

MR. TILLS:

MR. ARCARO: The STP, right.

CONSULTANT WALLIS: It's never clear to me what you mean by a cfm.

MEMBER ABDEL-KHALIK: IS the 409 a SDP or is at the actual conditions?

MR. BARRETT: It's at the actual conditions.

MEMBER ABDEL-KHALIK: Okay.

CONSULTANT WALLIS: The coming in conditions, yes.

MR. BARRETT: It's set at 509, 117, 100, whatever it is.

Okay. And we've gotten some RAIs from the staff discussing different clarifications or descriptions into the surveillance requirements required.

CONSULTANT WALLIS: Eighty feet a second was clarified. Eighty feet a second was clarified.

MR. BARRETT: Yes, it was.

CONSULTANT WALLIS: And it now seems to be something more like 20 feet a second? If I'm right on that one eighth water gauge is.

MR. ARCARO: We had a typo in one of the responses, one of the RAI responses. It was coming in at 80 feet a second.

CONSULTANT WALLIS: But now it's something like 20 feet a second, is that right?

MR. ARCARO: I'm thinking that -- was asking about the distribution inside the control room. So how do you get through --

CONSULTANT WALLIS: But you claimed its well mixed because you got 80 feet per second going in.

MR. ARCARO: Well, and we increased that to 800 feet per second or some value that is more reflective of the ASHRAE requirements for a defuser.

CONSULTANT WALLIS: 800 feet per minute, 15 feet a second. Okay.

So 13 feet a second, this amount of air, is much more stirring then just people walking around?

MR. BARRETT: Right.

CONSULTANT WALLIS: And you say the location and configuration of supply registers will be optimized to distribute and mix the air. So is someone going to check then that it does do that? Is there an ITAAC?

MR. ARCARO: There is ITAACs for heat removal.

CONSULTANT WALLIS: So again, I've learned there's always a devil in the details. And is somebody going to check that you really do mix the air? Is there some sort of an ITAAC?

MR. ARCARO: There is an ITAAC.

MR. MARQUINO: Well, the staff has requested us to reflect some additional details of these analyses in the DCD or in LTR so that the as-built design can be checked against it and to clarify --

CONSULTANT WALLIS: You aren't going to build a louver just behind a piece of equipment so that it doesn't mix? Or blow the air in just behind a piece of equipment, all that?

MR. MARQUINO: No. And they've also asked how we'll assure that people don't put up wall hangings in the offices that prevent heat transfer to the --

CONSULTANT WALLIS: Or the carpet on top of a floor register or something?

MR. MARQUINO: Yes.

MR. WACHOWIAK: This is Rick again.

So to try to get it back into this question about some of the mixing, on slide 14 you show the flow rates

CHAIR CORRADINI: Are we at that slide?

MR. WACHOWIAK: Can you describe the magnitude of the flow through the floor versus the magnitude of the flow through the in-registers, supply registers?

CHAIR CORRADINI: Are we at this slide naturally? Because I was waiting to get to this one.

MR. McLAMB: We skipped a couple.

CONSULTANT WALLIS: So it goes out through that little hole near the floor? The air goes out through that little white hole in the floor.

MEMBER STETKAR: Why don't we just to that slide. Because otherwise we're not going to get to -- all they have is presentations of what they're going to do. This is the key of the whole analysis.

Let me ask it,f rom what I read, you're taking credit for the fact that those exterior surrounding rooms are unoccupied and have zero heat sources in them, right? Those rooms -- the control room is the thing where you have the little mannequins seated and the exterior rooms are rooms like offices and toilets and a hallway, and things like that that have no heat sources in them, is that correct?

MR. BARRETT: That's correct.

MEMBER STETKAR: Okay. So you get a good convective heat flow. Without that convective hat flow you lose. The walls that you show between the control room and those exterior rooms on this cartoon seem to end at the raised floor. So you get a good convective heat flow below that raised floor?

MR. BARRETT: No, they --

MEMBER STETKAR: They don't really do

that, do they?

MR. BARRETT: No. They continue --

MEMBER STETKAR: They're solid concrete walls?

MR. BARRETT: Right.

MEMBER STETKAR: How do you get the heat flow through those -- the convective air flow through those walls?

MR. BARRETT: There's openings in between all the walls.

CHAIR CORRADINI: I'm not sure what you're talking about.

MEMBER STETKAR: On the drawing here if you look, there's a big concrete slab to the left. You move to the right of that, you see a vertical line.

CHAIR CORRADINI: Right.

MEMBER STETKAR: That's a wall.

CHAIR CORRADINI: Right.

MEMBER STETKAR: Now that wall on the drawing here ends at that dashed line that's a raised floor.

CHAIR CORRADINI: Oh, I see your point.

MEMBER STETKAR: So there's a good flow coming -- circulating very, very well.

CHAIR CORRADINI: So there's vents or connections even though the wall goes on through --

MEMBER STETKAR: Sold concrete walls.

MR. BARRETT: So, yes, it should have like a line continuing with some holes in it. There are holes within. So that all the rooms can communicate with each other.

MEMBER STETKAR: Is there confidence that those holes are big enough?

CHAIR CORRADINI: What are you asking? Are you asking --

MEMBER STETKAR: I'm asking if there's good confidence that the holes are big enough?

CHAIR CORRADINI: They haven't designed it yet.

MEMBER STETKAR: Okay.

CHAIR CORRADINI: Is that a fair guess?

MR. BARRETT: Yes, I would say it's fair.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: Well I guess what we're getting here is what we've had throughout this while ESBWR review is until you look at the details, like where does the wall really go assumptions about mixing and circulation and so on are just very theoretical. And you have to really look at the details and see if it will do what you modeled. And I've had trouble with so many things. You know, until we know the details of the drain pan or something, we don't really know what happens in it. So I think we may need to go further than just a cartoon and have something like a real drawing of what it's going to be like.

Maybe in the DCD, is there a real drawing of this that we can use?

MEMBER STETKAR: Not very well.

CONSULTANT WALLIS: Not very well, no.

MR. BARRETT: I think we've been requested to put a drawing into the DCD and I think we've agreed to do that. So we're going to look at putting some more of those details into the DCD.

CHAIR CORRADINI: So this is a work in progress relative to open our eyes? I guess that's what I wanted to end with on this. This is going to end up a design drawing from the control room envelop? That's what I thought I heard you just say.

MR. ARCARO: Yes. We do have an RAI that's specifically asked to put this level of detail in the DCD.

CHAIR CORRADINI: Okay.

MEMBER ARMIJO: I had a question. Is

there a significant heat load in this Q-DCIS room that are beneath the control room, and have you taken that into account in order to calculate?

MR. BARRETT: Yes. Yes. We have taken that heat load into account. So that room-to-room interaction, the heat coming up from the floor, is taken into account.

MEMBER STETKAR: Do you have any idea what the temperatures are in those Q-DCIS rooms? Because they're a separate ventilation --

MR. BARRETT: Yes, it's in the DCD. I can't remember the value off the top of my head, but it is in there.

MR. WACHOWIAK: So in the GOTHIC model did we model a flow resistance in the subfloor area between the office areas.

MR. BARRETT: Yes.

MR. WACHOWIAK: And it's not zero?

MR. BARRETT: No, it's not zero.

MR. WACHOWIAK: So what you're asking about a minute ago is taken account in the model and the flows that we depict here qualitatively and would confirm our other calculations, our flows that are based on not a open area, but a wall with holes?

MR. BARRETT: Right. That's correct.

MR. ARCARO: And the whole control room habitability area is modeled as it built in a GE drawing. So you have all the walls, all the heat sinks, the raised floors, the dropped roof. You've got the communication between the different areas. You got the doors going to the shift sup office. So it's a true model of what the configuration is.

MEMBER STETKAR: When you run the analyses, do you find that the Q-DCIS rooms are a net heat input to the control room habitability area? I mean, right now this drawing just shows a nice blue line along the floor there. I was curious whether it was a sort of a yellow line along the floor.

MR. BARRETT: Yes. I mean, what it really does is it raises part of that gradient, temperature gradient so it really doesn't have too much of an effect, but it does effect the gradient slightly within that mesh noding of the floor.

MEMBER STETKAR: Right.

CONSULTANT WALLIS: So the habitability area is probably well mixed by the fans. I can believe that. The adjacent rooms don't have any obvious mixing mechanism except for natural convection of some sort?

MR. BARRETT: That's correct. So as the

EFU flow goes into the main control room, it's going to be displacing that air throughout the rest of the area.

MR. ARCARO: The idea was that we would direct the flow to the occupied areas. So the personnel are going to be in the main control room, the areas outside of there, the offices not be supplied with the same air flow. But, you know, those areas aren't also going to have the habitability and the CO_2 concerns that you'd have in the central location.

And I think we did see, you know based on the GOTHIC analysis, which was done to ensure that we did have mixing, adequate mixing. The GOTHIC analysis if you look at the flow vectors and the distribution shows that you have about seven to nine times the EFU flow circulation through the area. So you're getting a lot of internal circulation through that area that's mixing that's minimizing the temperature gradients and maintaining the temperature in the occupied area, the OSHA required or the ASHRAE required area for people, you know, within the limits.

CONSULTANT WALLIS: Is the adjacent room significantly different in temperature from the habitability area?

MR. BARRETT: Well, what do you consider to be significant?

CONSULTANT WALLIS: Well, I'm just thinking about my house. If I'd heat one room in the house, th adjacent rooms --

MR. BARRETT: We get enough flows. Like, for example, if this occupied area is between, let's say 88 and 93, and the adjacent rooms would be somewhere around 85 or so.

CONSULTANT WALLIS: That's because there's good circulation or natural circulation that's shown here?

MR. BARRETT: Right. That's correct.

CONSULTANT WALLIS: Because there's a cold wall in there.

MR. BARRETT: Yes.

CHAIR CORRADINI: Are you done?

CONSULTANT WALLIS: Did you calculate any of these things in this cartoon or is it just a cartoon?

MR. BARRETT: IT was calculated.

CONSULTANT WALLIS: No numbers on anything here.

MR. BARRETT: Yes. The numbers, we looked at the numbers inside the calculation and we produced this cartoon with the insights that we gained from the calculations.

CONSULTANT WALLIS: Well, you could, you could sort of say the concrete temperature surface is 75 and the temperature at the hottest part of the control room is 95 and an adjacent room is 83 or something. That would give some idea of what you're predicting.

MR. BARRETT: We could do that.

CHAIR CORRADINI: But before you volunteer to do anything, let me make sure I understand where we're going.

So is this your last slide?

MR. BARRETT: Yes.

CHAIR CORRADINI: Okay. All right. So we're kind in open, I thought what this was, and we're in open discussion.

CONSULTANT WALLIS: Well, it's a slide with no numbers.

CHAIR CORRADINI: But this was to give them a qualitative feel. I don't think they meant this to be a quantitative --

CONSULTANT WALLIS: It's interesting to see what it would be if it were quantitative.

MR. BARRETT: In one of our RAI responses we actually showed the output of the GOTHIC that showed the temperature is isotherms.

CONSULTANT WALLIS: That would be good.

CHAIR CORRADINI: And is that something that has been submitted?

MR. BARRETT: Yes.

MR. SULVA: This is Mike Sulva on the phone.

RAI 94-29 supplement 3 submitted with this pictorial and it explains that the -- and that's why I guess you're asking a lot of questions about it. Because the tests describes the flows and it was an illustrative attached to that RAI. It works through the tests and explain the mixing as well. There's another pictorial in there which shows a cross section showing the temperature distribution as well.

CHAIR CORRADINI: Could you repeat the number? 94-29 supplement 3?

MR. SULVA: That's correct.

CHAIR CORRADINI: Thank you.

CONSULTANT WALLIS: Now I have supplement 2; do you have supplement 3? Yes, I do. Okay.

CHAIR CORRADINI: Other questions?

MEMBER ABDEL-KHALIK: Is there a tech spec limit on the temperature in the Q-DCIS room?

MR. ARCARO: Yes, there is.

MEMBER ABDEL-KHALIK: And what is that?

MR. ARCARO: All of the rooms that contribute to the analysis do have tech spec limits against them.

MEMBER STETKAR: That would get back to the same question about internal cabinet temperatures and things that they really haven't looked at yet.

MEMBER ABDEL-KHALIK: But I'm just trying to figure out how much heat load comes in from the floor vis-à-vis the 9.6 kilowatt.

MR. WACHOWIAK: Mike, this is Rick.

Do you have the tech spec? I think the way it describes the tech spec is that if the control room habitability area or any of the surrounding rooms, right?

MR. ARCARO: Well, there's a table in the basis. It's broken up into groups. So you got the control room habitability, heat sink group 1, heat sink group 2 that's the Q-DCIS room. The design temperature established, the design temperature is 78 degrees. So the control room itself is 74. The surrounding rooms are 78 with the exception of the

HVAC rooms, which are 104 degrees Fahrenheit. So those are the temperatures you need to maintain or you get into the actions for air temperature and then for concrete temperature.

CHAIR CORRADINI: Other questions?

MEMBER ARMIJO: Yes. Just we skipped over the $C0_2$ bullet on slide 12. You talk about an emergency filter system for the CO_2. That's not really a filter, is it? It's just a --

CHAIR CORRADINI: An alarm.

MEMBER ARMIJO: Yes. Because you can't filter $C0_2$, is that right?

MR. ARCARO: Okay. Yes. When you're running the EFUs, like that's what's providing your circulation. So based on previous RAIs there was some questions about the mixing in the control room. So this bullet is saying that ESBWR control room will meet the requirements for CO_2, which is an ASHRAE requirement for 5,000 PBM.

MEMBER ARMIJO: But it's just sweeping the gas out, it's not some chemical recombiner or --

MR. ARCARO: That's correct. Yes. You take fresh air in and you pump it out and --

MEMBER STETKAR: Your variable orifice is really maintaining the CO_2?

MR. ARCARO: That's correct. Yes. Actually that's good for 21 people. The heat up analysis for 11, the flow we have is enough to support habitability for much more.

MEMBER STETKAR: One last question. That variable orifice, I don't get into design, it really is something that is -- is there a design that people will adjust the size of that orifice on a real time basis or is set and fixed for all times once you actually get the thing designed and know what the heat loads and air distributions are? In other words, is a balanced damper and an HVAC system that's set and that's it, or is it something that actually is a you can put your hands on it and move it type of device?

MR. ARCARO: Yes. And again, we have a supplemental RAI on that particular device.

Big picture, the idea is you wouldn't have to adjust it. We did some sensitivity analysis and runs. And the idea is that we could actually go back to one of those slides that show the ventilation system. Yes, this guy here.

When you're in normal operation you're running on outside air, right? So your EFUs are secure. You've got an outside air handling unit that's putting fresh air into the control room. You got a recirc air handling unit that's recircing the air in the control room.

You also in normal operation up on the right hand side up on the top of the roof you've got the bathroom ventilation.

If you add up the flows for the outside air and the bathroom, that equals the flow for the EFU. So the idea is radiation condition, you shut off your normal flow, you start up your EFUs, it's going to be a seamless transfer. Because it's the same flow coming from the EFU that you were coming in from the normal airflow and adding the bathroom exhaust.

So if you were maintaining an eighth of an inch pressure before, you should be maintaining that eighth of an inch pressure afterwards.

We looked at I think an earlier response to the RAI we said it would take minimal operator action, you know. For 72 hours you should be able to maintain that pressure.

We did do some analysis and I think the response for the follow up RAI is it's going to be that for the first 72 hours it will require no operator action. And it can take the differences in pressure due to the temperature swings both daily and over the 72 hour period going from 70 degrees up to 90 degrees.

So the orifice itself shouldn't be adjustable. It could be as simple as a piece of pipe, eight inch pipe that just provides you an area to ensure you got circulation and get rid of the flow.

CHAIR CORRADINI: Other questions?

Okay. Let's take a break until 4:00 and we'll come back with our final presentation on the staff's control room ventilation.

(Whereupon, at 3:42 p.m. a recess until 4:01 p.m.)

CHAIR CORRADINI: Dennis, go ahead.

MR. GALVIN: So this afternoon the staff's going to present on the control room habitability system. It's covered by section 9.4 of the SOP and section 6.4. Jim O'Driscoll will present it.

MR. O'DRISCOLL: Hello, everybody.

Next slide.

I just want to give you a brief on the status of our review, Chapter 6.4 and 9.4 control room habitability and ventilation issues.

The previous briefing to ACRS was on

November 15th, and the other purpose of the brief is to answer the Subcommittee's questions on the review.

Next slide.

These are lead reviewers.

Next slide.

The staff focus on two things. First objective is the expected performance of the passive cooling in the control room habitability area and the reactor building. Basically the ability to maintain the habitability and operability of equipment for 72 hours following an accident.

The other focus area right now we're looking at is the post-accident EFU operation: The quality of air supply; air distribution; air quality issues essentially.

CONSULTANT WALLIS: Are you looking at humidity, too? Humidity?

MR. O'DRISCOLL: We are looking at humidity.

Next slide.

This is status of the RAIs. We have five open for 9.4 and three open for 6.4.

Next slide.

The first question the staff is asking itself is can the passive cooling of the control room habitability area and reactor building maintain habitability and operability of equipment for 72 hours following an accident. These are the questions we have to ask and answer ourselves. We first need to determine reasonable habitability acceptance criteria for the control room habitability area temperature.

We need also to get an idea of the -- to determine the required level of detail for supporting heat up analysis. How much detailed analysis do you need to be confident that you're going to achieve your goal.

And then going forward, the appropriate level of configuration control to maintain the assumptions that you have observed in those analyses.

Next slide.

The review approach for temperature. What we're doing is we reviewed the proposed performance goal the applicant proposed, the input assumptions and their design basis calculation. We're looking at the alternate means or alternate ways of figuring out that temperature at the end of 72 hours. And then take all those analyses, identify insights and compare to what's the design basis information and to assure that we've got those insights captured correctly.

We also need to identify sensitivities to understand the relative importance of these insights and address uncertainties.

Next slide.

The applicant's actions that we've completed is they submitted to us a CONTAIN 2.0 analysis as their design basis calculation for the habitability area.

They also submitted a control room habitability a GOTHIC analysis is supposed to be used for the demonstration of convection mixing in the area only, not really to be used to determine the heat up of the control room.

They also submitted a First Principles calculation around September to demonstrate an alternate means of calculating the heat up of the room. They've also added ITAAC to update and validate the design basis calculation with as-built dimensions.

Those actions are the actions that were done since the last time the ACRS was briefed.

What the staff has done. We've reviewed the CONTAIN 2.0 analysis of the control room habitability area. We're still looking at it as we gain insights from other analyses methods, but we've done an initial review of what they provided us.

We've also reviewed the CONTAIN 2.0 analysis of the reactor building. What's going on right now is we're reviewing the GOTHIC analyses that was submitted to the staff which is an older analysis with different initial conditions then what was provided in CONTAIN. So what we're trying to do is match those initial conditions to what's CONTAIN and observe any differences.

We're also reviewing the applicant's First Principle calculation. And we're reviewing the RAI responses when they come that. We've issued RAIs about three weeks ago.

MEMBER STETKAR: I'm not familiar with either of the codes. I understand the modeling principles are different. But are you looking at the details analyses and comparing the two to look at differences in models, differences in --

MR. O'DRISCOLL: We've got the input and output decks for CONTAIN. And we're checking how those were built. And we also have the input and output files for the GOTHIC analysis that was used to support the mixing RAI response. And that's what we're working with. We're not just looking at a report, we're actually looking at the data files.

MR. GALVIN: We have a couple of slides on that.

MEMBER STETKAR: Okay. No problem.

MR. O'DRISCOLL: Yes. The applicant's control room habitability maximum temperature criteria. This is what was proposed to us. It was based on EPRI's Utility Requirements Document guidance. Essentially what the URD says is that you can be allowed a 15 degree rise in main control temperature for a main control room that's normally maintained between 73 and 78 degrees. And what the applicant has done is they're controlling their control room at 74 degrees per tech spec and they're allowing themselves a 19 degree rise to get to less than or equal to 93 degrees.

We're also looking at their outside environmental input assumptions. They're using 117 degrees Fahrenheit with 80 degree wet-bulb, that's in Chapter 2. That's the site condition.

CONSULTANT WALLIS: I want to ask you about that. Because I looked at a response to RAI 6.4-21 and there they have 117 degrees Fahrenheit and 20 percent relative humidity.

MR. O'DRISCOLL: Right.

CONSULTANT WALLIS: And that didn't make sense to me. That's much too low. You have 80 degrees F. Well 20 percent humidity is something like a 63 degrees F wet-bulb. So something doesn't seem consistent here.

MR. O'DRISCOLL: Right. We're looking at--

CONSULTANT WALLIS: So are you looking at that?

MR. O'DRISCOLL: Yes. We didn't ask an RAI on that, but we are looking at the initial conditions that they've assumed.

CONSULTANT WALLIS: Then I had real problems seeing if it were this wet, how they could get that moisture out. Because there's no mechanism for taking moisture out in the control room.

MR. O'DRISCOLL: That's right.

CONSULTANT WALLIS: There's only mechanism for putting it in.

MR. O'DRISCOLL: Right.

CONSULTANT WALLIS: Unless its condensing on the walls.

MR. O'DRISCOLL: The URD requires that the applicant use -- or actually it doesn't. It recommends. The guidance is is that you use the zero percent exceeds the value. That's all it really says about your initial conditions.

You're supposed to take the coincident-- the dry-bulb coincident with wet-bulb and use zero percent exceedance. But the applicant chose the 27 degree cycle from ASHRAE's Fundamentals Handbook. That magnitude of that swing is from a representative site. So that's what they've used for input criteria.

Next slide.

CHAIR CORRADINI: So I guess -- I'm listening. Can you go back a slide?

MR. O'DRISCOLL: Sure.

CHAIR CORRADINI: So that's their assumption and their analysis is not matching their assumption? I'm confused.

MR. O'DRISCOLL: No. The message is is this what they're using. What they put into their analysis does match these assumptions. But what we have to do as a staff is to determine if those assumptions are valid or in the --

CHAIR CORRADINI: Well, I misunderstood then. I'm sorry. Excuse me.

MR. O'DRISCOLL: Yes. Excuse me.

MR. O'DRISCOLL: The next slide.

For operator functionality criteria the applicant is proposing they use a wet-bulb globe temperature of less than or equal to 86 degrees which allows an unlimited stay time for light work for numerous standards. And that's essentially a heat stress value. It tasks about physiological conditions on the body. It doesn't --

MR. GALVIN: We had our HFE staff here to, I guess -- they're getting ready to leave. But if they could just speak to that for a moment and if the ACRS had any question, we'd like to throw that out.

CHAIR CORRADINI: Yes.

MR. GALVIN: So PAula Pieringer is going to speak.

MR. PIERINGER: I'm Paul Pieringer. I'm technical reviews in the human factors area.

The applicants are committed to NUREG-0700, which is the HFE program, which in turn reference NUREG-0700 which has various design requirements, one section of which addresses heat stress.

There's the classic curve that plots wet-bulb globe temperature against stay times. And using standard work clothing dress for the control room with a low metabolism, the stay time for 90 degree is unlimited. There's no stay time limits.

Now that's the NUREG-0700. We went back, did a literature search, talked to the primary author for NUREG-0700 which took us back to a document called DR INP-4493, an EPRI document. That document basically develops the system of curves which, as you might expect, show short stay times at high temperatures and basically they plateau at 85 to 86 degrees depending on which set you take and which researcher's information you use.

So from a conservative standpoint all the literature points to 85 to 86 degrees being the maximum limit for no stay time requirements. If you go above 86 degrees you start entering and requiring additional controls to make sure that the people can perform. And it's physiological, it's also mental. In fact, 85/86 is specifically addressed by NIOSH under a mental performance codes is the characterization they give to it. So we're specifically looking at the operator's cognitive capabilities in this setting.

CHAIR CORRADINI: So you concur with the applicant's criteria?

MR. PIERINGER: Yes, sir. We concur with

86 degrees wet-bulb temperature. Right? I want to make sure that's clear. It is always wet-bulb temperatures that are correct for humidity.

MR. GALVIN: Did anyone want to ask questions? Otherwise, I would like to have them leave.

CHAIR CORRADINI: You'd like to let him leave.

MR. GALVIN: Okay. Thank you very much, Paul.

MR. O'DRISCOLL: The second part of this slide is, again, what's driving that is the applicant's outside environmental assumptions, a 117 degree coincident with 80 degree wet-bulb. They're allowing an average daily temperature cycle which result in outside relative humidity from 20 to 45 percent.

