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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

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SUBCOMMITTEE ON THE ESBWR COL APPLICATION

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MEETING

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THURSDAY,

AUGUST 21, 2008

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ROCKVILLE, MARYLAND

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OPEN SESSION

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., DR. MICHAEL L. CORRADINI, Chairman, presiding.

MEMBERS PRESENT:

MICHAEL L. CORRADINI, Chairman

SAID ABDEL-KHALIK

GEORGE APOSTOLAKIS

DENNIS BLEY

MEMBERS PRESENT (Continued):

CHARLES H. BROWN, JR.

WILLIAM SHACK

JOHN W. STETKAR

ACRS CONSULTANT PRESENT:

THOMAS S. KRESS

NRC STAFF PRESENT:

MARK CARUSO

DONALD DUBE

ROCKY FOSTER

ED FULLER

GARY MILLER

ERIC OESTERLE

HAROLD VANDER MOLLEN

ALSO PRESENT:

JUSTIN HOWE

MOHSEN KHATIB-RAHBAR

JONATHAN LI

GLEN SEEMAN

RICK WACHOWIAK

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

(8:34 a.m.)

OPENING REMARKS AND OBJECTIVES

CHAIRMAN CORRADINI: Let's get going here. The meeting will come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, the Subcommittee on the ESBWR. My name is Mike Corradini, Chair of the Subcommittee.

Subcommittee members in attendance today are Said Abdel-Khalik; Bill Shack; John Sieber, perhaps not; John Stetkar; Dennis Bley; George Apostolakis; and soon to be Charlie Brown.

MEMBER BROWN: Thank you.

CHAIRMAN CORRADINI: And Tom Kress, a consultant to the Committee. The purpose of this meeting is to discuss the probabilistic risk analysis and severe accident management strategies which form the basis of chapter 19 of the SER with open items associated with the ESBWR design certification application.

The Subcommittee will hear presentations by and hold discussions with representatives of the NRC staff and the ESBWR applicant, General Electric Hitachi Nuclear Energy, regarding these matters. The

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

Harold Vander Mollen 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 July 22nd, 2008. Portions of this meeting may be closed to protect information that is proprietary to General Electric Hitachi Nuclear Energy and its contractors pursuant to 5 USC 552(b)(C)(4).

And just a side note, if we're coming to that, I would really appreciate if GEH tells us that before we enter into it and have to backtrack. So if we're coming to something that's proprietary, give us fair warning so we can close the session.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard. We have not received any requests from members of the public to make oral statements or written comments.

So we'll proceed with the meeting. And I will call upon Rick Wachowiak of General Electric Hitachi Nuclear Energy to lead us off.

PRESENTATION OF SEVERE ACCIDENTS

MR. WACHOWIAK: All right. Good morning, everyone. To start with, my name is Rick Wachowiak from General Electric Hitachi. I've got with me this morning for the first part of the session Glen Seeman, senior engineer in the ESBWR PRA group. He mainly works on thermal hydraulics in the severe accident area.

Just as a bit of background on this, on the proprietary portion that you brought up a minute ago, there are aspects of the BiMAC test report that are proprietary.

And just so that you would all know, as you brought up this morning, those things that in the report are marked with double brackets and then a superscript next to them, those are the proprietary things. So if we get into anything that is associated with the dimensions or specific performance of the BiMAC, anything that you would need to construct it essentially, then we would have to move to a proprietary session on that.

My slides that I have out here do not contain any of that information. Everything that's on the slides is public.

CHAIRMAN CORRADINI: So, just to make sure that the members are all on the same page, so if we're going to want to ask questions about that, if we start going down that path, let's try to note that. And we'll close the session at the end if necessary to get back to dimensional -- if there are things that come down to dimensional questions.

MR. WACHOWIAK: Right.

CHAIRMAN CORRADINI: Okay.

MEMBER SHACK: But the dimensions, for example, the refractory layer, are not in brackets because they are not really defined anywhere.

MR. WACHOWIAK: It is probably not in brackets because it's not defined yet.

MEMBER SHACK: So we can discuss that.