CONSULTANT WALLIS: So this 20 percent is supposed to cause to the 80 degrees F?

MR. O'DRISCOLL: My understanding is, is that that's what they're -- they're saying if you go to a psychometric chart --

CONSULTANT WALLIS: But didn't you check that?

MR. O'DRISCOLL: We are checking that.

And, yes. If you go to a psychometric chart -- and what they're doing is they're allowing the humidity to remain the air and let the air cool and you'd get 45 percent.

They've also put the control room --

CONSULTANT WALLIS: At night, it went up at night to 45 percent?

MR. O'DRISCOLL: That's correct.

They're also allowing the maximum range starting for a control room habitability of a humidity being at 60 percent at the beginning of the observed period.

Next slide.

CONSULTANT WALLIS: Do you recall how much they assume a person emits of water vapor at these hot conditions per day?

MR. O'DRISCOLL: It's in the NIOSH standard. There's actual a number, you can liters per person.

CONSULTANT WALLIS: I couldn't find that anywhere.

MR. O'DRISCOLL: Yes. I can give you that. That's in Part 8 of the NIOSH standard. We've actually referenced the NIOSH standard in the DC, but there's a number as far as the --

CONSULTANT WALLIS: Could you just let me have that sometime?

MR. O'DRISCOLL: Absolutely.

CONSULTANT WALLIS: All right. Thank you. Of these conditions, you know, the worst conditions.

MR. O'DRISCOLL: Okay.

CONSULTANT WALLIS: I think it depends a bit on how active you are, as well?

MR. O'DRISCOLL: Right. And the way we're looking at, is we're accepting light work as what the -- even though they'll be under, I'm sure, a lot of stress. But they're not chopping wood or anything. Okay.

Next slide.

These are the results that were passed to the staff on the three analyses. These are the take aways.

Bulk room temperature from CONTAIN was 92 degrees with a 43 percent relative humidity at the end of the 72 hour period.

GOTHIC demonstrates mixing.

And the First Principles calculation, bulk room temperature is 91.3 degrees.

We've got these results, some of these

results as late as September. And we're looking at them.

Next slide.

MEMBER ABDEL-KHALIK: 93 percent relative humidity with 92 degree F dry-bulb temperature. What's the wet-bulb temperature?

MR. O'DRISCOLL: The wet-bulb is -- I'm sorry. Dry-bulb of --

MEMBER ABDEL-KHALIK: 92.

MR. O'DRISCOLL: I think it's around 75 percent. And it's below. And that's the basis for someone to meet the --

MEMBER ABDEL-KHALIK: 86 degree wet-bulb temperature?

MR. O'DRISCOLL: Yes. Yes. But, you know, if you look a psychometric chart and you look at the range of the control room, you know below 90 you can exceed 86 degrees wet-bulb globe temperature but still be below 93 degrees.

MEMBER ABDEL-KHALIK: Right.

CHAIR CORRADINI: I don't think I understand your explanation. Can you just say it again slower?

MR. O'DRISCOLL: Sure. I'm sorry. Okay.

The bulk room temperature value of 92

degrees is a dry-bulb temperature.

CHAIR CORRADINI: Yes.

MR. O'DRISCOLL: It's coincident with the 43 percent relative humidity.

CHAIR CORRADINI: Right.

MR. O'DRISCOLL: The corresponding wet-bulb temperature using just the psychometric chart, the corresponding wet-bulb temperature at that is on the order of about 71 or 72 degrees.

CHAIR CORRADINI: Okay. Okay. So they're in their limit?

MR. O'DRISCOLL: They're under the acceptance criteria for human performance, the 86 wet-bulb globe temperature.

MR. PARKS: Ed Parks for the staff.

The wet-bulb globe temperature here is an index. It's not really a temperature itself. It's made up of about 70 percent of the wet-bulb temperature plus 30 percent of the dry-bulb temperature, roughly. And it turns out that a 93 degree control room at about 75 percent relative humidity gives you something on the order of an 86 degree wet-bulb globe temperature index. And that index is used to measure heat stress on the body.

MR. O'DRISCOLL: Right. That's correct.

The wet-bulb globe temperature, it's an index and the actual corresponding wet-bulb temperature is 71, but the index you're getting, it's actually higher. But it's below their acceptance criteria.

CHAIR CORRADINI: I'm sorry to sound like I don't understand this.

MR. O'DRISCOLL: Sure.

CHAIR CORRADINI: But we're throwing a few things around here.

MR. O'DRISCOLL: Yes.

CHAIR CORRADINI: So is the acceptance criteria a 100 percent relative humidity at 86 degrees or is the acceptance criteria this index? That's what I'm still not clear --

MR. O'DRISCOLL: The acceptance criteria is the index. The wet-bulb globe temperature index of 86 degrees.

CHAIR CORRADINI: Which is not a temperature, it's a --

MR. O'DRISCOLL: It's an index.

CHAIR CORRADINI: -- stylized average?

MR. O'DRISCOLL: That's right. As Ed said, it's 70 percent of the --

MEMBER STETKAR: That index, that acceptance index, as I understand it, at 92 or 93 degrees would correspond to 75 percent relative humidity?

MR. O'DRISCOLL: Yes.

MEMBER STETKAR: Something that I can think about.

MR. O'DRISCOLL: Yes.

MEMBER STETKAR: Is that right?

MR. O'DRISCOLL: Yes. And they're getting 71 percent wet-bulb temperature, so they're below the 75 -- they're getting 71 degrees wet-bulb temperature. And that corresponds to less than the WBGT.

In other words, if they use --

CHAIR CORRADINI: That's all right. I just wanted to make sure that -- I'm trying to determine between a real temperature and an average index. And so this is an index comparison?

MR. O'DRISCOLL: Yes.

CHAIR CORRADINI: Okay. I'm happy. Thank you.

MEMBER ARMIJO: I have a question. I guess I'm really confused.

MR. O'DRISCOLL: Sure.

MEMBER ARMIJO: If you built this plant in the deep south, Wilmington, North Carolina or something like that, the humidity is 100 percent, no problem.

MR. O'DRISCOLL: Yes.

MEMBER ARMIJO: Now you're going to be pumping that into the control room at that site?

MR. O'DRISCOLL: Yes. Yes.

MEMBER ARMIJO: Will they still meet their habitability?

MR. O'DRISCOLL: That is yet to be determined. We're looking at that. I cannot categorically say that they would based on what they gave me.

MEMBER ARMIJO: Where does the water go? The humidity is going in, there's nothing going out as far as moisture?

CONSULTANT WALLIS: Right. Where does the water go?

MEMBER ARMIJO: They have a lot of wallboard.

MR. BARRETT: So Ed stated earlier that 92 degrees -- Ed states earlier that if you have a control room that's at 92 degrees and it will take about 75 percent humidity to get to an 86 degree wet-bulb temperature. And from the sensitivity calculations that we did earlier where we used a 100 percent, we were getting around 89 degrees. So its corresponding humidity would have to be almost 100 percent or probably more than 100 percent to get you over the limit. So that should help to give you an idea of where we are.

MEMBER ABDEL-KHALIK: Do you actually do a lot of balance calculation?

MR. BARRETT: No.

MEMBER ABDEL-KHALIK: So how do you figure out the final relative humidity?

MR. BARRETT: The code calculates it.

MEMBER ABDEL-KHALIK: I mean --

CONSULTANT WALLIS: But just common sense. If it comes in a 100 percent humidity, it doesn't get cooled down, the water must still be there.

MEMBER ABDEL-KHALIK: I mean just because the code calculates it, do you know what's in the code? How does it do a water balance?

MR. BARRETT: Yes. Well, we have flow coming in and flow coming out. So there's a volumetric flow coming in and a volumetric flow coming out. So when that humidity, when all the humidity and stuff goes into the room, there is some coming out.

MEMBER ABDEL-KHALIK: But there are people there also.

MR. BARRETT: And there is actually -- we have, I guess you would call it, like a boundary condition or a flow boundary condition where we're placing more moisture due to people into the volume.

CHAIR CORRADINI: So can I ask one clarification at this point? So you have sources, you have no sinks? You're not counting for any condensation on the walls and drainage?

MR. BARRETT: We do account for a condensation on the walls.

CHAIR CORRADINI: You do?

MR. BARRETT: Yes.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: Oh, you do?

MR. BARRETT: Yes.

CHAIR CORRADINI: That's why I wanted to ask. So there is a sink?

MR. BARRETT: Yes.

CONSULTANT WALLIS: Maybe that's how you manage to get the water out.

MEMBER ABDEL-KHALIK: So does the code tell you at the end of 72 hours you have a puddle of water on the concrete floor?

MR. BARRETT: It tells you how much moisture is on the wall. But in the low moisture case, there is none. In the 100 percent humidity case, there is.

MR. McKIRGAN: This is John McKirgan again.

This is something the staff is looking at: The humidity, the water balance, this is something that is part of our ongoing review.

CONSULTANT WALLIS: But if there's water on the wall, then you must below -- you must be supersaturated. It must be 100 percent humid.

CHAIR CORRADINI: On the wall. The wall's cooler. The wall's always cool.

MS. CUBBAGE: But you're not at 93 degrees.

CONSULTANT WALLIS: There's a transient in the wall. The wall has got a lot of resistance back there. The wall temperature is probably fairly close to the --

CHAIR CORRADINI: We established early on when we were questioning Antonio that the wall's always cooler. So the wall is a sink.

MR. O'DRISCOLL: Right.

CHAIR CORRADINI: So you're losing some

and you're gaining some.

CONSULTANT WALLIS: So that's where the water went. It went on the wall.

CHAIR CORRADINI: So you guys are still looking at it?

MR. O'DRISCOLL: Yes, we are.

CHAIR CORRADINI: Good.

MR. O'DRISCOLL: The next slide talks about what we're ding with CONTAIN. We reviewed the heat up calc report and the data files with no issues at this time with the data that they provided us as far as its accuracy, as far as the math in it.

The sensitivities on CONTAIN we've done. We've changed concrete density, specific heat, humidity of the outside air, the heat transfer area, outside air temperature and the EFU fan flow rate.

What we find here is that the take away is that there is some sensitivity with concrete densities, sensitivity being you can get some -- there's some performance improvement if you increase concrete density. But others are relatively insensitive.

When I wrote this I didn't -- you know, if you have humidity you're going to get some movements too. But what we did is we forced humidity and ran it, I think, on one run in CONTAIN and got the percentage of what we got there.

MEMBER ABDEL-KHALIK: How about concrete conductivity?

MR. O'DRISCOLL: We also did that as well.

CONSULTANT WALLIS: That's influenced by the rebar, isn't it?

MR. O'DRISCOLL: Yes. What the applicant provided us was the aggregate values for those because the wall was an aggregate of rebar and concrete. The concrete that they have in, they put in for their analysis, is 120 pound concrete as opposed to a more denser concrete. And when you put those extra, you get some improved performance.

CONSULTANT KRESS: And then you do the CONTAIN calculation. The concrete is divided up in little nodes so you can find the transient through--

MR. O'DRISCOLL: Yes. There's I think at least five nodes in the wall, I believe.

CONSULTANT WALLIS: Your hand calculation will show that it comes not quite to equilibrium, but significantly towards equilibrium in three days the concrete, I think.

MR. O'DRISCOLL: Right. I mean it's got more potential to cool at the end of 72 hours. I mean --

CONSULTANT WALLIS: But the thermal wall has penetrated right through the concrete, I think, by three days if you look at the square root of alpha T and all that stuff, transient conduction has gone through significantly into the concrete and probably reached the other side.

MR. O'DRISCOLL: What we're doing, I don't want to jump too far ahead. But we're doing a First Principles calculation of our own.

CONSULTANT WALLIS: Okay. Good. So you've got it all under control?

MR. O'DRISCOLL: Yes.

CONSULTANT WALLIS: Okay.

MR. O'DRISCOLL: It makes it easier because it's quicker to get answers instead of going back to the applicant every time we want to --

CONSULTANT WALLIS: So I don't need to do it? You'll do it.

MR. O'DRISCOLL: Okay. GOTHIC. What we got here is that the applicant's analyses that we've looked is different than CONTAIN. It uses 20 percent sensible heat loads, lower EFU fan flow rate and it uses a higher initial heat sink temperature, which is an opposite effect. So what we have to do here is we have to get those initial conditions to match the CONTAIN initial conditions in order for us to really compare apples-to-apples with GOTHIC.

So we're going to do basically two cases. One case is just to verify their model with no changes. And then we're going to match the input assumptions and see what we get.

The First Principles calc, next slide. They've provided us on or about September, September 4th I believe, a First Principles calc. Essentially is a conductive heat model. It's a single mode calc. It's pretty simple.

We looked at that and we're trying to build a model that you can -- a little bit more sophisticated that works from First Principles. It's essentially a math cad with First Principles' point of view. And we just got it. We're close to being able to get answers from that.

CHAIR CORRADINI: So what is this First Principles calculation that you're checking?

MR. O'DRISCOLL: They provided in a teleconference, telepresence meeting a First Principles calc on September 4th. It was a letter. It wasn't in response to an RAI.

CHAIR CORRADINI: But a calculation of

what?

MR. O'DRISCOLL: Of the heat removal, passive heat removal as an alternate means of demonstrating the CONTAIN analysis.

CHAIR CORRADINI: Okay.

CONSULTANT KRESS: You have to get the rates right because it's a race between the rate of heat coming in and rates going into the concrete.

MR. O'DRISCOLL: I don't want to go into too much detail, but what we want to do is the convection, the heat transfer coefficient for convection needs to be modeled.

CONSULTANT KRESS: Yes, that wasn't in the hand calculation.

MR. O'DRISCOLL: That's correct. So we want to see what that does for us.

CONSULTANT KRESS: Yes. It may be that the concrete conductivity controls, so that may happen too. But I think you do need to have that in there.

MR. O'DRISCOLL: It was their confidence in --

CONSULTANT KRESS: It will slow down the rate in which you're going into the concrete.

MR. O'DRISCOLL: Yes.

CONSULTANT KRESS: And it's this rate that --

MR. O'DRISCOLL: And it could result in a high room temperature. So if we did that, we would get a higher confidence in the proposed model.

CONSULTANT WALLIS: Now were you looking at some sort of condensation coefficient for the wall, too?

MR. O'DRISCOLL: No.

CONSULTANT WALLIS: So how do you know the rate of condensation on the wall, which seems to be important for humidity control.

MR. O'DRISCOLL: We'll have to look at that more.

CONSULTANT WALLIS: That one, okay.

MEMBER STETKAR: Are you also modeling heat input from surrounding areas?

MR. O'DRISCOLL: Yes.

MEMBER STETKAR: You are?

MR. O'DRISCOLL: Yes. We're looking at the heat input. Basically the heat input from the EFU fan, the sensible heat load that's in the room and I believe we're doing solar load as well.

MEMBER STETKAR: I was thinking more the Q-DCIS rooms down below.

MR. O'DRISCOLL: We'll have to look at that.

CONSULTANT KRESS: Can you use your First Principles calculations you're talking, and the input will be the room temperature that you get from CONTAIN, you don't calculate actually all the heat losses and the inputs and stuff with your hand calculation?

MR. O'DRISCOLL: Right. We're going to take, basically, their input assumptions from CONTAIN, the 85 degree room, the heat sink temperatures at the end of the eight hour period of time of loss, you know which is all our output from the CONTAIN step 2. They call it CONTAIN step 2. We can plug that in and come up with a number.

CONSULTANT KRESS: Now the question I wanted to ask you about that is that already has the concrete heat sink in it. If you look at the temperature of the control room as a function of time, it already has this concrete sink in it. I was wondering how you were going to take that out of the CONTAIN to give you your boundary condition for your hand calculation. Do you understand --

MR. O'DRISCOLL: No, I don't understand your question.

CHAIR CORRADINI: He's basically saying you're already biased the calculation by the sink so you can't use a forcing function that already has the answer in it.

CONSULTANT KRESS: Right. That's basically it.

CONSULTANT WALLIS: Well, you can check compatibility, though. You can use it to calculate whether he went and see if its compatible with the CONTAIN. He can CONTAIN to calculate how much heat went into the wall and then he can go back and see if that's consistent with what CONTAIN says.

MR. McKIRGAN: If I could, yes, I think that's really the intent of the First Principles calc is as an independent check, somewhat confirmatory of the CONTAIN analysis.

It's really not our intent to try to add back all the physics of CONTAIN or GOTHIC in the First Principles calc. It's we're trying to do something fairly basic and simple that we can run very quickly with just a few parameters.

Syed? I've got Syed Haider here. He's on our staff. He's been looking and developing this First Principles. Do you want to try and address that issue?

MR. HAIDER: Yes. This is Syed Haider. I'm working on the First Principles analysis.

The analysis is pretty flexible. So we can change the initial conditions and we can account for sensitivity to turbulent correlation that we are using for convective heat transfers.

So essentially the model is pretty flexible and we can model different phases. So we can take out the impact, the effect of CONTAIN analysis from the heat sink.

MR. McKIRGAN: But again, the purpose of the First Principles is for the staff to develop confidence. It's the CONTAIN analysis that the applicant has submitted that will be the design basis for the plant.

CONSULTANT WALLIS: For the wall, you could do things like, say, well we know the solution to a step function because it's in all the books. We can take the step function to the worst one we can assume and so it jumps to the highest temperature. We can assume the other extreme, which it jumps to the lowest temperature it jumps to. And you can sort of bracket the heat transfer to the wall and see if it's reasonable. You can do all kinds of little checks like that.

MR. HAIDER: This is Syed Haider.

CONSULTANT WALLIS: That's how it's going to work out. And if you do it, it's going to work out. It's just that we haven't heard all the details yet. But it should work out.

MEMBER ABDEL-KHALIK: Now when you do the condensation on the wall, how do you account for latent heat? Or is that considered the part of the latent load that people put out?

MR. O'DRISCOLL: Well, we haven't modeled the condensation in this model yet, so we don't have it. I can't answer that question. We haven't model condensation in our First Principles calc yet. But I can get you that answer.

MR. McKIRGAN: I'm sorry, Jim. So not to belabor that, but this is an area of review. The staff is going to look at condensation and the water balance. It may not be in the form of the First Principles calc. So this is an area that is still under staff review. And so I'm trying to keep the First Principles calc very clean. And it's not our intent, again, to add back every piece of physics.

MEMBER ABDEL-KHALIK: I understand. But I think it would be important to look at what the applicant has done to make sure that the calculation is internally consistent.

MR. McKIRGAN: Absolutely. And we continue to review the GOTHIC analysis and the applicant's First Principles calculation. Those are still under staff review.

MEMBER ABDEL-KHALIK: Do you understand my question?

MR. O'DRISCOLL: Yes. You want to basically know how we're going to model that, if we can model that in our First Principle calc.

MEMBER ABDEL-KHALIK: Well, not necessarily, but to make sure that the applicant claims to have done a lot of balanced calculation which results in condensation on the walls. Well, how do you handle the latent heated vaporization that results in this energy exchange?

CONSULTANT WALLIS: I think it's just a few hundred watts when I was looking at it.

MEMBER ABDEL-KHALIK: Is it?

CONSULTANT WALLIS: I've already got eight times 25 watts from just the heat from there generating. And then the vapor they're generating if it's condensed, it adds up maybe another 50 percent to that, which has to be taken away on the wall. But it's not that big a proportion of the total --

MEMBER ABDEL-KHALIK: I'm just wondering if it's counted twice.

MR. O'DRISCOLL: CONTAIN has two numbers for heat load for -- they have latent sensible for a human being. And that was used as an input into the CONTAIN model. So we make sure that we're not double dipping there with that.

CONSULTANT WALLIS: Right. In fact, you're helping us a lot because you're revealing more about what was in CONTAIN than we heard from GEH. That's very helpful.

CHAIR CORRADINI: Just think of CONTAIN as MELCOR without meltdown. That's all it is. It's the same code.

CONSULTANT WALLIS: The same code?

CHAIR CORRADINI: It's exactly the same code.

MR. O'DRISCOLL: Yes. Next slide.

Okay. Some of the insights we can talk to you about already from the staff analysis is that CONTAIN model has some conservatism in it by a demonstration of this low density concrete.

GOTHIC has demonstrated convective mixing would be expected in the room.

The highest temperatures we observed of

these analyses are actually in GOTHIC. So we're still looking at that calc.

The impact of those is that it primarily impacts equipment qualification assumptions. And the closer agreement between all these calcs would add confidence to their proposed design basis calculation model.

The open items to these insights is we're asking for more specific definition and references in the design basis heat up cal required in tier 2. Basically tier 2 doesn't really mention what the actual calc is in the reference. So we're asking for more specificity in the design certification.

We're also asking for more specific ITAAC description. In other words, what is the actual calc by name that you're going to update at the end of the day? What is the methodologies? Is it going to stay the same? Is it going to be different? So that's an RAI that's out to the applicant.

Next slide.

MR. GALVIN: Just if I could elaborate briefly?

We've asked them to a tier 2 star which would lock them in and so they couldn't change. And I think in principle they're considering that idea.

So, I mean, we're going to have another report with just some sort of actual calculation that you'd be able to see it.

CHAIR CORRADINI: What are considering again?

MR. GALVIN: Make A tier 2 star which requires staff approval prior to changing. There would be certain variables that we would lock in and then certain variables we know would change based on as-built conditions.

CHAIR CORRADINI: Oh, I see. Okay. Thank you.

MR. O'DRISCOLL: An additional insight was the applicant's CONTAIN and First Principles results are close to the acceptance criteria 93 degrees Fahrenheit at the end of 72 hours. So that essentially maintenance of margin here is important to us. Configuration control is important, you know in order to be confident that we're not going to exceed 93 degrees, the acceptance criteria.

So the related open items. There's an RAI out from the EQ Branch that talks more about how the EQ service temperatures will be to explain. That basically you're taking this 93 degree bulk room temperature and translating it into what's going inside these electrical cabinets. And an explanation of why it would be bounding, you know the outside air would be bounding, air temperature would be bounding.

MEMBER STETKAR: Jim, let me interrupt you there because I'll do the broken record thing here again.

We focused all this afternoon on the control room habitability area. Does the EQ Branch have a similar question out for the control building general ventilation area?

MR. O'DRISCOLL: Yes. It's the same RAIs.

MEMBER STETKAR: Same RAI?

MR. O'DRISCOLL: Yes.

MEMBER STETKAR: Okay. Because there we don't have external air flow and it's a different reactor.

MR. O'DRISCOLL: It covers the reactor building.

MEMBER STETKAR: It covers the reactor building also?

MR. O'DRISCOLL: Well the RAI has to do with the reactor building and the control room habitability area.

MEMBER STETKAR: Yes, but there are areas inside the control building that the control building general ventilation area that contain the Q-DCIS rooms and other equipment in the control building. It's a separate ventilation area. So the three that I was concerned about was the reactor building because there's stuff -- again, I'm an equipment guy. I don't are about the people. Yes, I'm an insensitive -- you know.

But the three areas that contain important equipment, there are the rooms in the reactor building, clean air and ventilation system rooms. There are general areas in the control building outside of the control room habitability area. And then the control room habitability area. Sort of those three areas are --

MR. O'DRISCOLL: I need to check the RAI.

MEMBER STETKAR: -- of concern because they all take credit for completely passive heat removals for the full 72 hours.

MR. O'DRISCOLL: I'll need to check the RAI to make sure that we didn't --

MEMBER STETKAR: Because there are areas, the reactor building, the clean area ventilation system area areas contain big heat sources. All the inverters and things are out there. They're putting out a lot of heat.

Again, that's not -- I don't care about radiation for those things and there's no people out there, but they're kind of important stuff.

MR. PAL: This is Amar Pal. And the lead for the EQ.

When we asked the question about additional details on the -- temperature on electrical equipment including computer I&C equipment, will be determined for the ESBWR.

MEMBER STETKAR: Okay. So it's a general --

MR. PAL: It's a general question. So should that cover the --

MEMBER STETKAR: As long as they cover the equipment located in those three --

MR. PAL: Areas.

MEMBER STETKAR: -- areas, that's important.

MR. PAL: Yes.

MEMBER STETKAR: Okay. Thanks.

MR. O'DRISCOLL: Okay. Moving to the second bullet. Another open issue is a description of the controls used to maintain the passive heat sink configuration and the heat load assumptions during life of the plant. So moving forward how do you control these walls?

ITAAC needed to update and validate the design basis calc with as-built dimensions for the reactor building. There is no ITAAC right now, so we need to have a similar type of ITAAC.

The next issue we're looking at is the post-accident control room habitability area air quality. And what the staff is asking is will the air quality be acceptable in the control room habitability area at the end of the end of a 72 hour cooling period? And again, the key question the staff asked itself for this feature is to determine reasonable habitability acceptance criteria for air quality: Quality of air, quantity of air supply that should be used, the carbon dioxide levels that should be used.

Determine if there is assurance of air distribution and mixing.

Determine if the required levels of detail -- when the required level of detail is required in the DC and related to the design features that are proposed.

And determine level of configuration control needed if you need to put the room in a certain configuration to maintain your assumptions.

The staff review, again, approach was to review the proposed performance goal and review the performance design features to assure that goal was met and identify insights in the analyses versus design basis information and ITAAC. And assure that that information in the design for certification document.

The applicant actions completed thus far are:

For air supply, distribution and mixing they stated in tier 2 that the air quality adheres to ASHRAE 62.1 air quality. And that's for 21 people in the control room;

They've added a remove exhaust below the occupied zone in the control room habitability area. And what that does it serves to assure that there will be -- the air flow will be guaranteed. From the EFU will actually get down and go out through the room;

The EFU air delivery will be optimized to deliver air to occupied zones of the control room habitability area. They made that commitment in tier 2.

They've also since the last time you were briefed they made the power supply RTNSS for the post-72 hour period for the EFUs. That was an open issue the last time you were briefed. It was a portable battery system was proposed at that time and now it's a RTNSS diesel.

CONSULTANT WALLIS: This is a dedicated diesel that does nothing except power these --

MR. O'DRISCOLL: No. It's the ancillary diesel -- I believe it's the ancillary diesel generator. It's a load now on the ancillary diesel generator.

CONSULTANT WALLIS: Okay.

MR. O'DRISCOLL: The open items associated with these items are:

We need more design and instrumentation requirements for the remote exhaust path. As you've seen before, it's illustrated as, more or less, a box. I'm not sure exactly what that is. We need to do an SRP 9.4.1 review on that equipment to make sure because it's going to be safety-related, I assume;

Other details or actions to promote convective mixing and prevent short cycling of supply air. Basically is there anything required as far as closing control room habitability area doors to make the air flow per their design intent?

And details of the design intent of the

airflow, and also how are they going to optimize this airflow. Basically on that is that they got a lot of insights from GOTHIC. They've defined the control room as a occupied zone. In other words, they made a subset of the control room habitability area and called it the control room occupied zone, which is essentially the main control room from the raised floor six feet up. And they said that area would be the area of concern.

So the issue is is to get that information into tier 2 and to make sure the EFUs are optimized to served that area.

And that's all I have.

MEMBER STETKAR: Before you leave this one, you unfortunately hauled out the bullet on the power supply for the EFUs.

MR. O'DRISCOLL: Yes.

MEMBER STETKAR: And I'm now a bit confused. The EFUs right now are powered from the safety-related batteries. Is that correct? I don't know whether they're DC motors or AC motors, but they're powered from the safety-related batteries?

MR. WACHOWIAK: This is Rick Wachowiak, GEH.

Yes. they're powered by the batteries for the first 72 hours is the assumption. After 72 hours we have our ancillary diesel generators that we use to power various RTNSS class B loads for continuing things.

And so one of the loads that it powers is Q-DCIS. So when the safety-related batteries run out, the ancillary diesel generators can be turned on to continue to the operation at Q-DCIS which picks up the EFUs. And, in fact, it also picks up a small air conditioning unit on the roof to provide additional cooling for the control room.

MEMBER ARMIJO: Can you back to 17? You had a statement on a key question for your review is to determine reasonable habitability acceptance criteria. And my question is isn't this already defined what the reasonable acceptance criteria?

MR. O'DRISCOLL: Well, it's very defined. From a radiological point of view it is. But for air quality --

MEMBER ARMIJO: You don't have some other code or some other standard?

MR. O'DRISCOLL: No, it's not very easy to find. It's not all in one place.

MEMBER ARMIJO: What do we use for power plants today, nuclear plants? Do they have --

MR. O'DRISCOLL: Well, they have inactive systems.

CHAIR CORRADINI: It's all safety-related active systems.

MEMBER ARMIJO: So they don't have any--

MR. O'DRISCOLL: Yes, it's not really a concern as opposed to here.

MEMBER ARMIJO: Okay. That answers my question.

CHAIR CORRADINI: Other questions by the Committee?

Okay. I want to thank the staff. I wanted to --

MR. GALVIN: I have one more presentation.

CHAIR CORRADINI: Oh, you do? I apologize.

MR. GALVIN: Yes.

CHAIR CORRADINI: I missed that.

MR. GALVIN: We're going to have a one page presentation, right?

CHAIR CORRADINI: Okay. Oh, I'm sorry. I missed it.

MR. FORREST: My name is Edwin Forrest. And I'm going to talk about reactor building mixing.

And it's important because in the design basis analysis for a LOCA accident there's an assumption on the dilution that comes from the secondary containment. And the assumption that GE is proposing is 50 percent mixing. And the way that's achieved is by reducing the secondary containment volume to a volume of about 50 percent. So it goes from 806,000 cubic feet down to 400 and something thousand cubic feet. And that's done in the design basis analysis.

Now to justify this we have to make some assumptions about what the dilution within the reactor building is. To do this we agreed in NUREG-1242 that as the staff's safety evaluation for the upper URD, that we would consider holdup in the reactor building and we would not require a standby gas treatment system that draws the reactor building down. But we did this for a price. We put a requirement that the building must be a concrete steel well built structural thing. It must be tested periodically at a quarter inch to an exfiltration rate. And that exfiltration rate should be no more than 25 percent of the volume of the reactor building.

In this case the reactor building is the contaminated portion of the reactor building. It does not include the clean area of the reactor building. It does not include the refueling pool area of the reactor building.

The staff noticed that GE requested essentially 50 percent volume per day exfiltration rate which translates to 300 cfm, which is the number they included in their design basis LOCA analysis.

Staff took this under consideration and realized that the contaminated area of the reactor building is almost entirely enclosed within the clean areas of the reactor building. So there's another barrier. And there's very little potential for wind loading on the contaminated portions of the reactor building.

So in essence, we have considered the 50 percent volume per day, 300 cfm leakage as acceptable to the staff.

GE submitted a detailed comprehensive GOTHIC analysis of the reactor building and particularly the contaminated area. It's room-by-room, it's exhaustive. It looked, I think, at every penetration, doorjamb, door crack, HVAC duct that you can imagine.

It used generally more conservative areas for these gaps and things than really would exist, and this was part of their conservatism. And they applied the full 300 cfm leakage from the reactor building. And they used this GOTHIC analysis to determine the amount of holdup that could be anticipated.

We realize that there are a lot of assumptions that could be made in these type of things. There were assumptions made, like on where the leaks occur and the total leakage rate from the primary to the reactor building would be .35 mass per day of the primary containment.

What they did was they took this .35 mass per day and they divided it among every penetration based upon the size of the pipe and the penetrations are prorated. And they accepted essentially in each room.

One of our concerns is real life you might not get that nice proportional split. You might get a lot higher in one room than another room. And we started looking at these things an we asked for some sensitivity studies. Sensitivity studies like if you had higher leakage in one of the rooms, how does this effect it? If you had different sizes on your door gaps or different release point, or multiple release points?

And GE came back with a fairly detailed assessment based upon a nominal GOTHIC analysis which show that the sensitivities to these parameters were small and in no case would they violate the amount of holdup that they were predicting. And the amount of holdup that they were predicting was essentially translated to around 70 percent or more in terms of dilution effect.

The staff did its own simplified type of assessment. We looked at some multiple room type things. We got results that were very consistent with the GOTHIC analysis.

We then looked at its translation to the 50 percent mixing assumption that was put into the RADTRAD. And we found that the 50 percent mixing assumption was conservative. It was also what we normally would give to a power plant that had a standby gas treatment system once it had drawn down the secondary containment.

So it's not a number that we haven't used before. It sort of accounts for the fact that maybe there's portions of the contaminated building that don't come into play for the dilution effect.

And so the end result is that we feel comfortable with the approach used by General

Electric. That they do have a robust containment. It is tested.

They also have administrative controls that assure that the doors maintain control within the contaminated areas. There's alarms in the control room. There's, I imagine, operator walkdowns on a periodic basis to assure that it's maintained in the configuration that's within the analysis. And we believe that there's ample conservatism in the results.

Thank you.

CHAIR CORRADINI: There's a question.

MEMBER STETKAR: And this is a bit beyond me, so I want to make sure I understand.

I think I heard you say that basically the analysis now takes credit for the clean areas to help in the holdup in the dilution.

MR. FORREST: I don't think I said that, John.

MEMBER STETKAR: Okay.

MR. FORREST: I think what I said --

MEMBER STETKAR: If it doesn't, I need to understand that.

MR. FORREST: I think what I said was that in terms of exfiltration rate --

MEMBER STETKAR: Okay.

MR. FORREST: -- exfiltration is really caused by wind loadings on surfaces. And since the contaminated area of the reactor building is almost entirely surrounded by the clean areas of the reactor building, the surfaces that are available to wind loading are very few and far between.

MEMBER STETKAR: On the contaminated area?

MR. FORREST: On the contaminated.

MEMBER STETKAR: Okay.

MR. FORREST: And thus, it's hard to really get a differential pressure that would push you to the tested value of 300 cfm.

MEMBER STETKAR: Okay. Thanks. I don't have any more questions then.

CHAIR CORRADINI: Okay. That was a very complete one side. I might recommend this would be a nice way to do it from now on.

Any other questions from the Committee?

CONSULTANT WALLIS: Well, I'm still a little puzzled. Because in NUREG-1242 requires an exfiltration less than 25 percent and yet they asked for 50 percent. And you had a long explanation of why that was acceptable, but it still leaves it twice what it's in NUREG-1242.

MR. FORREST: NUREG-1242 is not a regulatory requirement, it's guidance in this case.

CONSULTANT WALLIS: I see.

MR. FORREST: And if the applicant is able to convince us by whatever means he uses; his methods that his approach is acceptable to us, then we have the ability to consider it and accept it. And that's what we've done in this case.

CONSULTANT WALLIS: Okay.

CHAIR CORRADINI: Other questions?

Let me review some of the things that I wrote down, and I hope the Committee will help me if I've missed something in terms of side notes that I had that we asked for clarification.

One was we're going to, we just did, got a paper copy of supplement 05 that we're going to look at. And I assume the consultants will get us, since they seem to be very thorough, their look at supplement 05 relate to that.

Also, there's some sessions that Graham had about what's happening relative to oscillations that cause differences in noncondensibles. What I heard GEH say was they though that had something to do with fan performance or addition of waters into the PCC pool, but they were going to check and get us an explanation.

CONSULTANT WALLIS: Well, I think that's also being superseded by --

CHAIR CORRADINI: Well, I'm sure another river will show up, but we'll at S05.

The second thing was is that they've committed to at least getting us more information on the details of the drain pan. And where's Wayne?

You had a pictured. You volunteered that you had a picture. Is this a good time to show it, or do you want to wait and maybe we'll start off tomorrow with that?

MR. MARQUINO: Okay.

CHAIR CORRADINI: Okay. Details of the drain pan. And we also wanted to get some idea about the energy balance, why do we not need that sort of modeling in TRACG.

And then we left with the final thing that we wanted to get some implication on combustion. And what I heard from the staff is this is still a work in progress that they're doing analysis, and they'll get back to us.

And the final thing is, let's see here, we asked for some details on the base summer case in terms of wall temperatures and potentially for one of he wide sensitivities at 88 degrees and 100 percent humidity sensitivity to look at wall temperatures versus other things. And what I hear is staff is staff is still evaluating these calculations by the applicant.

Have I missed anything?

MEMBER ABDEL-KHALIK: Can I add something for the containment analysis?

CHAIR CORRADINI: Sure.

MEMBER ABDEL-KHALIK: We need to understand the characteristic curve of the fans. Particularly the details of the ITAAC that will specify those characteristics. Because you have to couple whatever table you gave us with a specific density. And the problem that I'm having is that the operators are to start those fans early, the fans will not work. Because if you start with the fluid density is a lot lower than what you're assuming, which it corresponds to three atmospheres, then the head produced by the fan is going to be a lot less, and it's possible that it may not be able to overcome the ten inches of water in that pan.

So we need to understand how the characteristic -- the characteristic curve of that fan will be specified and exactly how the ITAAC will sort of confirm that the fan performance is what we want it to be.

CHAIR CORRADINI: So I want to make sure I've captured this. So it's not just the fan curve, you want to understand how its eventually going to captured in ITAAC for testing purposes?

MEMBER ABDEL-KHALIK: Right. Because the data that was specified in the table is incomplete without specifying the fluid density to go with it. And what we understood --

MR. WACHOWIAK: This is Rick Wachowiak from GEH.

I believe the way the ITAAC reads now is that you test it at ambient room conditions and then an analysis is performed to translate that to accident conditions. So I think the ITAAC does what you want it do. You just may not be clear on what analysis needs to be done to do that. But it's best to provide by test and analysis.

MEMBER ABDEL-KHALIK: That's fine. I think the information that we have right now does not allow an independent assessment as to whether or not these things will actually work if the operator turns the fan on before you get to the 72 hour point when the density is relatively high.

MR. WACHOWIAK: Right.

CHAIR CORRADINI: Got it. I think I've got it.

Okay. Everything. Graham, you had --

CONSULTANT WALLIS: The vacuum break temperature measurement to tell when its leaking. There seem to be some odd things about the TRAC model. And I think eventually there's going to be test, but are we going to not know whether it will work until we see the results of some test which is going to be what? A year from now or something?

CHAIR CORRADINI: Are you asking?

CONSULTANT WALLIS: Can we do something to get more assurance that that temperature measurement will be successful?

CHAIR CORRADINI: I guess I might state it differently. I would look to the staff to identify for us what they're satisfied with and then explain it to us so that we understand what their review was. Because if they're asking for a test and GE will do it, then we'll hear that from the staff's evaluation.

CONSULTANT WALLIS: So we're going to wait and see what the test --

CHAIR CORRADINI: I think it's best we hear what the staff -- I don't think I want to ask the applicant to anything. I want to hear what the staff --

CONSULTANT WALLIS: I want to hear something about that the next time or sometime in the future from the staff.

CHAIR CORRADINI: Yes, I think so.

MEMBER ABDEL-KHALIK: I guess my concern about that is just like all instruments, you would like the response of an instrument to be a unique function of the quality that you are trying to measure. And I'm not sure that that delta T that they're measuring will be a unique function of the leakage rate.

Does it have to linear; it can be a complicated function as long as a unique function.

CHAIR CORRADINI: Other comments?

CONSULTANT WALLIS: Well, yes. I think the staff is on the ball about control room habitability. They seem to be asking the same kind of questions that we're asking.

CHAIR CORRADINI: Right.

CONSULTANT WALLIS: So I'm thinking that they're going to resolve this without too much input from us. And when they come back and everything is resolved, presumably there are still some questions, then we may not have any questions because it's going to be so clear cut. That's what I'm hoping will happen. They seem to be getting there. And it's not that difficult a question.

What surprised me was it wasn't until 4:30 that we learned there was condensation on the walls and that's where the water went. We've been asking all day --

CHAIR CORRADINI: I assumed it, but I just wanted to make sure everybody else was assuming what I was assuming.

CONSULTANT WALLIS: You assumed there was condensation on the walls?

CHAIR CORRADINI: Yes. The wall's cold. It's got to go somewhere.

MEMBER BANERJEE: He's a condensation man. That's what he did for a living before he became an administrator.

CHAIR CORRADINI: Do you have any other comments, Dr. Banerjee, now that you've joined us?

MEMBER BANERJEE: I think the point that I was interested in coming in was the difference between the MELCOR and the TRACG calculations. And as far as I'm concerned that's a done issue.

CHAIR CORRADINI: Well, I want to remind the Subcommittee that that's the one thing that's going to result in a letter in the December member, which is the long term cooling. We had to address long term cooling for -- all the new plants are going to have to address it per the SRM from the Commission, but we're the first ones up to do it. So that's the one thing I wanted to hear. I was hoping to hear that both the applicant and the staff had thought it through.

MEMBER BANERJEE: I think they told us a convincing story.

CHAIR CORRADINI: Yes.

MEMBER BANERJEE: And the differences that still existed could be explained. I mean I haven't looked into it in any detail.

The concern I still have, apparently the staff had it before, was what's happening to the various noncondensibles, what are their compositions and lower flammability limits and things like this. It may or may not be something of importance, but it will be important to get that data and see.

There could be local regions where it could be above LFL. If so, we should know.

MEMBER ARMIJO: Mike,just another thing. For the next letter I think we should include the resolution on Chapter 15 radiological analysis. That thing looks like it's been done very well.

CHAIR CORRADINI: Well, I wasn't planning to write, so just to make sure we're clear. I'm not planning to write an interim letter. I'm simply addressing the requirement by the Commission on long term cooling. Just that.

MEMBER ARMIJO: Okay.

CHAIR CORRADINI: Other than that, my thought is not to write interim letters until we're pass interim and we're near final.

CONSULTANT KRESS: Well, put this on your list.

CHAIR CORRADINI: Yes, sir. Okay.

If we don't have anything else, we'll adjourn until tomorrow.

CONSULTANT KRESS: I have --

CHAIR CORRADINI: Oh, I'm sorry. Tom, I didn't see you.

CONSULTANT KRESS: You know, I originally felt --

CHAIR CORRADINI: That I had adjourned.

CONSULTANT KRESS: -- that because the

fan was needed to meet the GDC on rapid draining down the pressure, I don't think the GDC is for long term cooling. It doesn't specify it's 72 hours. And I still think it ought to be a safety component. But the staff doesn't seem to agree with me --

CHAIR CORRADINI: I think I sensed that when you asked the question earlier today. They're treating it as RTNSS since it's outside the 72 hour per the regulation.

CONSULTANT KRESS: But I don't see that in the GDC.

CHAIR CORRADINI: Maybe we should ask for the staff to explain. But my sense of it is this is based on the Commission's redefinition of what can be safety or does not have to be safety, or does not have be in terms of a safety system. But does any of the staff have --identify yourself with sufficient clarity and volume.

MR. QUEEN: I think in light of the Commission's policy on advanced reactors would encourage inherently passive designs and also in light of the police on the safety stable shutdown of being a hot condition rather than a cold condition, we've basically come to the conclusion that this system that they provided does meet GDC-38 by reducing the pressure and keeping it acceptably low.

CONSULTANT KRESS: Just a difference in--

MS. CUBBAGE: But as far as the timing on whether it's at 72 hours versus at time zero, our conclusion is that it's acceptable for it to be RTNSS.

CONSULTANT KRESS: The other thing I wanted to comment on was I'd raised the issue of iodine sequestering earlier.

CHAIR CORRADINI: Yes.

CONSULTANT KRESS: I particularly thought I was very positively impressed with the work done by Sandia and Jay Lee. I don't see how you could do that any better. And they put the issue to rest, I think.

CHAIR CORRADINI: Okay. Good. What I heard is the same kind of relative to what Sam had said.

CONSULTANT WALLIS: I say that Jack Tills is very helpful. It was worth saying at this point. But even without that, I think we did have questions remaining from the GEH presentation.

CHAIR CORRADINI: Other comments? I didn't mean to cut you off. It got quiet, so I thought we were done.

Okay. So we'll adjourned until tomorrow. And we'll talk about PRA.

(Whereupon, at 5:11 p.m. the Subcommittee meeting was adjourned, to reconvene tomorrow, November 18, 2009.)

ESBWR Containment

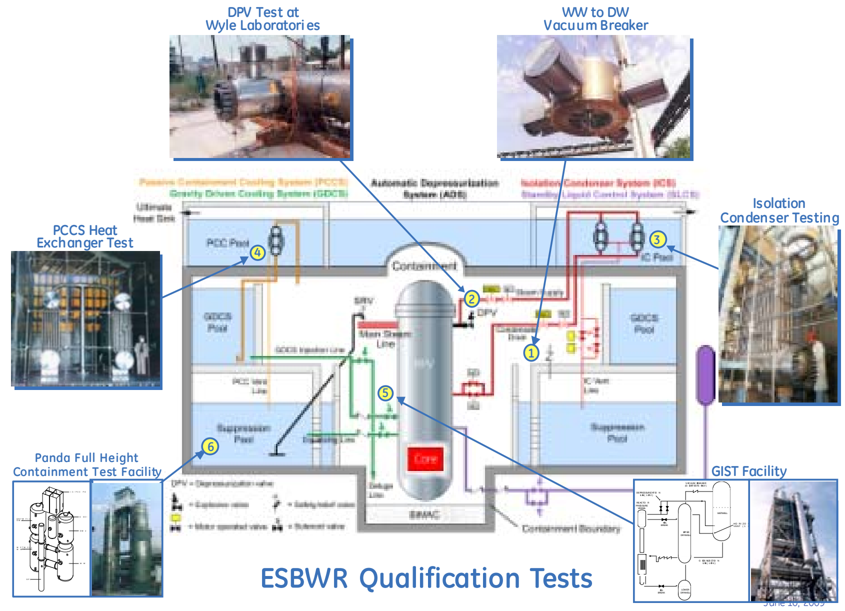
ACRS Meeting

Wayne Marquino

Matt Solmos

November 17, 2009

GE-Hitachi Nuclear Energy



GEH Proprietary Information removed

]

Agenda

- Staff & ACRS observations on TRACG model post 72 h, from June 2009
- Vacuum Breaker Leak Detection
- Design features for Radiolytic Gases in Piping & Heat Exchangers

RAI 6.2-139 -Corrected
Level 34, Ring 6 curve on Figure 9

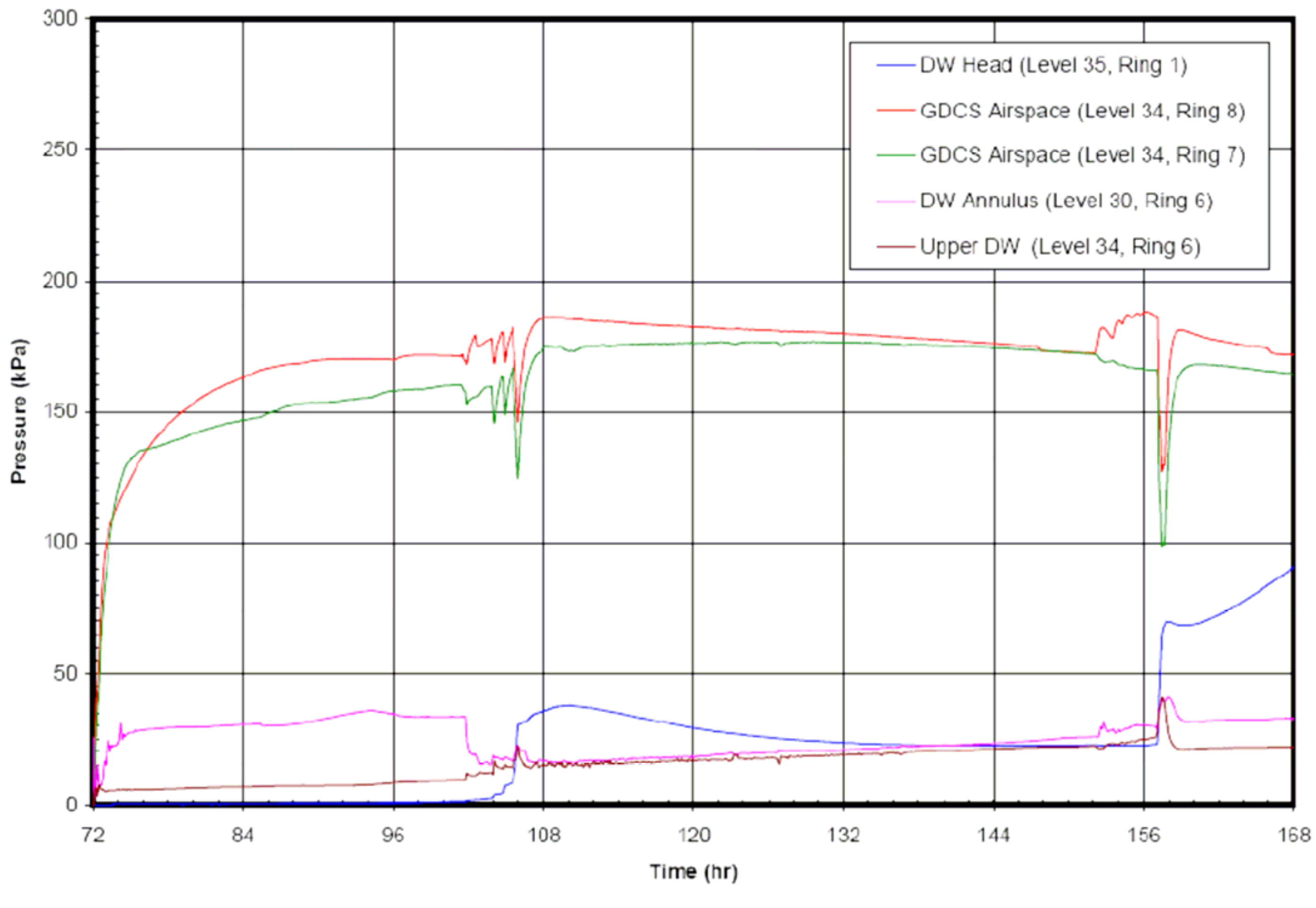


Figure 9. NC Gas Pressures in DW Annulus, DW Head and GDCS Gas Space

TRACG/MELCOR comparison RAI 6.2-140 S5

- Defined Head/Flow characteristic for fan which envelopes analysis
- Updated detailed results for the post 72h depressurization for NRC staff review to DCD Rev 6, 4 of 6 fans operating

Staff & ACRS observations on TRACG model post 72 h, from June 2009

- DW Head volume distribution & Elevation of top of DW
  - Elevation of the bottom or Upper DW cells are above the top of DW
  - 10% of DW Head volume extends into ring 5 of TRACG model
  - TRACG volume fraction assigned to the top level Upper DW cells is small fraction of the geometric volume
  - 0-72 h analysis contains bounding non-mechanistic features:
    Double pipe in GDCS airspace &
    All NC purged to WW @ 72 h

Staff & ACRS observations on TRACG model post 72 h, from June 2009

- Renode upper DW & PCC inlet & GDC airspace to DW head connection
  - Smaller Reduction in DW pressure
- Move MSL break & DPV pipe exit to DW different Radial cells
  - No significant change
- Move GDCS airspace to lower DW
  - Larger reduction in DW pressure

Evaluations to reconcile TRACG/MELCOR results

- PCC Power
  > Slows reduction in DW pressure

- Fan Characteristic
  > 10% Less Rated head
    - Slightly slowed reduction in DW pressure

  > 10% Less Rated flow
    - No Sig. Effect

- TRACG Wetwell heat loss to Reactor building similar to MELCOR

Summary

- Staff & ACRS observations on nodalization addressed
- TRACG and MELCOR use different models for PCC heat transfer
- Both predict the ESBWR containment pressure is reduced via PCC fan operation, and continues to reduce through the 30 day evaluation

Detecting vacuum breaker leakage

Type tests will be conducted to determine the temperature setpoints at analytical limit.