MR. WACHOWIAK: When it's defined, it will be in brackets.

CHAIRMAN CORRADINI: Well said.

MR. WACHOWIAK: All right. So where we are with this is last I'm guessing three or four months ago we had a meeting on --

CHAIRMAN CORRADINI: June 3rd.

MR. WACHOWIAK: June 3rd? That's about three months ago, three and a half or so. We had a meeting discussing the chapter 19 SER and draft SER with open items. And we ran short of time. So we didn't get to the severe accident area. And this first session this morning is intended to pick up where that left off.

So in the severe accident area, we're required to do two things. We're required to discuss the severe accident prevention and mitigation. And then, in addition, there's a section or a requirement that we talk about alternatives in the design, where we could reduce the risk of severe accidents.

The previous sessions that we had discussed the areas where we were recovering severe accident prevent ATWS, SBO. Those are level 1 PRA things, internal and external events.

So we're not going to cover that in this meeting. What we're going to cover here are the things that are addressed just in the severe accident area, things like hydrogen control, debris coolability, high-pressure melt eject, that sort of issue.

Everything that we have is contained in one of three documents. And, actually, there is a fourth document here that I should mention since it's referenced now.

DCD chapter 19 has the insights from the severe accident analysis and a brief description of what we did. NEDO-33201 is the PRA. And chapter 21 of that is the severe accident phenomena discussion. NEDO-33306 is the SAMDA report, where we discuss the cost-benefit analysis of adding additional features to the design to eliminate severe accidents.

And the one that I don't have on here is the test report for the BiMAC. Do you remember what the name of that is?

MR. SEEMAN: I believe it's 33392.

MR. WACHOWIAK: Thirty-three, three ninety-two?

MR. SEEMAN: Yes.

MR. WACHOWIAK: Okay. And I believe you have that report already because the question came up on what the funny markings were in there.

MEMBER SHACK: I don't think we have 33306, though.

CHAIRMAN CORRADINI: Yes, we do. That's the one I was going to ask about. That's your cost-benefit. Can you repeat what that one is?

MR. WACHOWIAK: Severe accident mitigation design alternatives.

CHAIRMAN CORRADINI: I don't think we have that. I have been looking as you were talking.

MR. WACHOWIAK: That has been submitted.

MR. OESTERLE: Yes. I'll have to check on that.

CHAIRMAN CORRADINI: That's fine. That's fine. All the others we have in some CD or electronic form.

MR. WACHOWIAK: And I'm not really going to get into that a lot here. It's in the SER. But, as we can see through this, we anticipated a lot of things that would go into the SAMDA report during the design.

So in the end, the answer, are there additional things that you can add to reduce severe accident threats, comes out essentially to be no, there are no other cost-beneficial ones because during the design, we pretty much got at --

MR. FULLER: This is Ed Fuller from the

NRC staff.

Regarding that, particular severe accident mitigation design alternatives, it came in as a response to an RAI we put out to NRC just about a year ago. And because it was a response to an RAI, it may have not gotten the visibility that it otherwise might have gotten had it come in as a stand-alone topical report.

CHAIRMAN CORRADINI: Okay. We can deal with that later. Go ahead.

MR. WACHOWIAK: Okay. One of the other questions that came up is that in some of the reports, like the BiMAC report, there's a reference to the severe accident treatment report, SAT report.

You don't have that as a separate report. That was supplied as an RAI response. However, everything that is in the SAT report is in chapter 21 of NEDO-33201. It's just reformatted to match the GE document guidelines. The SAT report is a UCSB-formatted document. Really, the only difference is the formatting.

CHAIRMAN CORRADINI: The information is there.

MR. WACHOWIAK: The information is the

same.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. WACHOWIAK: So let me quickly try to cover how we addressed severe accidents in this plant. And it's somewhat different than has been addressed in existing plants.

We look at each threat for what can affect the containment containing the core melt debris. And we look for different failure modes and basically come up with a set of things that can affect the containment from the different threats.

Then we analyze what mitigating features we have or what mitigating features we need to add to address those things. So where we depart -- and that's fairly typical for doing a level 2 PRA.