> DW & WW conditions over 72 hours will be tested

> TRACG analysis demonstrates concept, doesn't establish setpoints

> TRACG inputs provided to NRC staff

Extension of VB inlet into WW airspace cools low flowrate leakage and distinguishes temperatures from from high flow

Post 72 h PCC fan operation, or operation of RWCU/SDC will reduce DW pressure, and eliminate DW>WW leakage

Hydrogen radiolytic accumulation chapter 1 Generic Issue 195

- Review of Operating Experience is an integral part of ESBWR System Design, and GEH has already performed preliminary reviews on a system-by-system basis.
- The findings and recommendations from these reviews are being tracked and GEH procedures will ensure that they are dispositioned during the detailed design of the plant.
- Items such as hydrogen buildup in the PCCS have been identified as an issue to be addressed during detailed design. (See excerpts at left from GEH OER-SSR 07-0004.)

Hydrogen radiolytic accumulation chapter 1 Generic Issue 195

- GEH has historical guidance on how combustible gas accumulation has been addressed in past designs.
- Schedule has reserved time for future design reviews to address (among other things) issues identified in the OE review.
- During the design review process, various potential solutions are evaluated to determine the most effective way to address the issue of combustible gas accumulation.
- Appropriate industry codes will be applied to the PCC fan to prevent it posing an ignition source

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Presentation to the ACRS ESBWR Subcommittee

ESBWR Design Certification Review
MELCOR DBA Calculations

Presented by

Hanry A. Wagage, NRO/DSRA/SBCV
Jack Tills, Sandia National Laboratories

November 17, 2009

Project and Technical Review Team

- Project Managers
  - Ilka Berrios, Chapter 6 Project Manager
  - Amy Cubbage, ESBWR Lead Project Manager

- Technical Reviewers
  - Hanry Wagage, NRO/DSRA/SBCV - Lead Technical Reviewer
  - Allen Notafrancesco, RES/DSA/FSTB
  - Hossein Esmaili, RES/DSA/FSTB
  - Jack Tills, Consultant, JTA Inc.

Purpose

- To present comparison between TRACG and MELCOR for ESBWR containment long term heat removal

- Discuss remaining open issues

Status

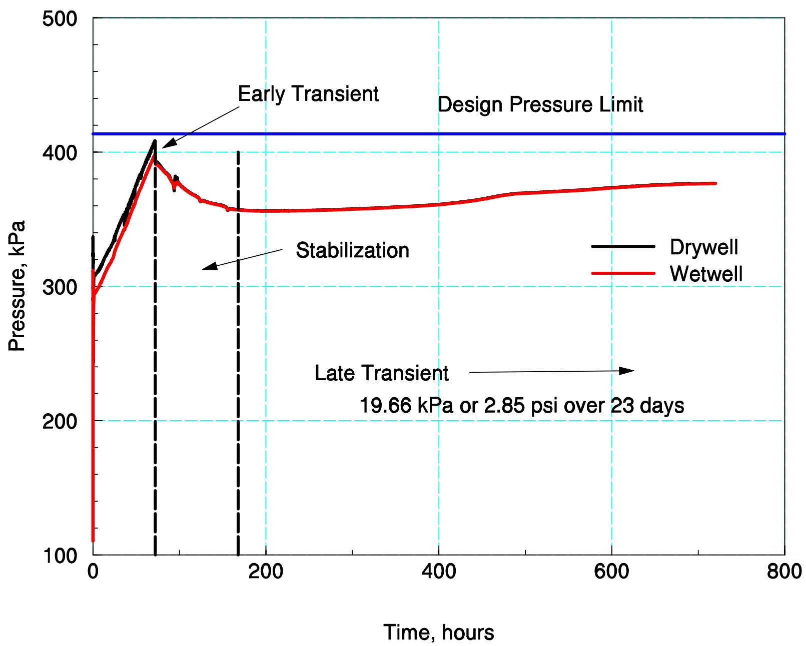
- Completed MELCOR Confirmatory Analyses
  - Gained understanding of differences in trend of TRACG and MELCOR long-term containment pressure
- Differences remain for the pressure drop at 72 hours
- Open RAI 6.2-140 Supplement 5
  - Based on insights from MELCOR Studies
  - Ensures that Design Basis is documented in DCD
  - GEH response pending

Previous Containment Pressure Calculations

[Comparison from 6/2009 for Rev 5 (RAI)]

6 Fans Operational: 1 Fan in each PCCS HX Loop

MELCOR



TRACG

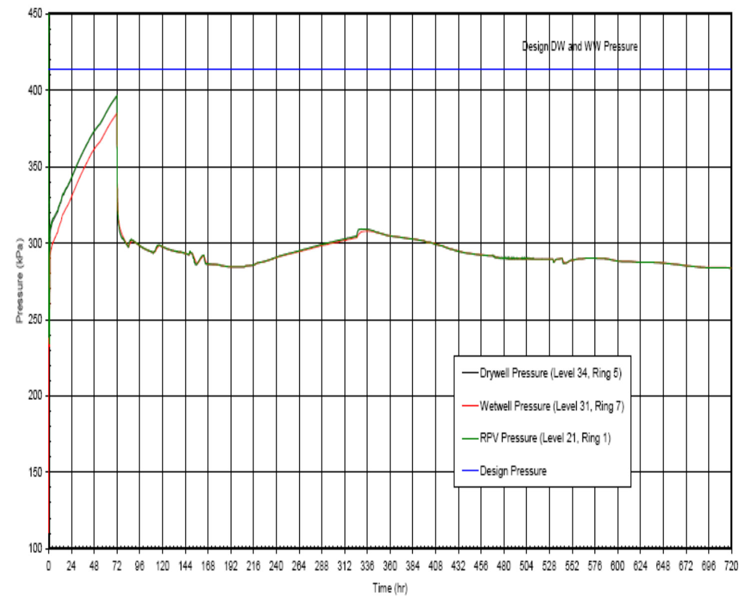


Figure 6.2-140 S04-C1 Main Steam Line Break, 1 DPV Failure (Bounding Case) – Containment Pressures (30 days)

Constant Upper Pool Refill @ 200 gpm

Fan flow fixed at 200 cfm

Refill Management

TRACG Semiscale Pump Option

Presentation Outline

- MELCOR DBA calculation for ESBWR Long-term Passive Period (peak pressure)
  - Long-term cooling phase compares well with DCD TRACG results to 72 hours [DBA (audit) and confirmatory calculations are equivalent]

- Intervention Period Revised Plant Model (72 to 720 hours) for MELCOR/TRACG (DCD Rev 6) comparisons; i.e., confirmatory
  - Updated input for TRACG fan curve with variable fan outlet submergence / PCC pool refill management capability
  - PCC/IC pool with multi-laying to track saturation temperature with depth
  - Include a maximum rule for mixed/transition heat transfer correlations

- MELCOR Plant Model for Intervention Period

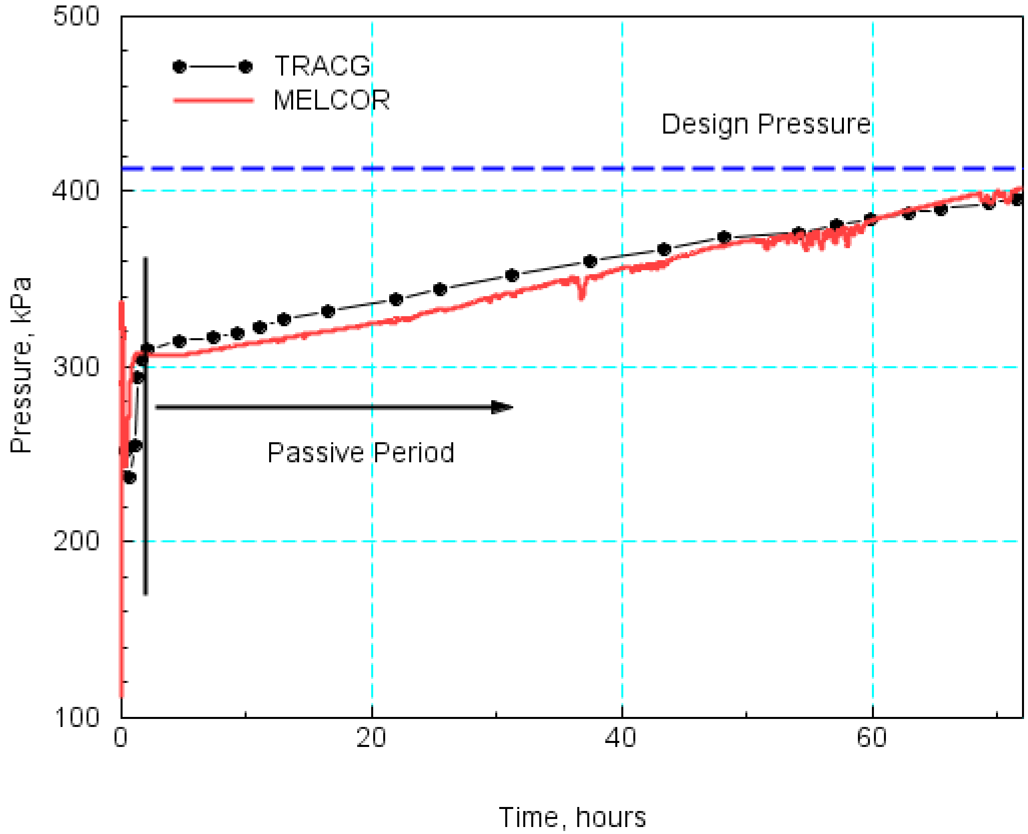
- Confirmatory calculation to compare MELCOR/TRACG results with 4 fans (upper pool refill management, without GDCS pool condensate trays)

- Calculations to investigate remaining differences between MELCOR and TRACG (DCD Rev 6)

- Bounding Intervention DBA Calculation (Audit) for Rev 6 with 4 fans (3 to 30 days) based on actual design and function

Figures-of-Merit for DBA (audit) Bounding Calculation
[Passive Period: 0 to 72 hours]

MSLB with 1 DPV failure
DW Pressure



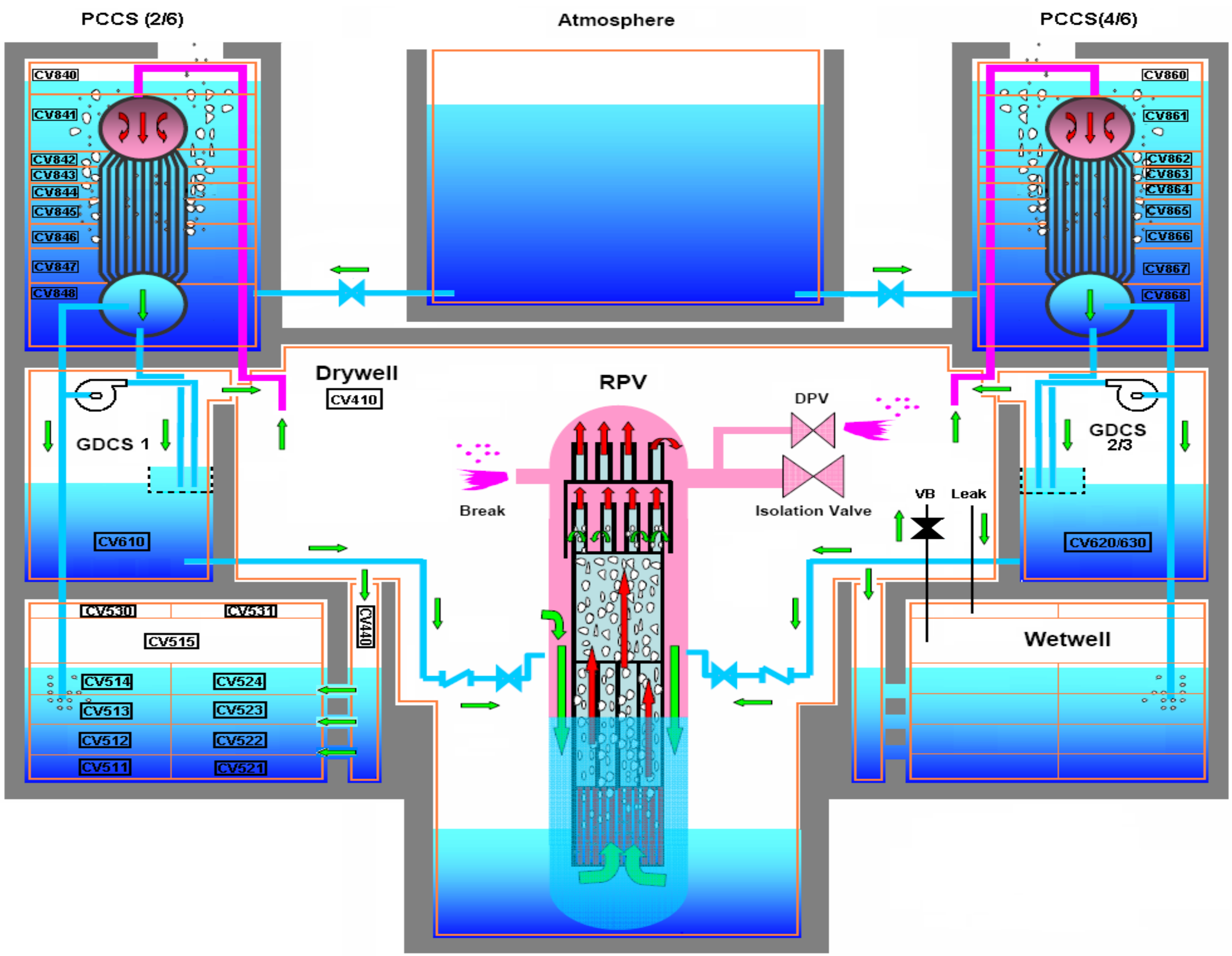
<u>DCD Rev 6</u>

Peak Pressure / Margin
396.25 kPa / 5% (TRACG)
400.03 kPa / 4% (NCG adjust)
Pressure trend at peak Increasing

<u>MELCOR DBA (audit/confirmatory)</u>

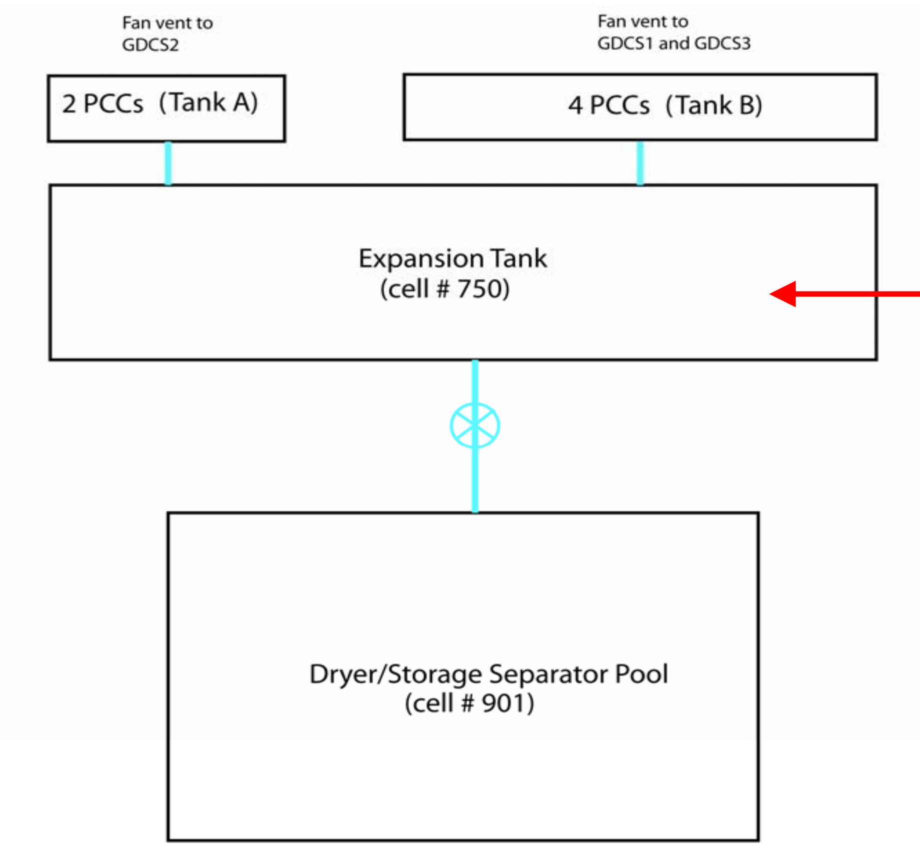
Peak Pressure / Margin
400.65 kPa / 4%
Pressure trend at peak Increasing

MELCOR ESBWR Plant Model



MELCOR ESBWR Plant Model (cont.) [External Pools]

Water Tanks (Outside Containment)



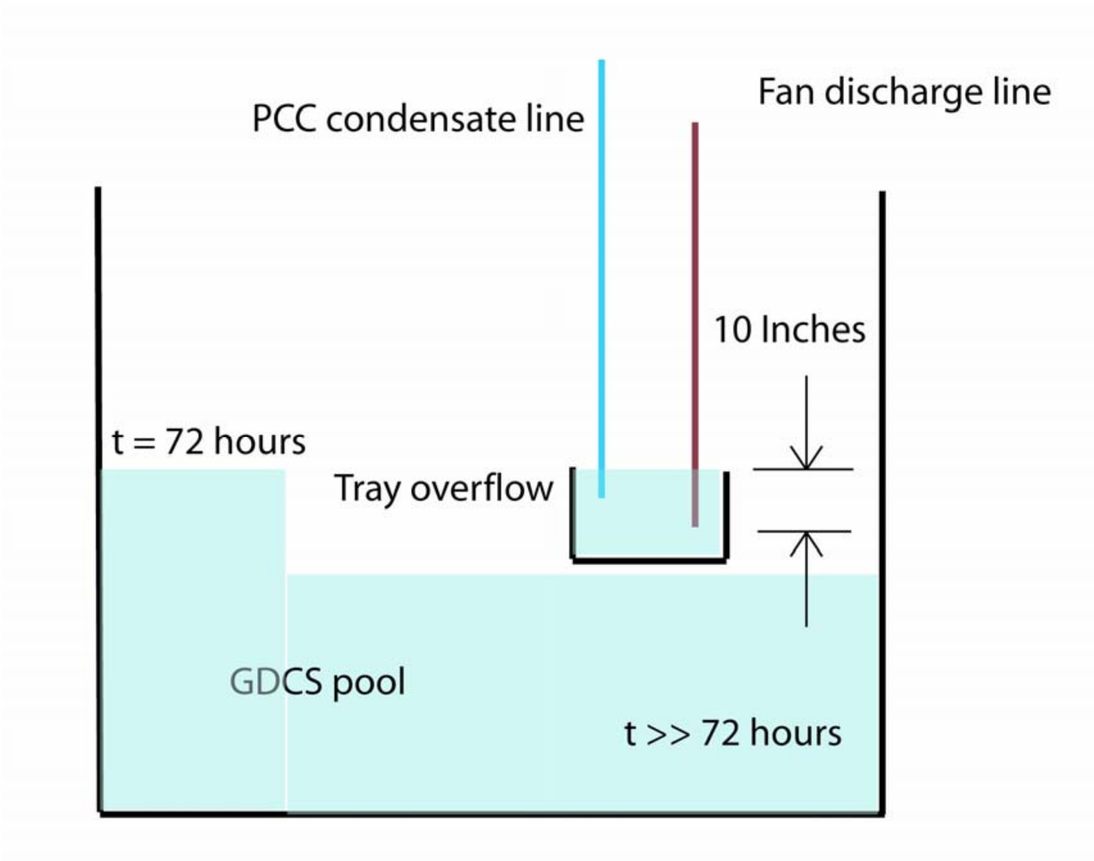
DBA (audit) Basis

Refill @ 200 gpm post-3 days with no refill management

Confirmatory Basis

Refill @ 200 gpm initially post-3 days followed by refill management (level at top of condenser tubes) consistent with TRACG simulation

MELCOR ESBWR Plant Model (cont.) [GDCS Tanks]



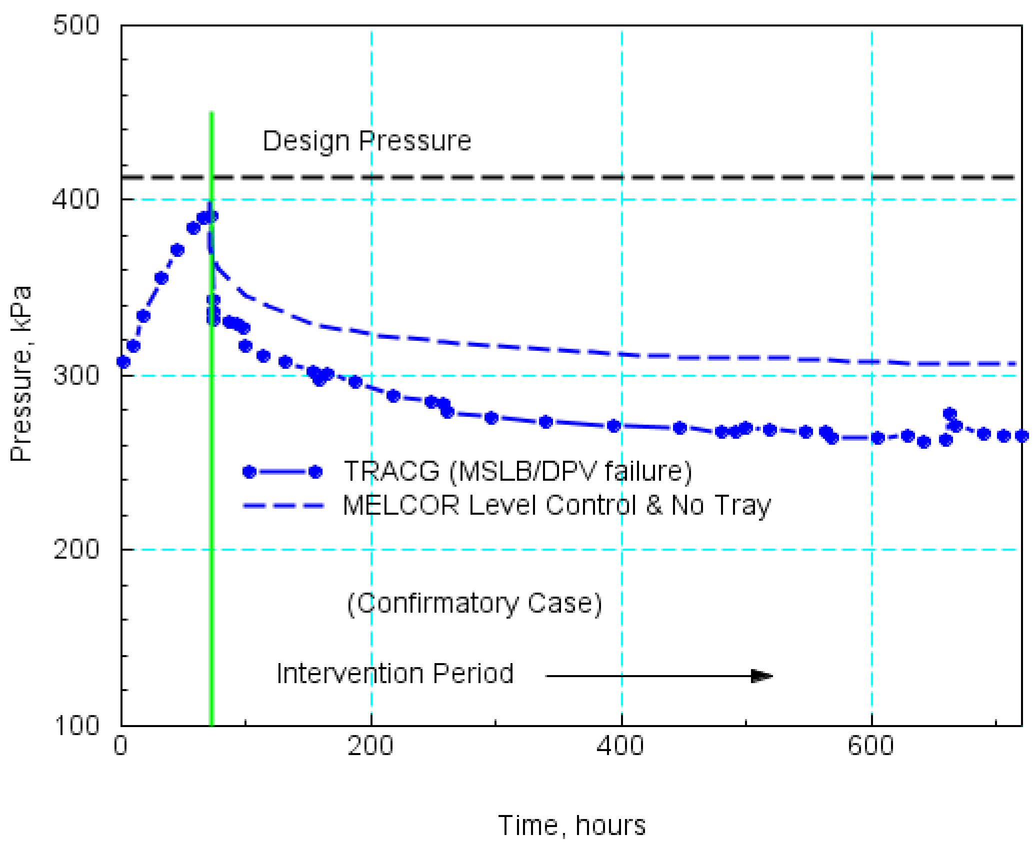
DBA (audit) Basis

Fan vent elevation is actually directed to the GDCS air-space -- tray effect simulated with fixed 10 inch submergence for calculating fan flow (in TRACG, fan discharge enters the GDCS pool and affects the bulk pool temp.)

Confirmatory Basis

Fan vent elevation set 10 inches below GDCS water Level at 72 hours – tray effect not simulated

MELCOR Confirmatory Calculation
(TRACG DCD Rev 6)



DCD Rev 6 (TRACG)

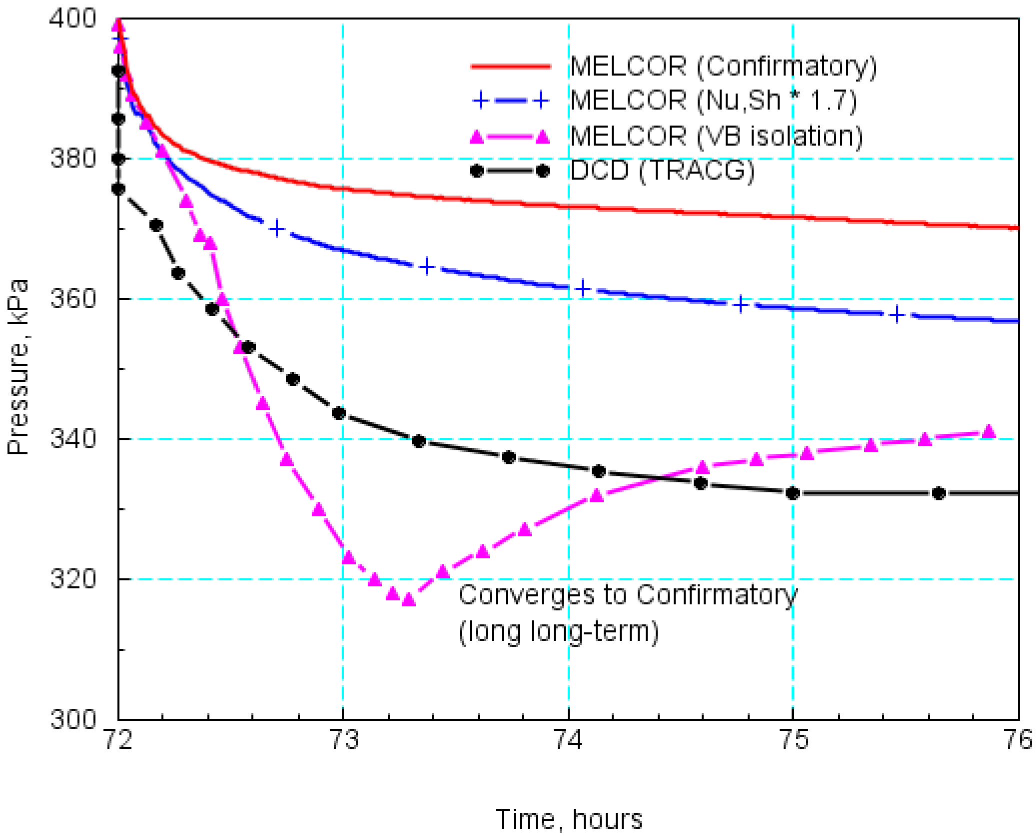
- pool level control (variant procedure)
- fan vent with varying submergence (variant design)

Confirmatory Calculation

MELCOR ESBWR plant with level control without GDCS pool tray

- late time trends confirmed
- early transient "cliff" difference remains
- long long-term offset (~ 0.4 bar)

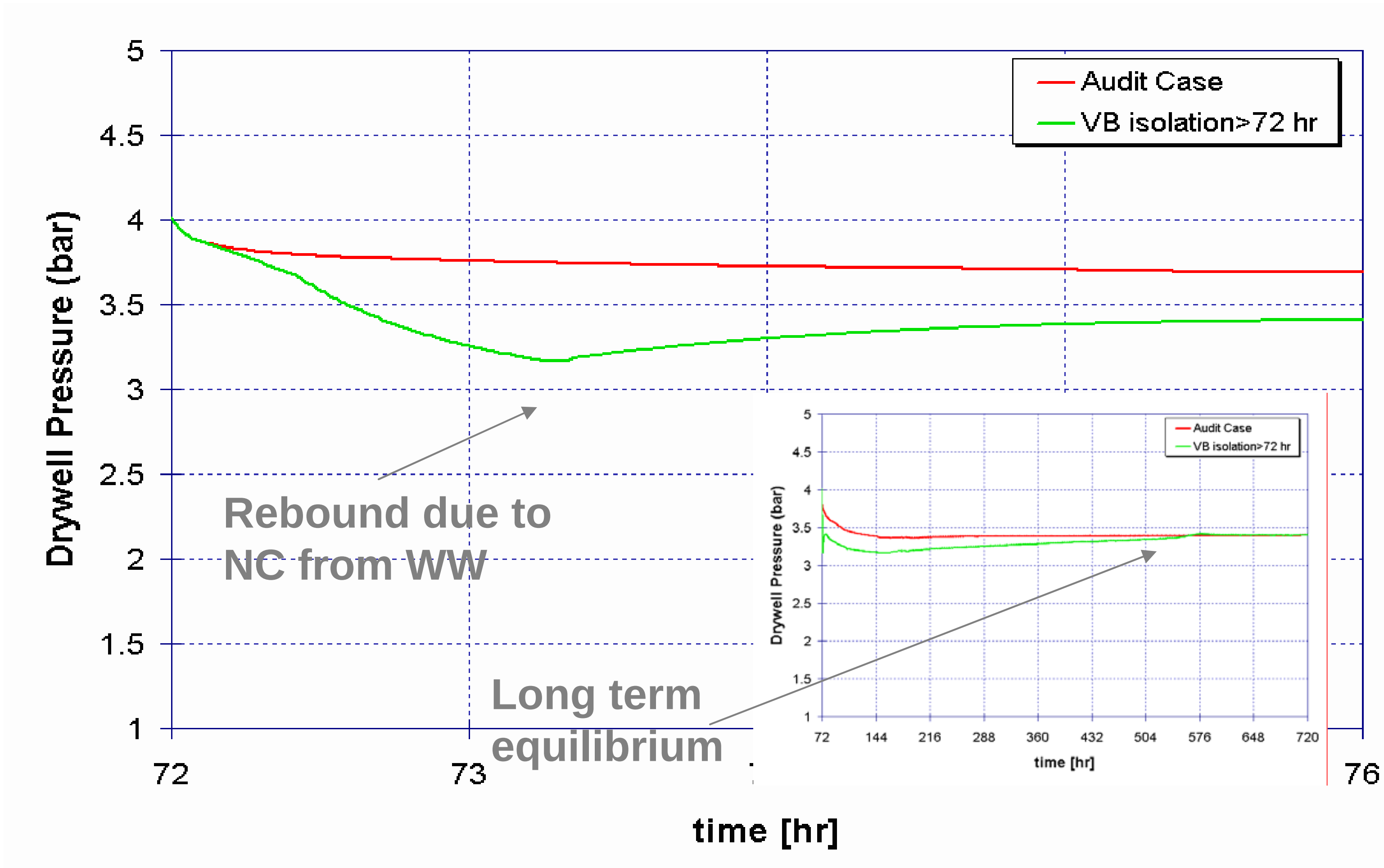
MELCOR Calculations to Investigate "Pressure Cliff" Response



- Vacuum breaker open at ~ 8 minutes following fan activation (MELCOR)
- Significant sensitivity to VB activation in short-term, with later convergence to confirmatory case
- Significant incremental increase in PCC HMTA model does not reproduce severe "pressure cliff" response
- Prediction of "pressure cliff" during this transient period extremely difficult to assess (due to integral effects and lack of data for fan activation impact on PCC performance during plant operation)

MELCOR Sensitivity Calculation for Case Without VB after 72 hrs

[Variation of PCC Inlet NCG concentration]



Investigation to Resolve Long Long-term MELCOR/TRACG Pressure Offset

- Reviewed previous HTMA modeling for UCB/MIT single-tube tests to confirm accuracy of tube-side calculation

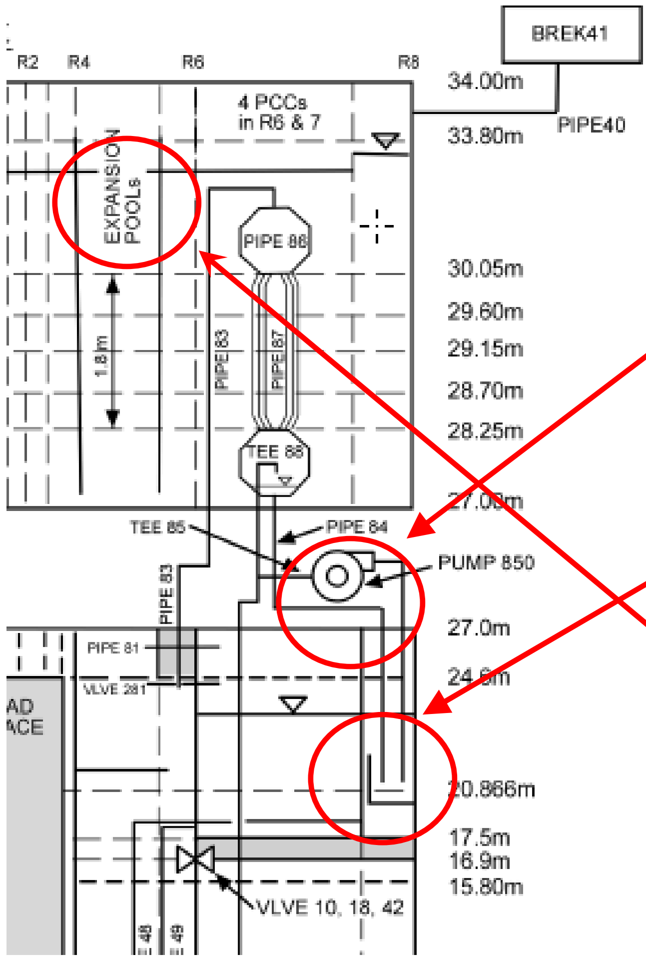
- Reviewed independent reports for HTMA/MELCOR modeling for 1) UCB single-tube tests and 2) PUMA test to confirm MELCOR PCC modeling basis

- Performed additional PANTHERS low flow calculations (ESBWR PCC nodalization) to show that MELCOR PCC prediction of heat removal is conservative by < 15% under plant conditions for long long-term application

- Applied the observed 10-15% conservatism in MELCOR PCC modeling to show this degree of conservatism can produce long long-term pressure offset of ~ 0.5 bar in DW pressure while removing all decay heat power

Post-LOCA Containment Cooling and Recovery DBA (audit) Calculation Basis

DCD Rev6 TRACG Plant Model



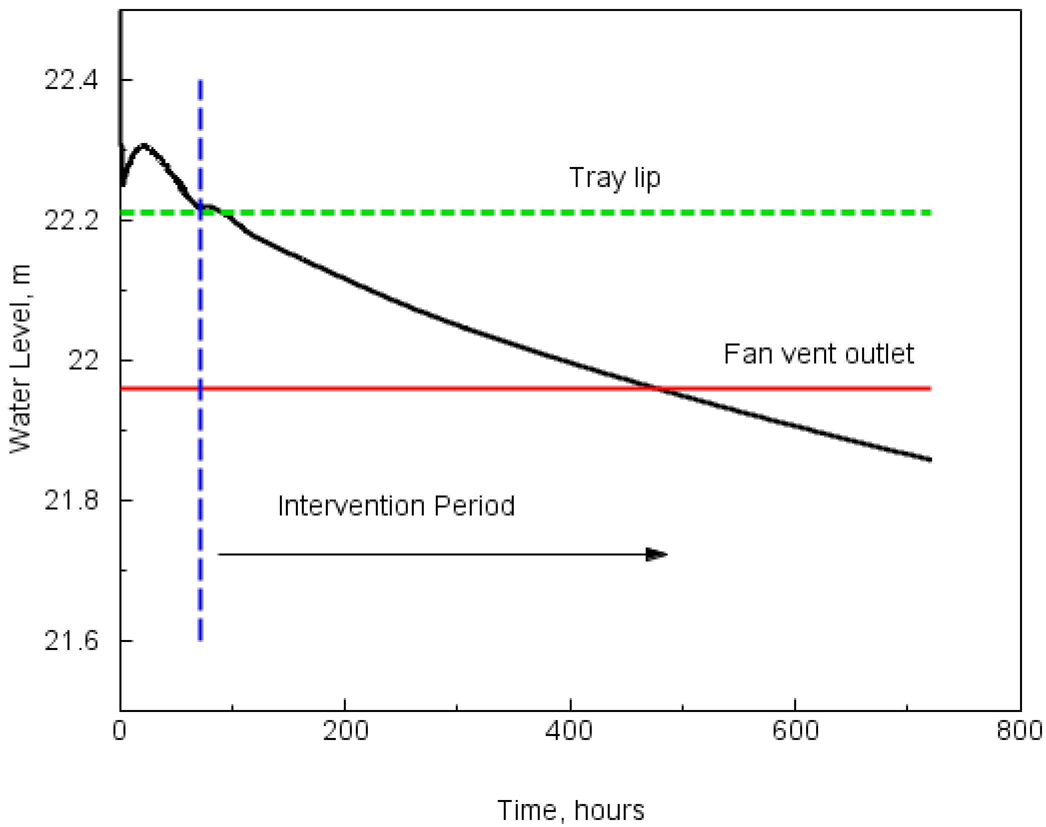
Governing Conditions for Post-3day DBA (audit)

- **Fan** (TRACG Semiscale pump model)
  - rated head = 2000 m^2/s^2
  - rated flow = 0.5 m^3/s per fan
- **Tray in GDCS**
  - maintain vent submergence of 10 inches @ start of intervention period and throughout
- **IC/PCC/Expansion pool refill**
  - refill at fixed rate = 200 gpm (with no level control anticipated, except for over-flow situation)

MELCOR Calculated GDCS Water Level with Tray Simulation

[DBA versus Confirmatory]

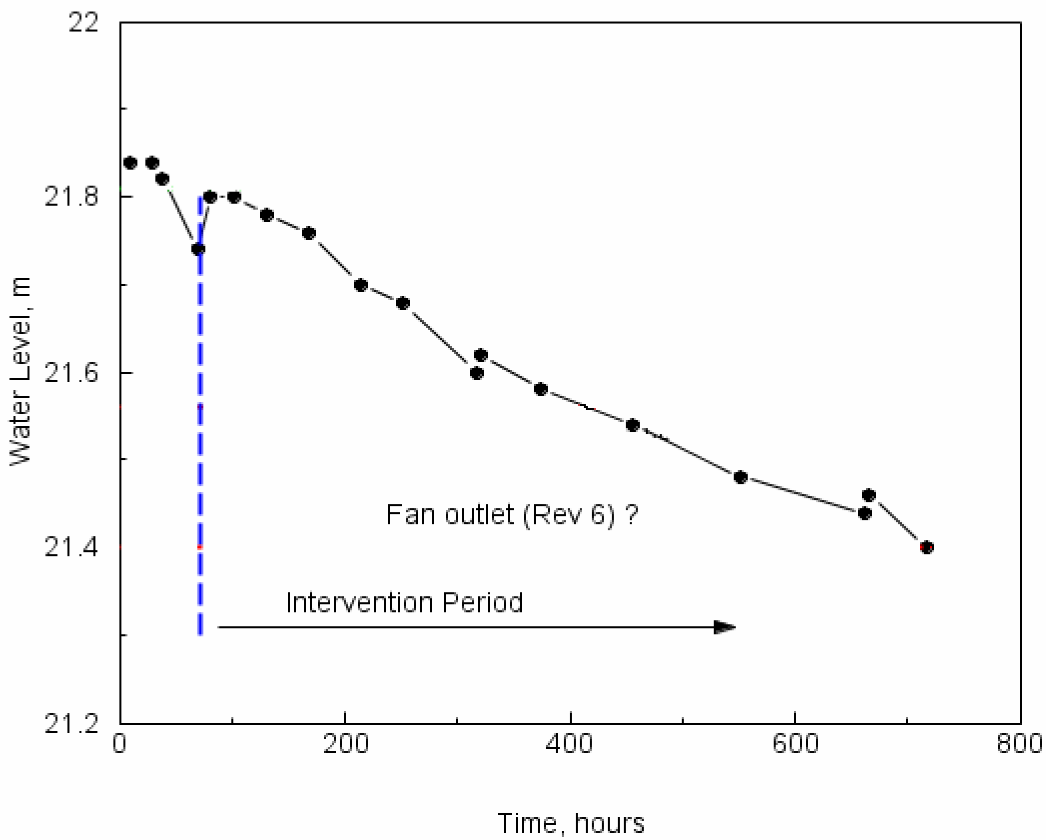
MSLB with 1 DPV failure
GDCS Water Level



- **Tray lip @ 10 inches (0.254 m) above fan vent outlet**
- **GDCS tank water level trends below fan vent outlet**
- **Recovery system design maintains fixed submergence**
- **MELCOR DBA simulates tray design by imposing a fixed 10 inch submergence during intervention period**

TRACG Calculated GDCS Water Level and Simulation of Vent Submergence

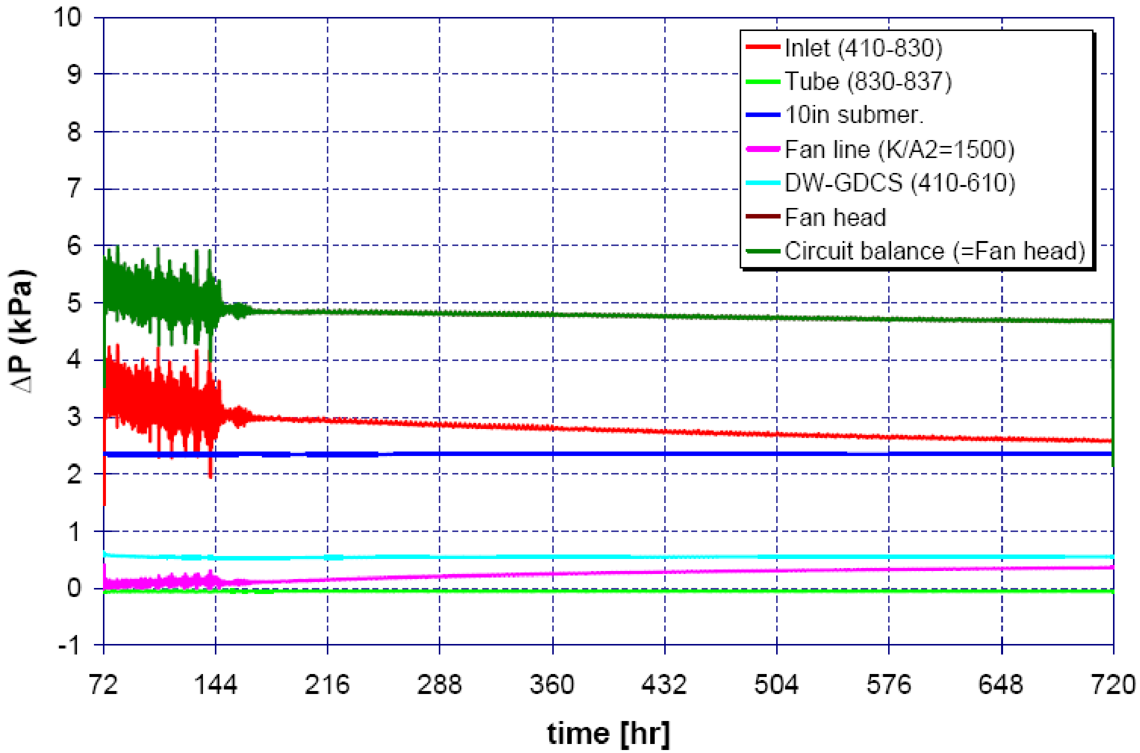
MSLB with 1 DPV failure
GDCS Water Level



- Tray lip at GDCS level @ 72 hours not simulated (fan vent submergence variable)
- GDCS tank water level trends toward fan vent outlet
- Recovery system design maintains fixed submergence
- DCD Rev 6 (neglects tray lip design → fan vent modeled with varying submergence causing increased fan flow due to reduced head)

Components of Fan Head Calculation

MELCOR Audit (MSLB with 1 DPV failure)



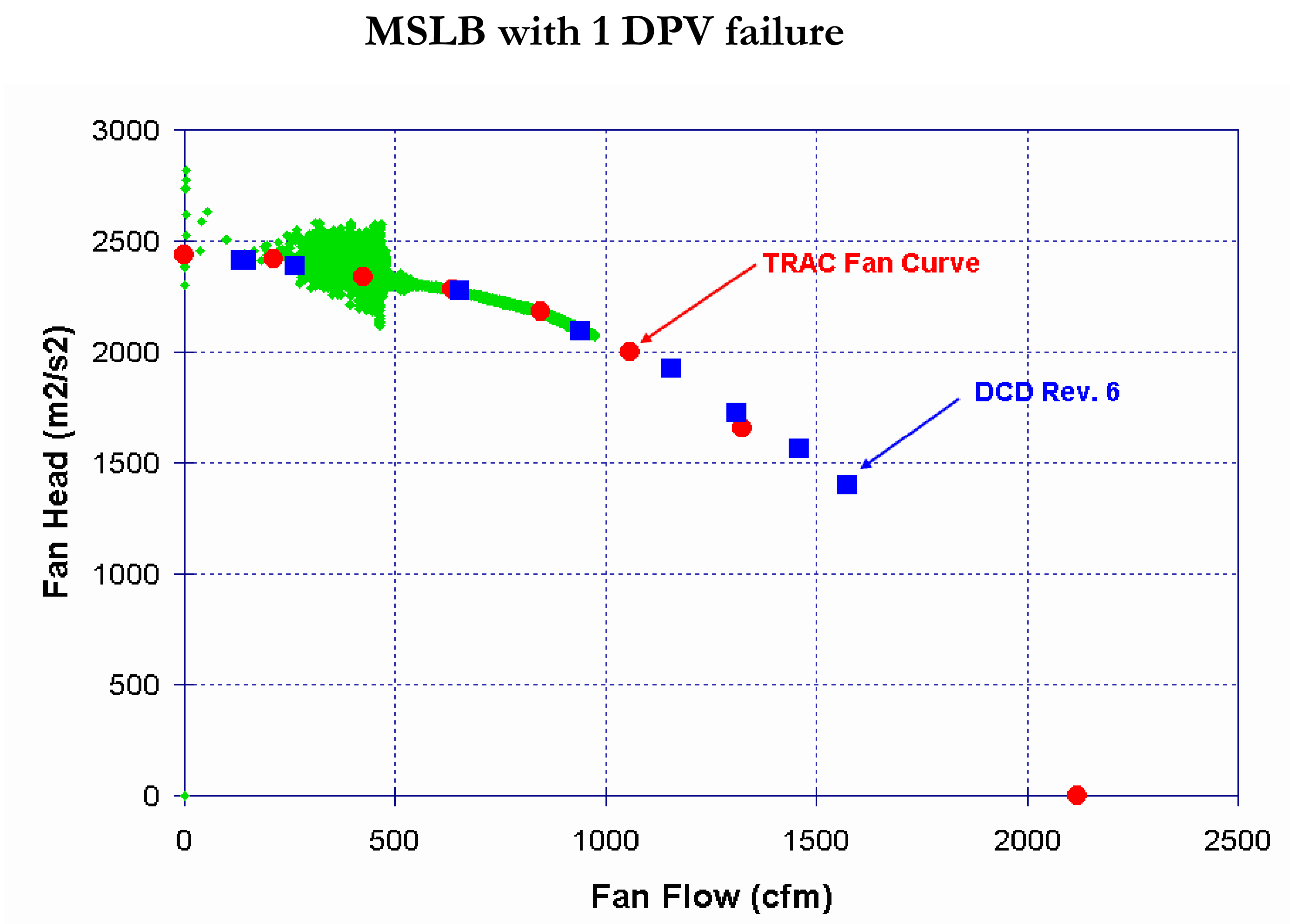
Fan Head Calculation

PCC Inlet Line Loss
+ Tube Loss
+ Fan Line Loss
+ Submergence Head
- DW to GDCS Loss
Fan Head (Circuit balance)

- **Important contributors for head calculation (and flow)**
  - -- PCC Inlet Line Loss
  - -- Submergence

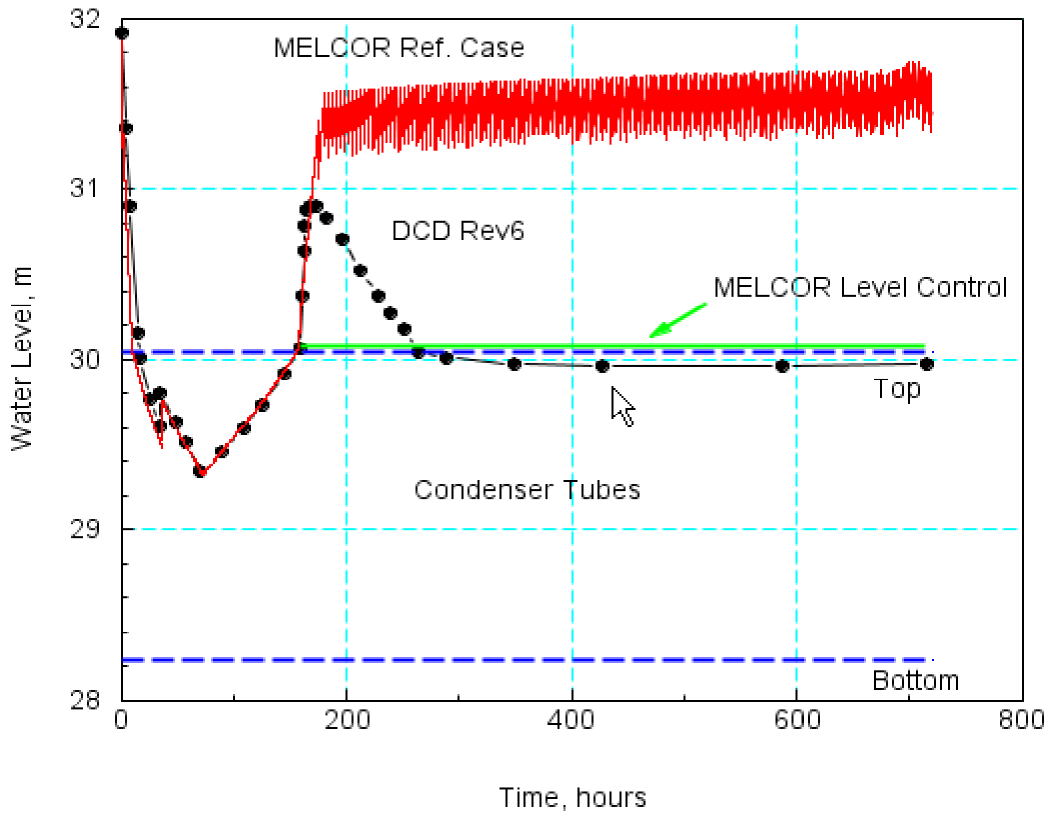
MELCOR Calculated Fan Flow (Audit)

[Intervention Period]



Intervention Period Flood Profile

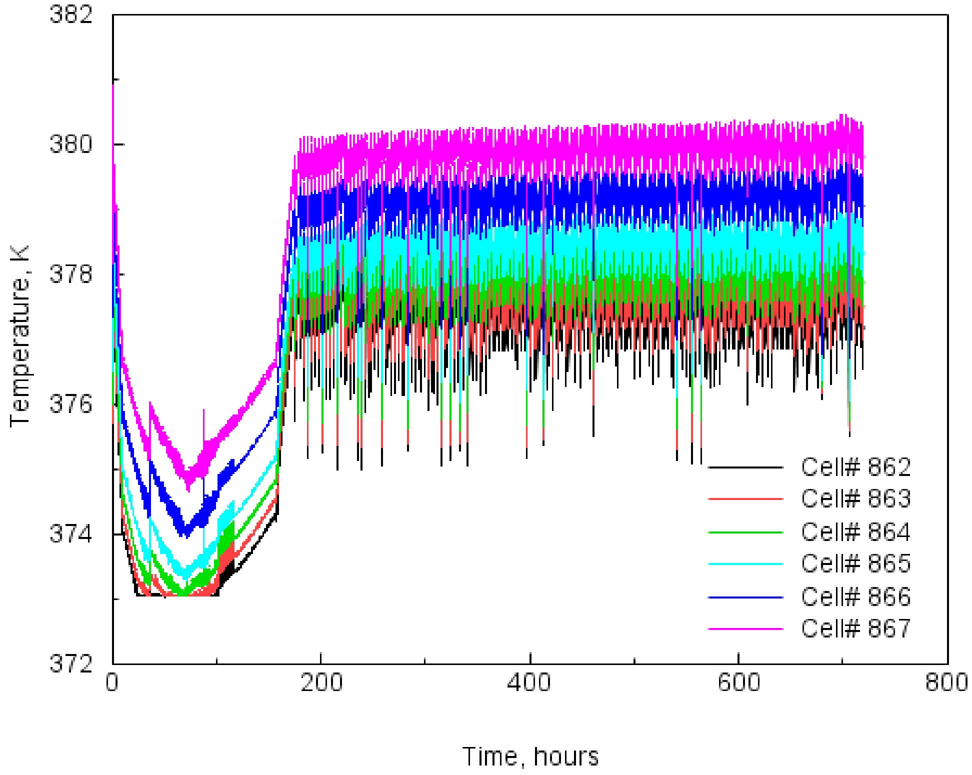
MSLB with 1 DPV failure
Expansion/PCC/IC tank

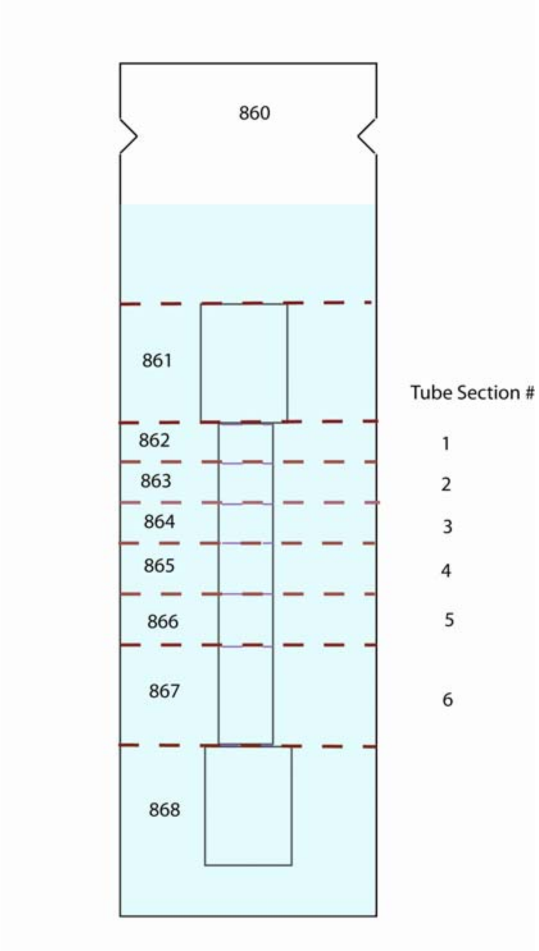


- **No water level control for MELCOR DBA (audit) -- based on NRC understanding of actual operation procedure**
- **MELCOR water level control assumed only for confirmatory calculation (@top of tubes)**
- **DCD Rev 6 assumed water level control**

MELCOR Calculated PCC/IC Pool Saturation Temperatures

MSLB with 1 DPV failure

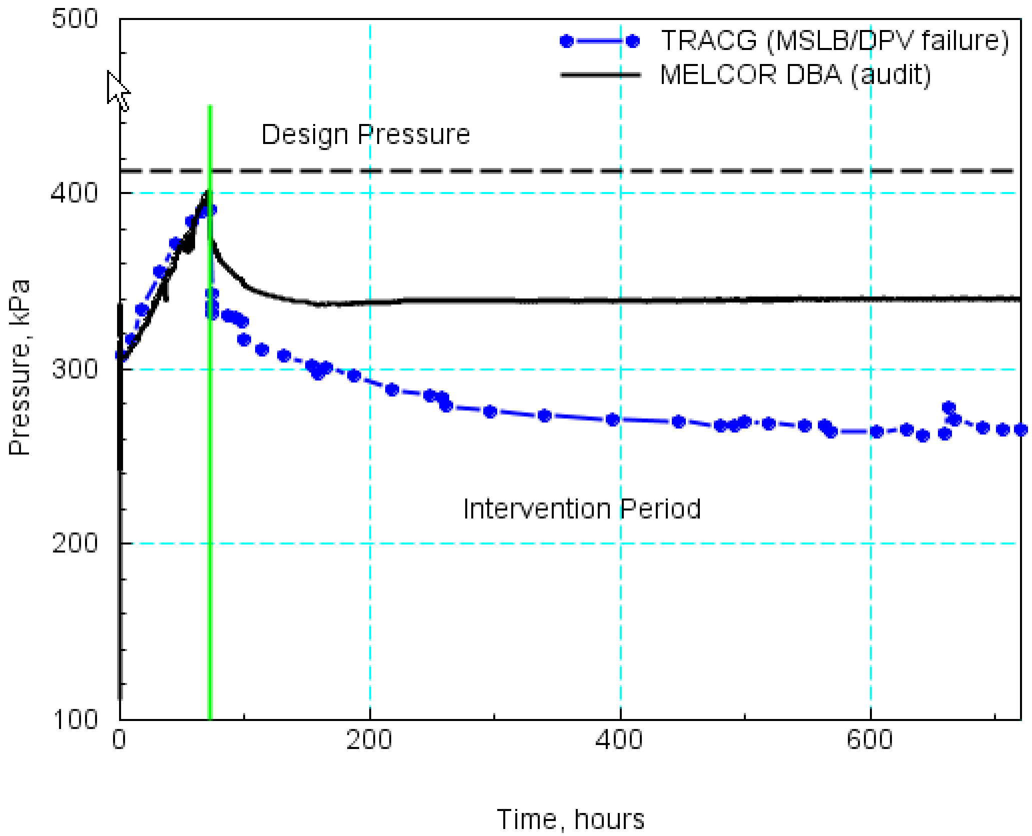




MELCOR DBA (audit) Calculation

[Intervention Period: 72 to 720 hours]

MSLB with 1 DPV failure / 4 fans
DW Pressure



DCD Rev 6

- **Margin @ 720 hours 48% (TRACG) with level control without GDCS tray**

Audit Calculation

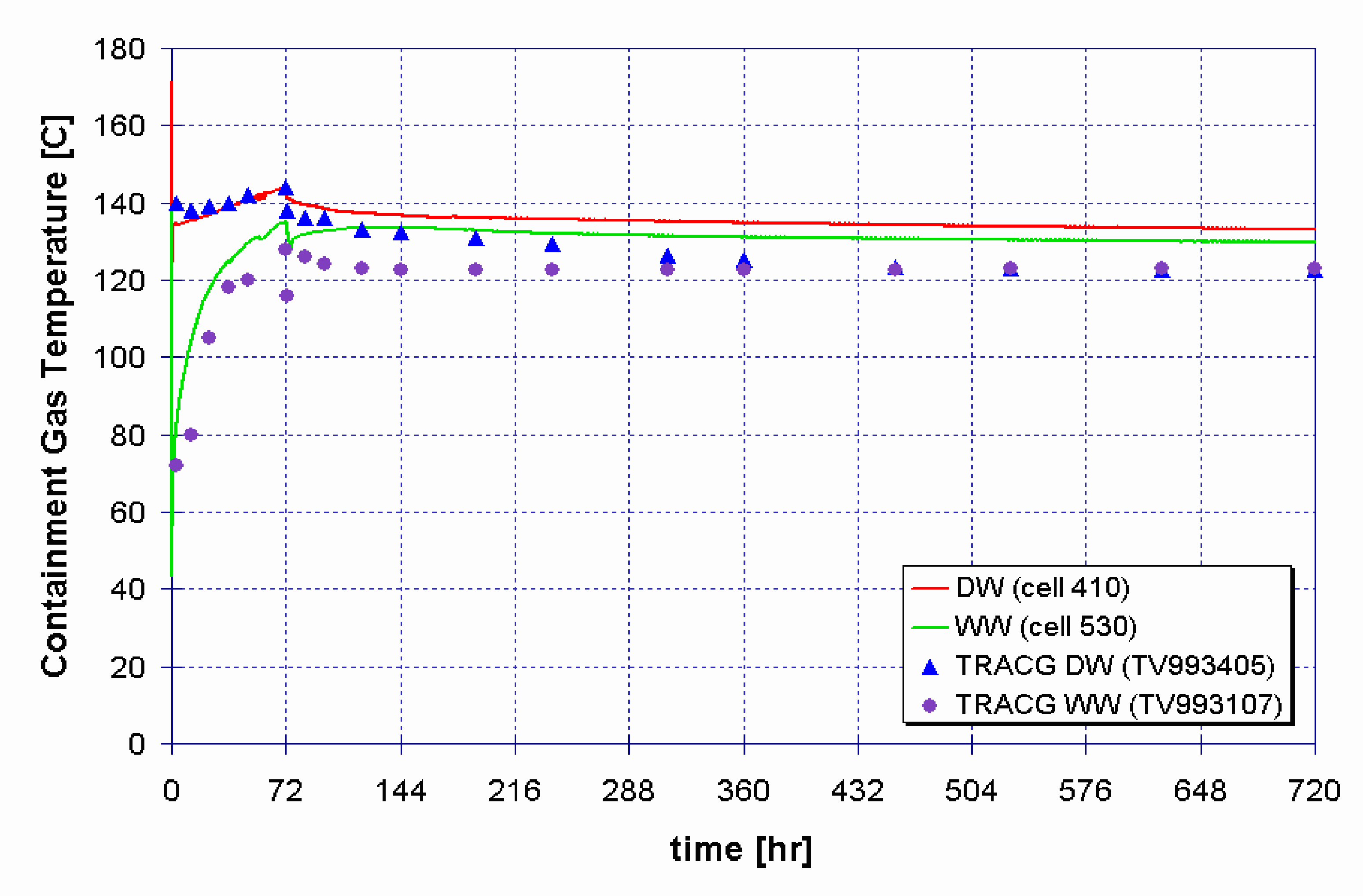
Margin @ 720 hours 24%

no level control (procedure) flood @ 200 gpm fixed

fan vent covered (design) min coverage = 10 inches

MELCOR Audit Calculation (MSLB Bounding)

[Intervention Period: 72 to 720 hours]



MELCOR ESBWR DBA Calculation Summary for Intervention (post-3day) Period

- MELCOR Plant Model for Intervention Period Revised (guided by GEH clarifications of post-3 day design/operation)
- MELCOR confirmatory calculations confirm DCD Rev 6 results were performed <u>without</u> GDCS pool tray function and <u>with</u> PCC/IC/Expansion pool refill management (both tray neglect and refill management are shown to trend the containment pressure lower than the DBA (audit) calculation)
- With the exception of early intervention transient effect (i.e., pressure “cliff”), the MELCOR and TRACG post- 3 day pressure trends are similar when design/operation parameters are similarly modeled, with MELCOR results showing an offsetting increase of ~ 0.4 bar at 30 days
- MELCOR DBA (audit) pressure calculation, based on ESBWR design/operation, during the late intervention period is flat with ~ 24% margin @ 30 days (720 hours)

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 15, “Radiological Analysis”

Presented by

Jay Lee - NRO/DSER/RSAC
Donald Kalinich - Sandia National Laboratory
Randy Gauntt - Sandia National Laboratory

November 17, 2009

Purpose

- Brief the subcommittee on the completion of fission product transport and removal evaluation in the ESBWR containment.
  - Briefing on the preliminary evaluation was given to the subcommittee on January 17, 2008
- Answer the subcommittee's questions

Technical Evaluation Completed

- Natural fission product deposition in main steam lines and main condenser.
- Iodine removal by passive containment cooling system - Iodine behavior in containment and reactor pressure vessel (RPV).
- Control of pH of water in containment and RPV pools to prevent iodine re-evolution.

Natural Fission Product Deposition in Main Steam Lines and Main Condenser

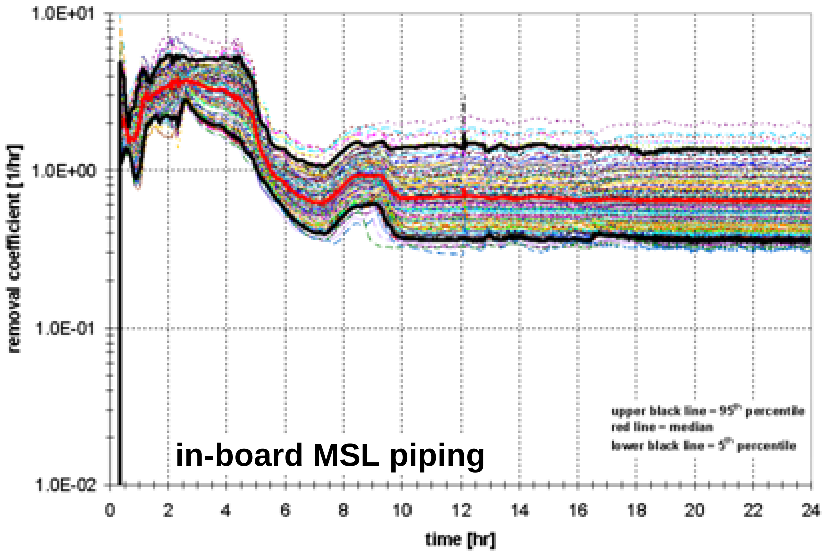
- Main steam lines, main steam line drain lines, and main condenser are designed to meet SSE criteria.
- Main steam isolation valve leak rate assumed (200 cfm) is specified in ESBWR technical specification.
- 200 cfm leak rate is assumed for the entire duration of accident (30 days).
- An independent RADTRAD confirmatory calculation has been performed by the staff.

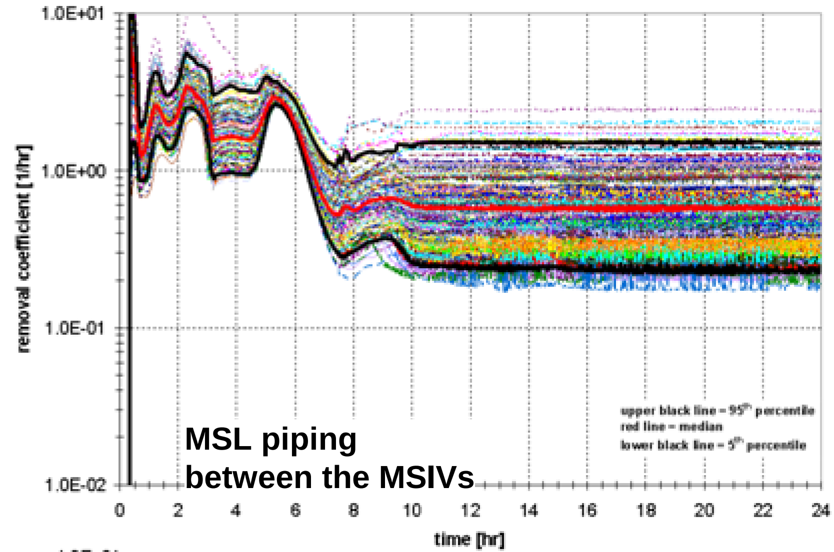
Natural Fission Product Deposition in Main Steam Lines and Main Condenser

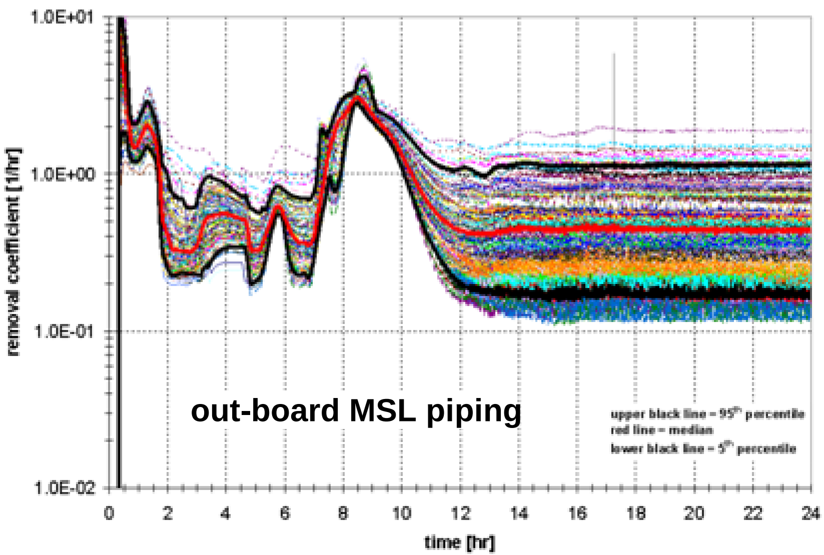
- Results from ESBWR MELCOR model used to establish thermal-hydraulic boundary conditions to estimate aerosol removal coefficients.

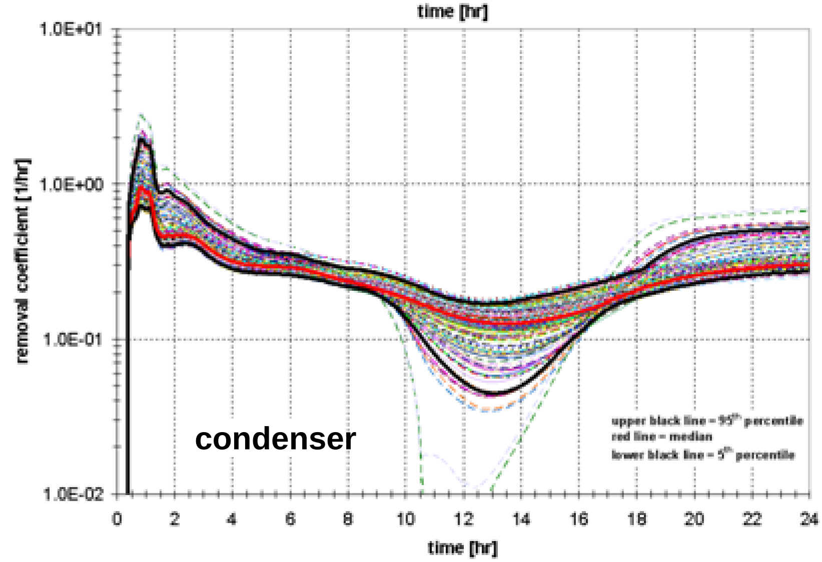
- Containment/Main Steam Line - only ESBWR MELCOR model used to perform quantitative analyses of uncertainties in aerosol physics parameters on aerosol removal coefficients using Monte Carlo sampling (150 realizations).

MSL and Condenser Aerosol Removal Rates









Natural Fission Product Deposition in Main Steam Lines and Main Condenser

- GEH Evaluation
  - Calculated containment aerosol removal coefficients.
  - Elemental iodine removal coefficient based on SRP 6.5.2.
  - No credit taken for removal in the main steam lines.
  - Credit taken for deposition (aerosols and elemental iodine) in the main condenser based on BWROG methodology (consistent with certified ABWR DCD).
  - No credit taken for removal of organic iodine.

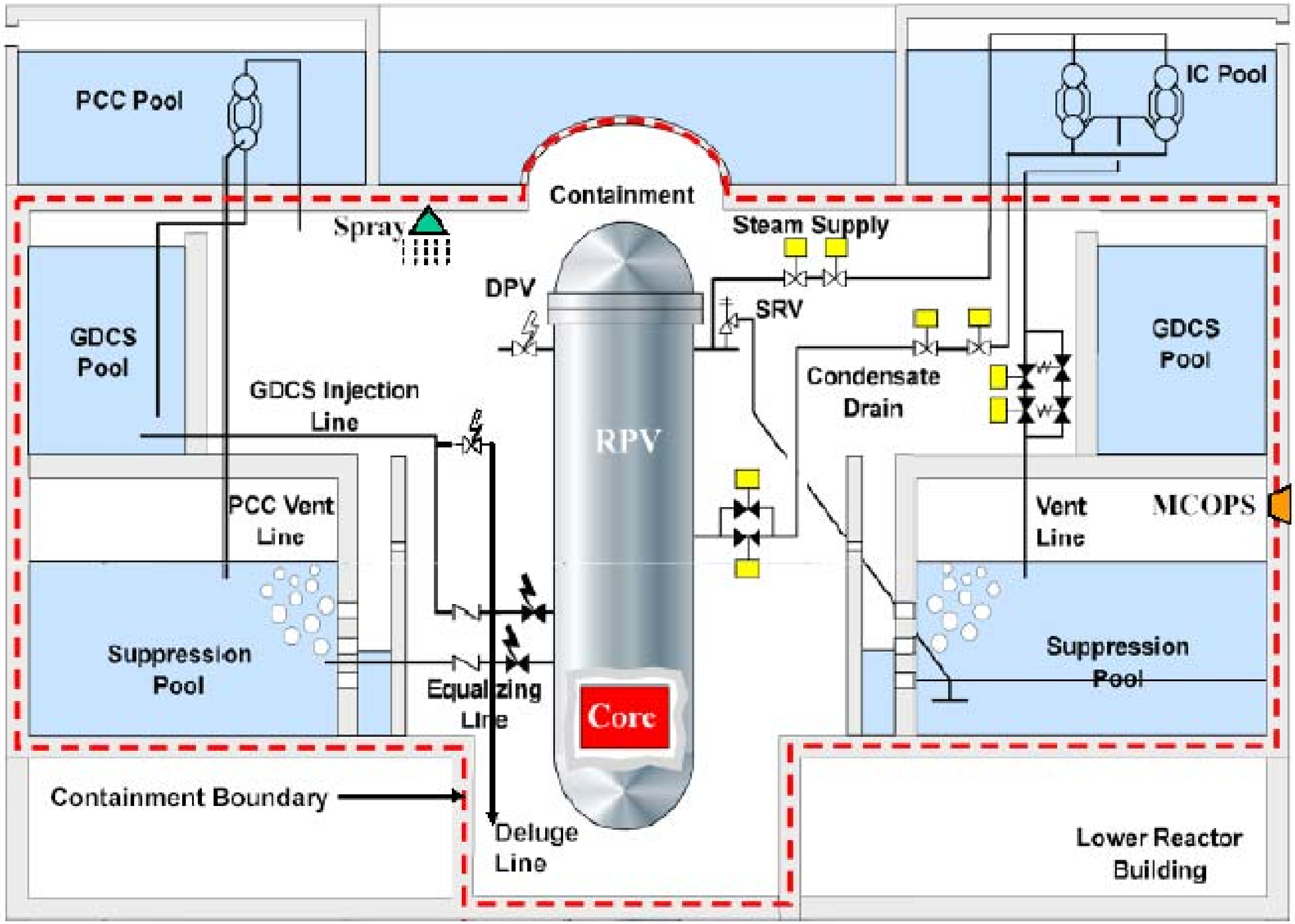
- Staff Evaluation
  - Calculated containment aerosol removal coefficients.
  - Calculated main steam line and main condenser aerosol removal coefficients.
  - No credit taken for removal of elemental or organic iodine.

- The results of staff independent confirmatory calculation bound the results of the GEH calculation.

Fission Product Removal by Passive Containment Cooling System

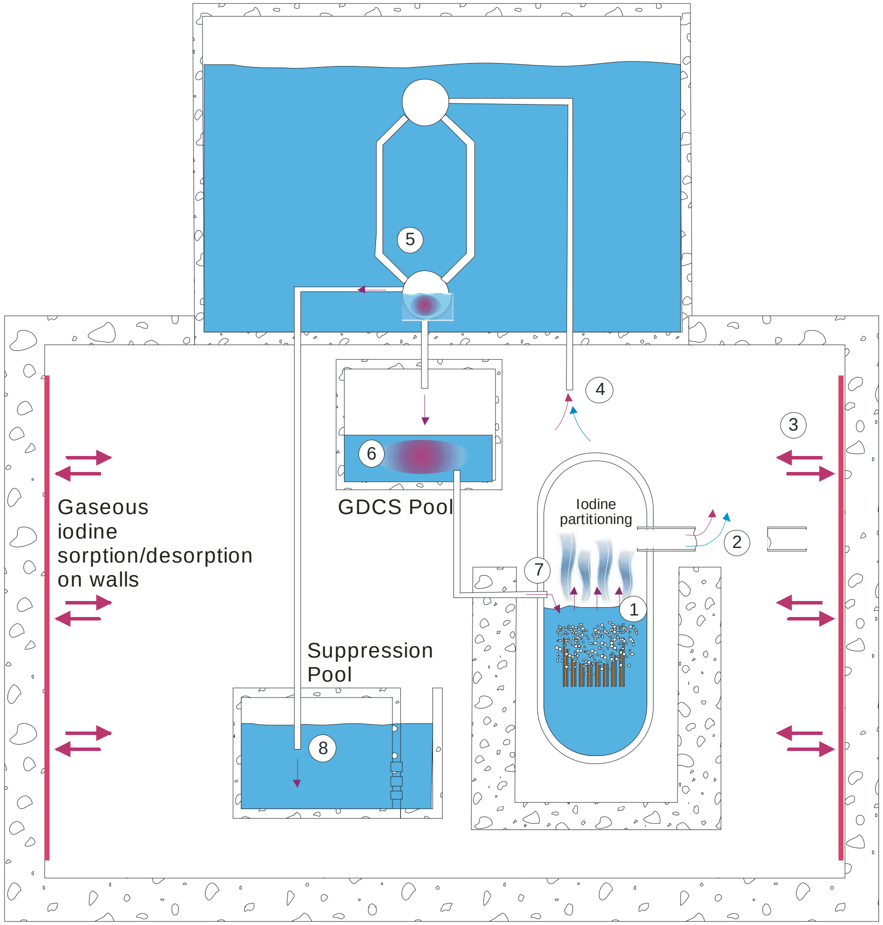
- Does iodine vapor removed by the PCCS stay removed?
- The staff completed a rate analysis of iodine transport between the PCCS, GDCS, RPV, the drywell, and the wetwell to confirm the GEH analyses.

Fission Product Removal by Passive Containment Cooling System



ESBWR Containment

Fission Product Removal by Passive Containment Cooling System



Simplified Schematic of ESBWR Containment Illustrating Iodine Transport and Deposition Pathways

Fission Product Removal by Passive Containment Cooling System

- Calculation performed with a simplified MELCOR ESBWR model.

- Iodine pool model implemented in the RPV, drywell, and wetwell.

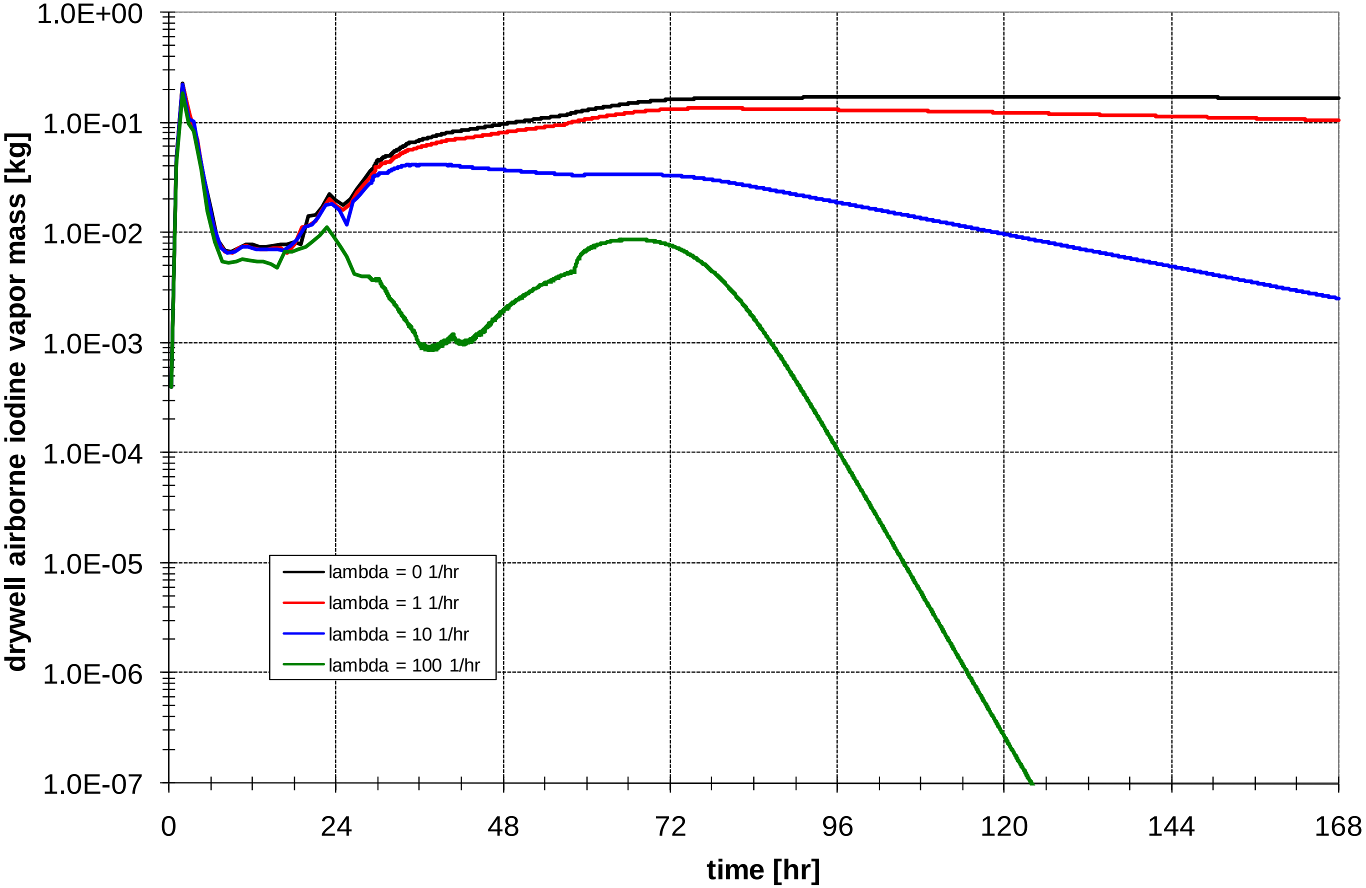
- No model currently available for diffusiopheric deposition of iodine vapor.

- Deposition (i.e., removal) of iodine vapor in the PCCS was evaluated parametrically.

Fission Product Removal by Passive Containment Cooling System

- Based on Iodine Pool Model in MELCOR code developed by Dana Powers
  - Acid generation and transfer to walls and pools
    - radiolysis of air produces nitric acid
    - radiolysis of cable insulation produces hydrochloric acid
  - Pool pH calculation
    - sodium pentaborate buffering accounted for
  - Iodine aqueous pool chemistry
  - Pool-atmosphere mass transfer
  - Iodine atmosphere radiolysis and recombination
  - Iodine atmosphere-wall deposition

Fission Product Removal by Passive Containment Cooling System



Drywell Airborne Iodine Vapor Mass as a Function of PCCS Iodine Vapor Removal Coefficient (lambda)

Fission Product Removal by Passive Containment Cooling System

- Results and conclusion

  – Higher PCCS iodine vapor removal rates result in lower iodine vapor mass in the drywell.

  – Results are indicative of removed iodine vapor remaining in pools rather than being re-evolved.

  – Supports the staff assumption that iodine in elemental form remains in water pools.

Control of pH in Containment Pools to Prevent Iodine Re-evolution

- Iodine in a pool will not significantly partition to the atmosphere if the pool pH is greater than 7.
- Formation of CsOH and addition of buffer (sodium pentaborate) results in an initial pool pH of ~ 8.0 to 8.5.
- Acid formation will eventually result in a reduction in pool pH
  - radiolysis of air produces nitric acid
  - radiolysis of cable insulation produces hydrochloric acid
- When does the pool pH drop below 7?
  - GEH calculation predicts drywell pool pH < 7 between 20 to 29 days.
  - Staff calculation confirms GEH results out to 7 days.

Control of pH in Containment Pools to Prevent Iodine Re-evolution

- GEH calculation
  - MELCOR ESBWR model run out to 24 hours provides
    - T-H information
    - CsOH and CsI formation rates
  - ChemSheet model uses MELCOR model output (extrapolated out to 30 days) in conjunction with acid generation rates to calculate evolution of pool chemistry out to 30 days.

- Staff calculation
  - Simplified MELCOR ESBWR model with Iodine Pool Model implemented in the RPV, drywell and wetwell.
  - Evolution of pool chemistry calculated out to 7 days.

- Staff Conclusion
  - iodine trapped in pools does not re-evolve and confirms GEH analysis

Regulatory Review Issue

- Does the ESBWR design provide adequate mitigation of radiological consequences in an event of a major reactor accident to protect public health and safety, meeting the dose acceptance criteria specified in 10 CFR 100 and 10 CFR 52.47?

Staff Conclusion

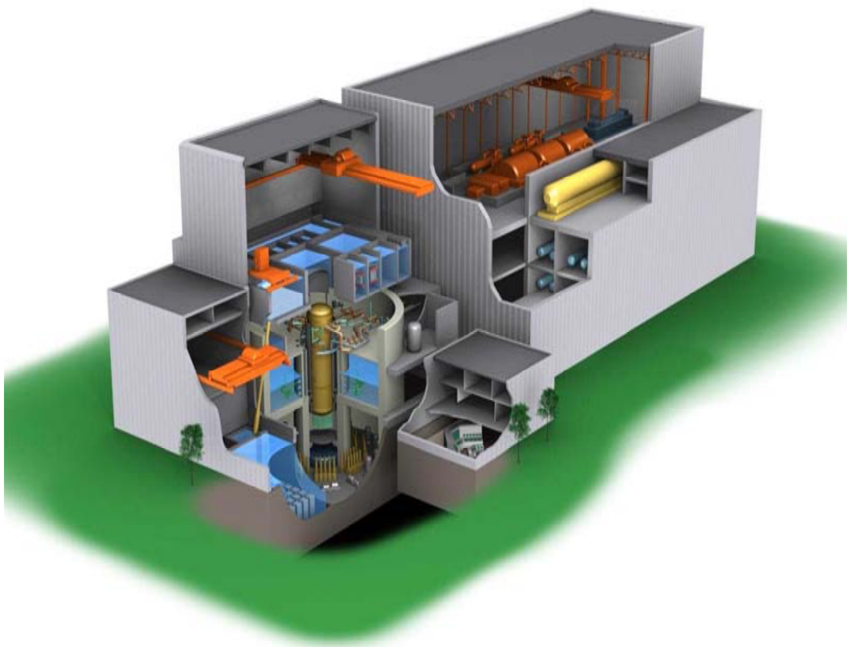
- An independent confirmatory calculation by the staff confirmed the GEH analysis.

- The staff concludes that ESBWR meets the relevant dose acceptance criteria.

Discussion/Committee Questions

Control Room Habitability and Reactor Building Mixing/Holdup Analysis

Advisory Committee on Reactor Safeguards



Antonio Barrett

Mike Arcaro

November 17, 2009

GE Hitachi Nuclear Energy

HITACHI

Agenda

- Control Room Habitability Area (CRHA) Thermal Analysis Model Description / Assumptions / Results
- CRHA Thermal Analysis Alternate Calcs / Sensitivity
- CRHA GDC 19 Design Parameters
- CRHA Adequacy of EFU Supply and Circulation
- CRHA Design Validation / Surveillance Procedures
- Reactor Building (RB) Holdup / Confinement Model Description / Assumptions / Results
- Validation of RB Holdup / Confinement-Sensitivity
- Summary

Introduction

A detailed thermal analysis of the ESBWR Control Room Habitability Area has been performed using the computer code CONTAIN 2.0.

The analysis includes the entire Control Building, which accounts for room-to-room interactions.

The analysis considers:
(a) loss of offsite power where normal HVAC is unavailable
(b) safety-related heat loads
(c) some nonsafety-related heat loads
(d) people
(e) lighting
(f) operation of an Emergency Filter Unit (EFU)

Model Description

The rooms of the Control Building are modeled as single nodes connected by concrete.

The thermal mass of the concrete walls, floor, and ceiling act as passive heat sinks that maintain the CRHA temperature within design goal limits.

The summer design goal for the ESBWR CRHA is a bulk average temperature of 93°F at the end of the period of interest (72 hours).

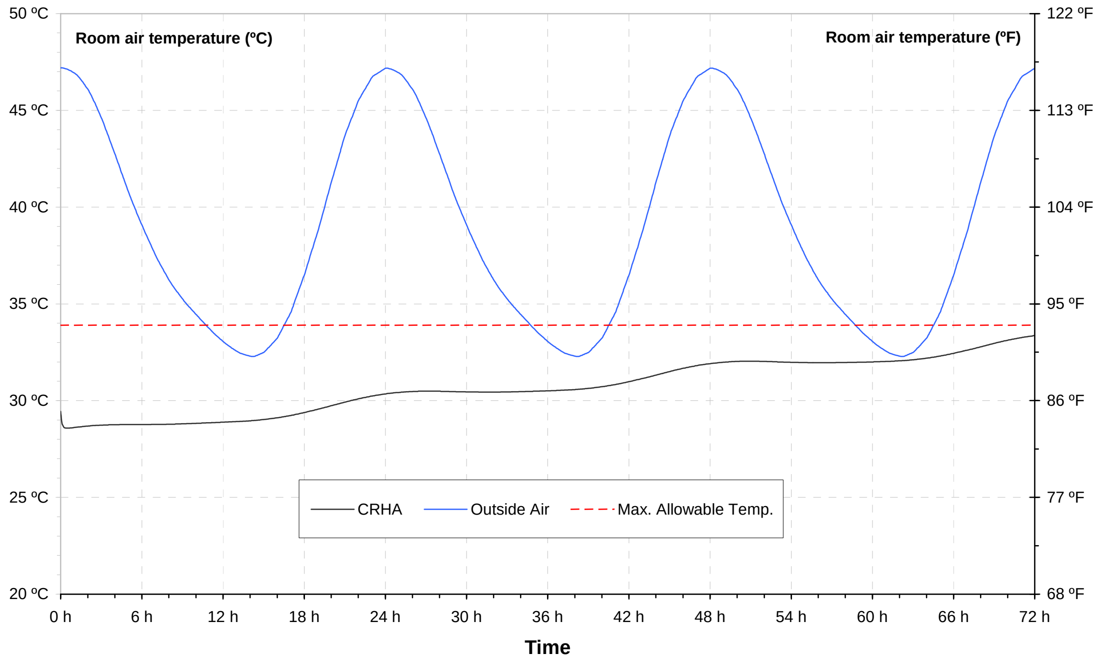
Summer Conditions Major Assumptions

- Total Heat Load – 9630 Watts (max)
- EFU Air Supply Temperature – 117°F (max)
- CRHA Initial Temperature – 74°F (max)
- Concrete Thermal Conductivity – 0.865 W/m°C
- CRHA Initial Humidity – 60% (max)
- EFU Flow Rate – 509 cfm (max)
- CRHA concrete has been exposed to an air temperature of 85°F for 8 hours before initiation of the transient
- Some nonsafety-related equipment deenergized

Summer Results

The analysis results show that the bulk average temperature in the CRHA at the end of the period of interest remains below 93ºF.

The wetbulb temperature is below 75ºF which is below the NIOSH recommendation of 86ºF.



HITACHI

Winter Conditions

An analysis was also performed for winter conditions.

The winter conditions analysis was performed using the code ECOSIM. ECOSIM was validated against the the CONTAIN code.

The winter design goal for the ESBWR is a bulk average temperature of 55°F at the end of the period of interest.

Winter Conditions Modeling/Results

The winter conditions model is similar to the summer conditions model except that is has lower heat loads, lower initial temperatures, and a lower EFU air supply temperature.

The concrete dimensions and thermal conductivity are the same.

The analysis results show that the bulk average temperature in the CRHA at the end of the period of interest remains above 55°F.

Summer Conditions Alternate Calculations

- GOTHIC 7.2a

  More detailed analysis using 3D modeling of the CRHA.

- ECOSIM

  CONTAIN model reproduced using ECOSIM to validate winter conditions calculation.

- 1st Principles Hand Calculation

  Heat transfer calculation to validate CONTAIN analysis.

Sensitivity Analyses

- 0% Exceedance Wetbulb EFU Supply Air Temperature
- Lower EFU Supply Air Temperature
- EFU Flow Rate
- Heat Load
- EFU Supply Air Temperature Profile

ITAAC/Surveillance Requirements

DCD Tier 1 ITAAC Table 2.16.2-4

DCD Tier 2 Chapter 16 Section 3.7.2

Additional clarifications/descriptions requested by NRC staff and will be included in DCD Rev 7.

CRHA GDC 19 Design Parameters

A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including loss-of-coolant accidents

- CRHA provides adequate protection against radiation. For all events, the control room dose is within the dose acceptance limit of 5.0 rem (50 mSv) total effective dose equivalent (TEDE)
- The CRHA temperature / humidity values calculated during the 72 hours following a DBA equate to less than 30°C (86°F) wet bulb temperature
- The CRHA heatup analysis indicates that the average temperature the CRHA would not exceed the 93ºF limit
- The Emergency Filter Unit System maintains CO_2 concentration in the CRHA to less than 5000 ppm

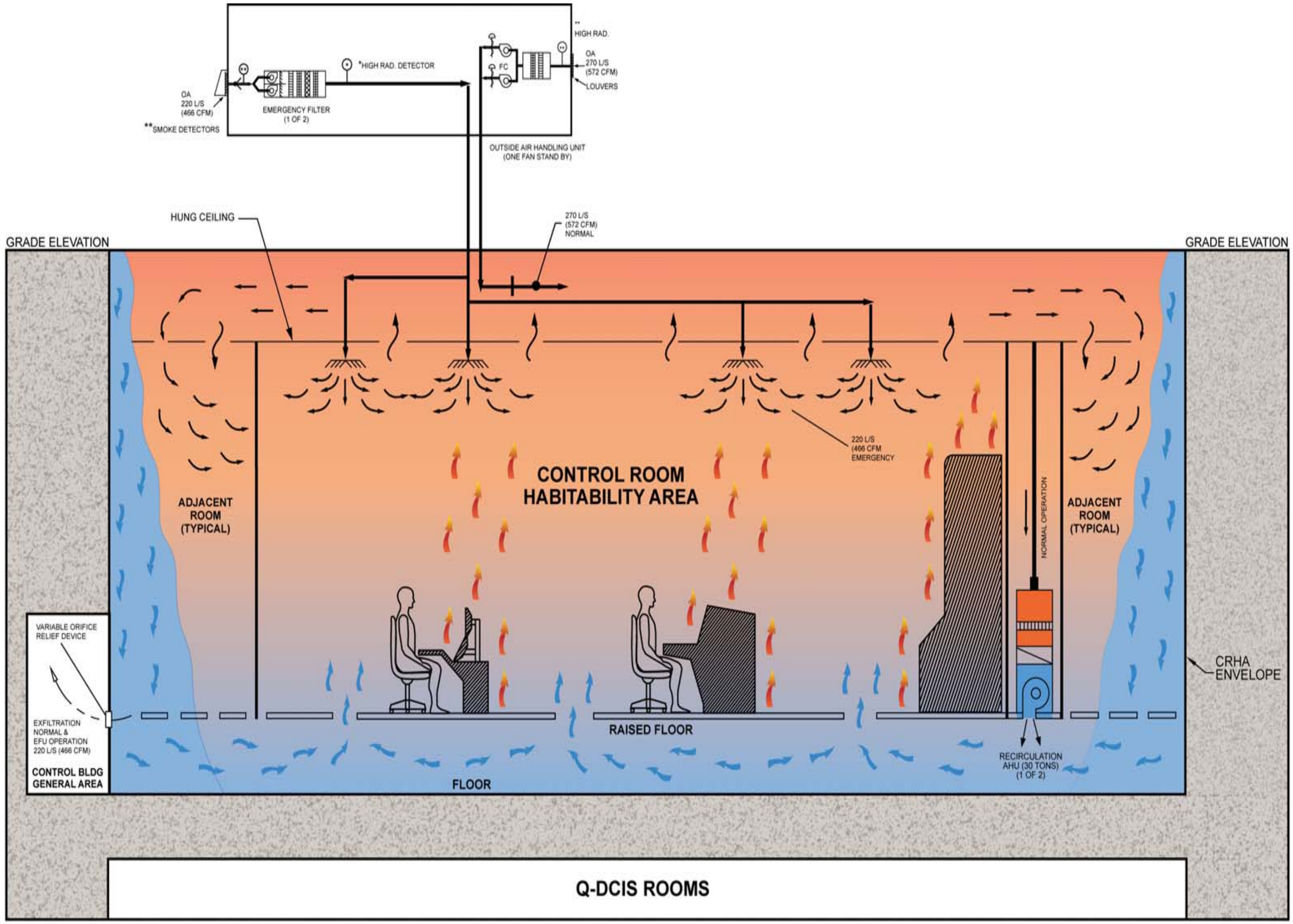
CRHA Adequacy of EFU Supply and Circulation

The CRHA accident HVAC design (mixing and displacement) in conjunction with the convective air currents (due to heat loads/sinks) and personnel movement ensures that temperature is within acceptable limits, buildup of contaminants (e.g., CO_2) is minimal and a freshness of air is maintained.

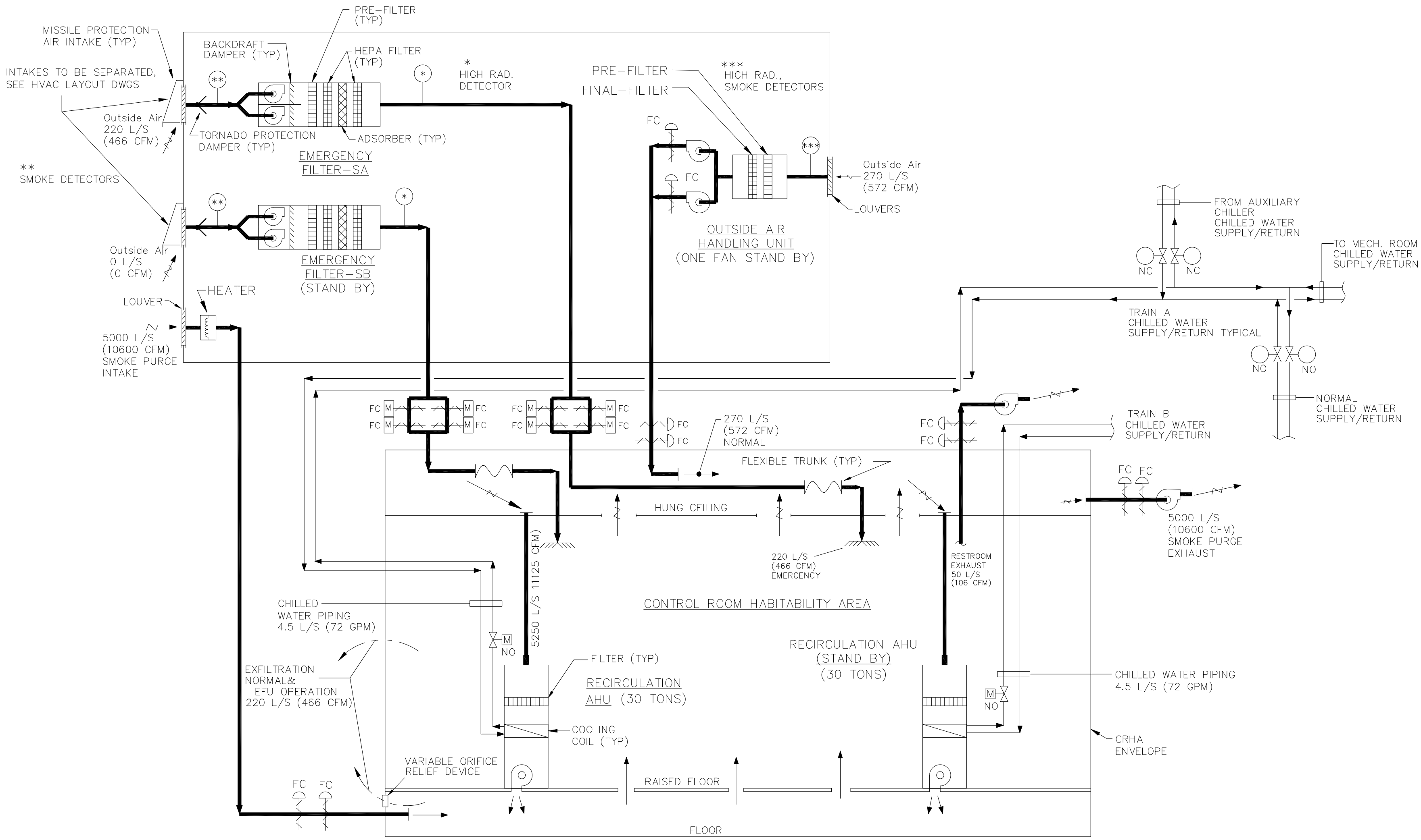
The EFU provides a minimum of 466 cfm of outside air that maintains the freshness of air and provides a positive pressure in the CRHA.

HITACHI

CRHA Adequacy of EFU Supply and Circulation



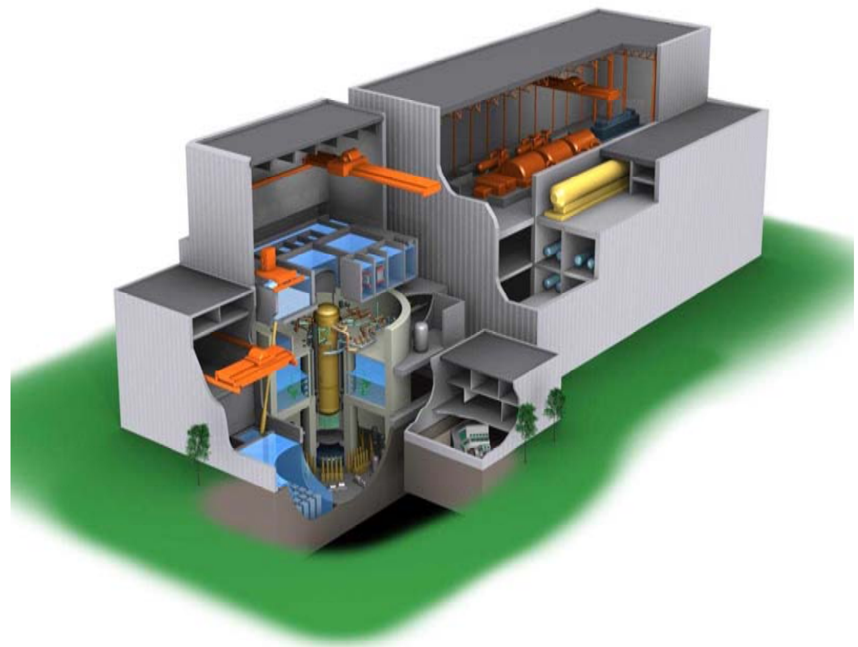
Control Room Habitability Area HVAC



HITACHI

Reactor Building Mixing/Holdup

Advisory Committee on Reactor Safeguards



Antonio Barrett

Mike Arcaro

November 17, 2009

GE Hitachi Nuclear Energy

HITACHI

Introduction

The ESBWR Reactor Building provides a holdup volume and delays the transport of radionuclides from the containment to the environment.

A detailed holdup/transport analysis of the ESBWR Reactor Building using the code GOTHIC 7.2a has been performed.

The analysis of the Reactor Building confirms that the mixing volume assumed in the ESBWR dose analysis is a conservative characterization of the Reactor Building holdup and transport delay of radionuclides.

Model Description

The GOTHIC model includes the Reactor Building contaminated area ventilation system (CONAVS) area and the clean area ventilation system (CLAVS) area.

The rooms in these areas are modeled based on the General Arrangements drawings and considers the connections between the rooms through doors and HVAC ducts.

The GOTHIC model has the same Reactor Building exfiltration rate as the LOCA dose analysis model.

Major Assumptions

- LOCA with fuel damage concurrent with a loss of offsite power and HVAC systems are unavailable
- Leakage from the Reactor Building occurs at the point closest to the Control Building
- The Reactor Building is pressurized to ¼" w.g. pressure due to wind loading
- Reactor Building exfiltration rate of 300 cfm
- Conservative containment leakage distribution location

Containment Release

Most of the mass inside containment during the accident is nitrogen and steam, which carry the radioactive releases.

The ESBWR containment is inerted with nitrogen. The steam comes from the pipe break. Radioactive releases reach the environment via nitrogen or steam.

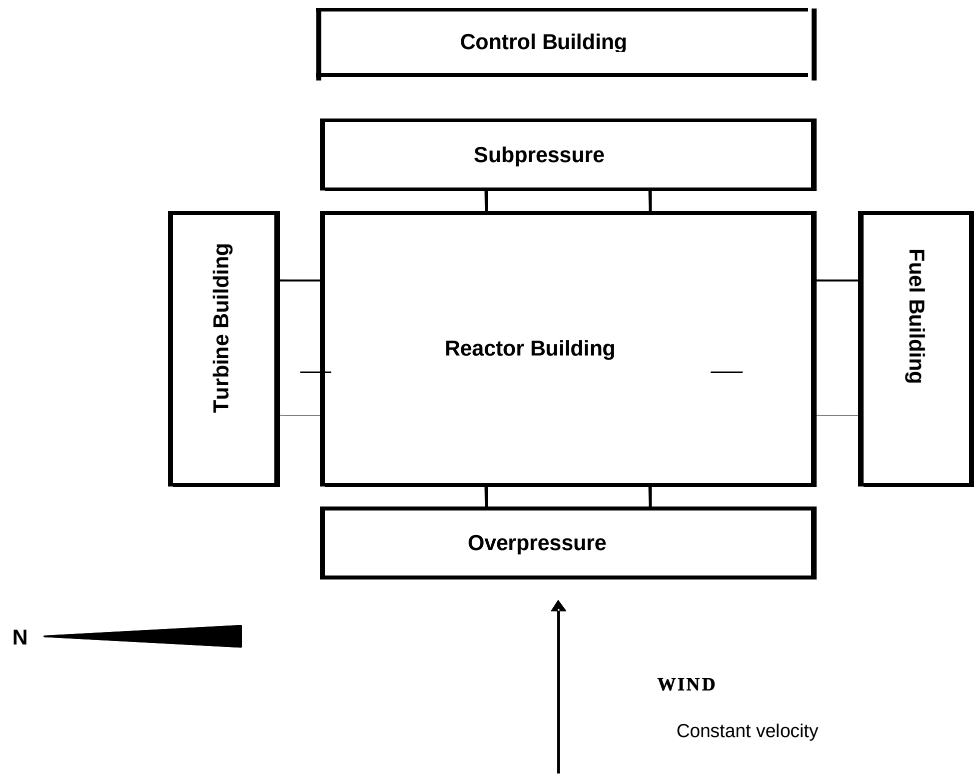
The GOTHIC model uses nitrogen to track holdup and transport of radionuclides, because it will not condense.

Comparing the representative containment releases and RB exfiltration rates allows for a comparison of the GOTHIC and dose calculation models.

Reactor Building Leakage

The Reactor Building is assumed to be pressurized to ¼" w.g. due to wind loading.

A ¼" w.g. pressurization of the Reactor Building results from high wind conditions. The dose analysis assumes calm wind conditions.



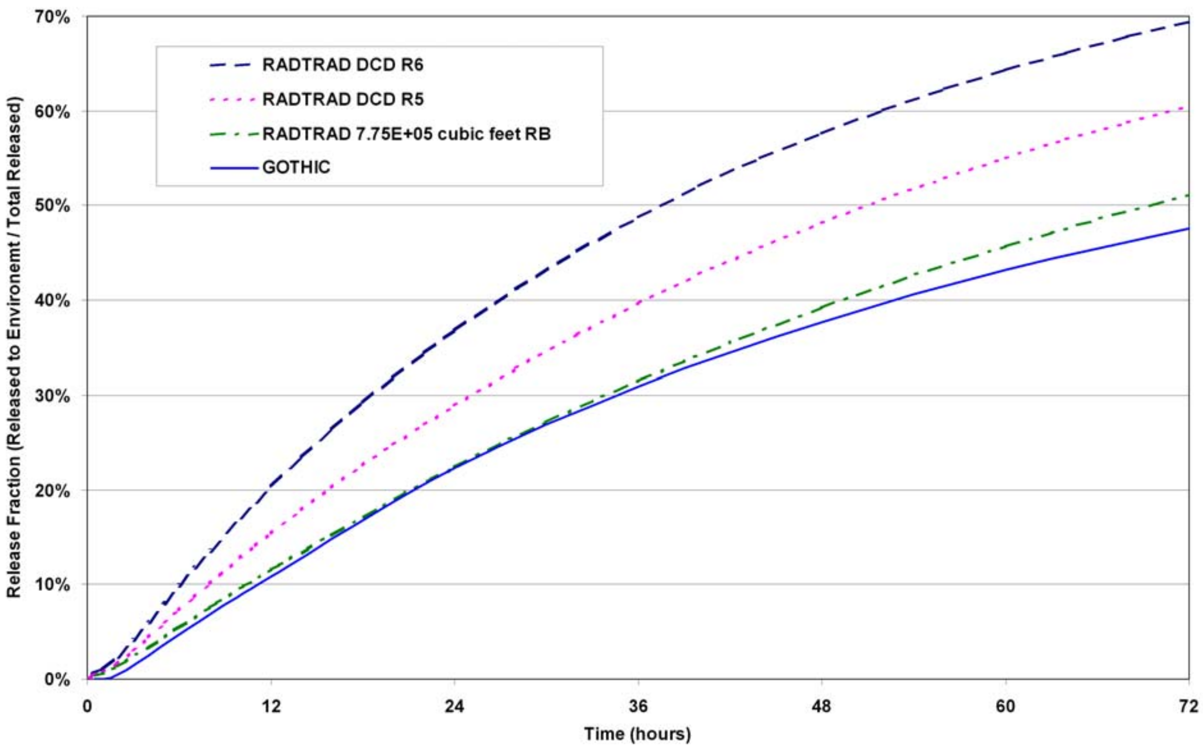
GOTHIC Results

After 72 hours, the ratio of the amount of nitrogen that reaches the environment over the amount released into the RB is approximately 48%.

The dose calculation ratio is approximately 70% when assuming a Reactor Building mixing volume of 50%.

GOTHIC vs Dose Calculation

A comparison between the GOTHIC ratio of release into the environment over the release into the Reactor Building shows that the GOTHIC ratio is always lower than the dose calculation ratio.



Sensitivity Analysis

- Nominal Case (Best Estimate)– Sensitivities run to determine uncertainties; CONAVS boundary most important parameter
- Nominal Case with 300 cfm Leakage
- 30 Day Calculations
- Dose Consequences for Additional Hold up

Sensitivity analyses address NRC staff request to consider model uncertainties, conservatism and adverse effects. GEH concludes that the GOTHIC analysis accounts for theses concerns.

HITACHI

ITAAC/Surveillance Requirements

DCD Tier 1 ITAAC 2.16.5-2 Item 4

DCD Tier 2 Technical Specification (TS) Surveillance Requirement 3.6.3.1.5

HITACHI

Conclusion

The ESBWR Reactor Building design has multiple volumes and flow resistances in the CONAVS area that provide holdup of radioactive releases from containment.

The GOTHIC analysis shows that adequate resistances exist in the ESBWR design when the Reactor Building boundary flows are equal to or less than the flow assumed in the dose analysis of 300 cfm.

The analysis of the Reactor Building confirms that the mixing volume assumed in the ESBWR dose analysis is a conservative characterization of the Reactor Building holdup and transport delay of radionuclides.

Summary

- CRHA design meets GDC 19 habitability requirements
- EFU Supply and Circulation is adequate to support CRHA habitability
- CRHA Design Validation / Surveillance Procedures assure functions will be met
- The ESBWR RB provides a holdup volume and delays transport of radioactivity from the containment to the environment
- Periodic testing verifies the RB exfiltration rate is less than the limit assumed in the radiological analyses

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Section 9.4,“HVAC,” and
Section 6.4, “Control Room Habitability System”
Ventilation Issues

Presented by

James O’Driscoll, NRO/DSRA/SBCV

November 17, 2009

Purpose

- Brief the Subcommittee on the staff's review of the ESBWR design certification application, Chapter 9.4, "HVAC," and Section 6.4, "Control Room Habitability System"; ventilation issues
  - Previous briefing on this issue was given to the subcommittee on November 15, 2007.
- Answer the Subcommittee's questions

Project and Technical Review Team

- **Project Managers**
  - Dennis Galvin, Chapter 9 Project Manager
  - Ilka Berrios, Chapter 6 Project Manager
  - Amy Cubbage, ESBWR Lead Project Manager

- **Technical Reviewer**
  - Jim O’Driscoll, Lead Technical Reviewer
  - John McKirgan, Branch Chief, SBCV

Staff Focus

- Expected performance of the Passive cooling of Control Room Habitability Area and Reactor Building
  - Ability to maintain habitability and operability of equipment for 72 hours following an accident.

- Post Accident EFU Operation
  - Quantity of Air Supply
  - Air distribution, mixing, flow paths, and temperature
  - Carbon Dioxide Levels
  - Power Supply

RAI Status Summary

- Section 9.4
  - Issued RAIs = 58
  - Resolved = 53
  - Open Items = 5

- Section 6.4
  - Issued RAIs = 23
  - Resolved = 20
  - Open Items = 3

RB and CRHA Temperature Control

- Can passive cooling of ESBWR CRHA and RB maintain habitability and operability of equipment for 72 hours following an accident?

- Key Questions for a review of this feature:
  - Determine reasonable habitability acceptance criteria for CRHA temperature
  - Determine required level of detail for a supporting heat up analysis
  - Determine appropriate level of configuration control

Staff Review Approach – Temperature

- Review supporting heat up analyses of RB and CB
  - Review proposed performance goal
  - Review input assumptions in DB calc
  - Review alternate method calculations
  - Identify insights in analyses vs. DB information and ITAAC
  - Identify sensitivities
  - Address uncertainties

Staff Review Approach – Temperature

Applicant Actions completed

- CONTAIN 2.0 analysis submitted
  - as the DB calculation for the CRHA analysis
- CRHA GOTHIC analysis submitted
  - to demonstrate mixing in MCR
- First principle calculation submitted
  - as alternate method of demonstration of passive heat removal
- ITAAC added
  - to update and validate DB calc with as-built dimensions (CRHA only)

Staff Actions Completed

- Staff review of CONTAIN 2.0 analysis of CRHA
- Staff review of CONTAIN 2.0 analysis of RB

Staff Actions Ongoing

- Staff review of GOTHIC analysis
- Staff review of first principle calculation
- Review of RAI responses

Staff Review Approach – Temperature

Applicant's CHRA Maximum Temperature Criteria

- Based on EPRI Utility Requirements Document guidance: CRHA max temperature rise limited to 15^{o}F for a MCR with a normal temp range of 73-78^{o}F
  - Proposed ESBWR CRHA temp acceptance criteria: <93^{o}F
    - ESBWR CRHA max temp limited to 74^{o}F per TS; allowing a maximum rise of 19^{o}F

Applicant's Outside Environmental Input Assumptions

- 117^{o}F coincident with 80^{o}F wet bulb.
- 0% exceedance value; as per EPRI URD
- Temperature cycle 27^{o}F: From ASHRAE Fundamentals Handbook
  - A representative site was chosen for this temperature swing

Staff Review Approach – Temperature

Applicant's Operator Functionality Criteria

- Widely used industry standards for heat stress
  - WBGT <86^{o}F allows unlimited stay time for light work

Applicant's Outside Environmental Input Assumptions

- 117^{o}F coincident with 80^{o}F wet bulb.
- Daily temperature cycle results in outside air relative humidity to cycle daily from 20% to 45%;
- Heat up analysis assumed a maximum normal CRHA humidity of 60%
  - Starting value equal to NUREG 0700 guidance for maximum normal CR humidity range.

Summary of Submitted Analyses

CRHA Temp at the end of 72 hour passive cooling

- Design Basis: CONTAIN single node model
  - Bulk room temp result: 92^{o}F; 43% RH

- GOTHIC Multi-node model
  - Demonstrates Mixing

- First Principles Calculation
  - Bulk room temp shown to be 91.3^{o}F

CONTAIN Review Actions

- Reviewed CRHA heat up calc report and data files
  - No issues

- Sensitivity Studies
  - Concrete density
  - Concrete specific heat
  - Humidity of outside air
  - Heat transfer Area
  - Outside Air temp
  - EFU fan flow rate

<u>Some sensitivity exists in concrete density;</u>
<u>other parameters have less sensitivity</u>

GOTHIC Review Actions

- Applicants GOTHIC analysis was designed to demonstrate convective mixing in the MCR due to temperature differences
  - Different model than CONTAIN
  - Used 20% lower sensible heat loads than CONTAIN
  - Used lower EFU fan flow
  - Used higher initial heat sink temperature

- Staff will compare GOTHIC against the DB analysis
  - Case 1: Staff run of applicant's input file- no changes
  - Case 2: Match to CONTAIN input assumptions

<u>STAFF is still reviewing GOTHIC analysis</u>

First Principles Calculation Review Actions

- Applicant submitted this analysis as an alternate demonstration of the CRHA passive cooling mechanism.

Currently under review by Staff

Insights From Staff Analyses

- CONTAIN model has some conservatism
- GOTHIC has demonstrated convective mixing is expected
- Highest temperatures observed in GOTHIC model
  - Primarily impacts equipment qualification assumptions
  - Closer agreement would support use of the proposed DB model
- Related Open Items to these insights:
  - More Specific definitions and references to DB Heat up Calc required in Tier 2
  - More Specific ITAAC description and Tier 1 information required

Insights From Review Of Analysis

Applicant's CONTAIN and First Principles results are close to the acceptance criteria of 93^{o}F at end of 72 hours

- Maintenance of margin important. Configuration control is important

Related Open Items:

- EQ Branch: more details on how EQ service temperature will be determined.
  - Explanation why bulk room temp would be bounding for equipment inside cabinets
  - Description of controls used ensure enclosures are designed correctly
- Description of controls used to maintain passive heat sink configuration and heat load assumptions during life of plant
- ITAAC needed to update and validate DB calc with as-built dimensions (RB)

Post Accident CRHA Air Quality

- Will the air quality be acceptable in the CRHA at the end of the post 72 hour cooling period?

- Key questions for a review of this feature:

  – Determine reasonable habitability acceptance criteria- air quality
    - Quantity of air supply
    - Carbon dioxide levels

  – Determine if there is assurance of air distribution and mixing

  – Determine the required level of detail need in DCD for related design features

  – Determine the level of configuration control need

Staff Review Approach – Air Quality

- Review supporting heat up analyses of RB and CB
  - Review proposed performance goal
  - Review CRHA design features to assure goal will be met
    - Identify insights in analyses vs. DB information and ITAAC

Staff Review Approach – Air Quality

Applicant Actions Completed

- Air supply, distribution and mixing
  - DCD states design adheres to ASHRAE 62.1-2007 air quality for 21 people
  - Remote exhaust added below occupied zone of CHRA
  - EFU air delivery will be optimized to deliver air to occupied zones of CHRA
- Power supply
  - EFUs now powered by RTNSS ancillary DG post-72 hours

Open Items

- Design and instrumentation requirements for remote exhaust path
- Other details or actions to promote convective mixing / prevent short cycling of supply air
- Details of design intent of airflow and how CRHA air flow optimization will be accomplished

Discussion/Subcommittee Questions

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Section 6.2.3, “Reactor Building” Mixing Issues

Presented by

Edwin Forrest, NRO/DSRA/SBCV

November 17, 2009

Reactor Building Mixing

- NUREG – 1242 - allows hold up to be considered
  - Tested, Concrete Steel Safety Envelope - CONAVS
  - Exfiltration less than 25% volume per day
  - ESBWR exfiltration is ~ 50% volume per day
- GOTHIC Analysis demonstrates holdup
  - Comprehensive Assessment /Sensitivity Studies
  - Subject to assumptions, physical parameters
- Staff Evaluation
  - Simplified multiple room holdup assessment
  - Results consistent with GOTHIC analysis predictions
  - RADTRAD 50% mixing assumption is conservative