Where we depart, then, is we look at whether or not that particular mitigating feature can be treated probablistically or not. We know a lot about how systems will perform, reliability of systems. That is a statistical treatment.

We know that we can apply failure rate distributions to components and to systems in a fault tree/event tree methodology that will give us a pretty good idea of how reliability those will perform. But we have other things that are in there that are just uncertain or unknown. How much melt will come out of the core following a core damage event is one example.

There are ways we can calculate that. There are different codes that show different amounts of material that would exit the vessel over a given time period. But we really don't know all the parameters that control that. So we'll say that that's not a probabilistic something that can be treated probablistically. And we'll try to treat those in a bounding manner.

The key to that is if you try to treat things that are just unknown probablistically, you have the potential of diluting their impact. If you say that 50 percent of the time there is a large amount of core debris and 50 percent of the time there is a small amount of core debris because we're not sure which side it is in, well, then 50 percent of your probability goes to the more benign side and you don't know whether or not that was the important side. If it really is 80 percent, 90 percent, whatever the large amount of core debris is, if there's large fraction there, that could have a much bigger impact on the results.

So in our analysis, we tried to make a determination. Do we know that this behaves in a statistical manner? If so, we treat it that way. We'll build a fault tree model. We'll set up success criteria. We'll put it through the fault tree/event tree process.

If we don't know that, it's just things that are associated with unknowns, we'll treat them in a bounding manner. So we'll assess what are the bounding conditions.

Do we know in that example about how much melt can come out. Can it be more than X amount? I think in the end, what we determined for some of these cases is it can't be more than 100 percent. We're pretty sure that it can't be more than 100 percent of the melt comes out. So we would use that as a boundary condition.

So we set up boundary conditions on these things that we don't know. We look at the fragilities of the containment essentially is what we're looking at there. And can these bounding loads affect the containment? If so, we'll treat the containment as failed in that situation and try to add different mitigative features or determine whether or not that the chance of getting into that situation is low enough or we'll add new mitigating features. That's kind of how we got the BiMAC into the ESBWR.

MEMBER APOSTOLAKIS: So what's the down side of it? On the left, where you say "No," is it more costly?

MR. WACHOWIAK: It has the potential to be more costly because we are adding features associated with things that are unknown.

MEMBER APOSTOLAKIS: And bounding.

MR. WACHOWIAK: And bounding, yes. It's bounding. So we may not need that feature. If this phase -- you know, I'm not sure what we do about that. You know, that's kind of where you end up in nuclear power design. So you end up adding features that you may not need but just in case.

The down side from the PRA, really, is that once we have decided that we need something based on a bounding analysis, it is really hard to understand what the importance of that thing is because it has been determined a priori that it is important.

So the BiMAC if you looked at the risk achievement worth in the PRA of the BiMAC, it comes out to be huge because we didn't analyze what happens if the BiMAC is not there.

CHAIRMAN CORRADINI: Then that answers a question I have been trying to dig out of all of the reports. So you did not calculations on the branch that the BiMAC is not functioning and you go into a condition that would look a lot like the ABWR, which you essentially have core concrete attack?

MR. WACHOWIAK: Right. Now, we did have a question early on "What happens if you get down onto that branch?" And I believe in response to an RAI, we provided an ABWR-like analysis that basically it took all of the parameters that the ABWR used for that same situation and calculated what the likelihood of a basemat breach or lower drywell wall breach would be based on that.

Once again, that doesn't fall into this category here because we don't know whether or not the melt is going to behave in such a way that we can just pour water on the top and, whatever it was, 90 percent of the time that the melt will be coolable.

MEMBER SHACK: But I was looking for a

commitment for example, to types of concrete that would minimize your gas generation. And I didn't find that.

MR. WACHOWIAK: Right.

MEMBER SHACK: So, I mean, when you say you didn't get down that path, you don't even have that as sort of a defense-in-depth kind of a backup, which you would have in the ABWR.

MR. WACHOWIAK: Right.

MEMBER BLEY: Which is the down side George was asking about.

MR. WACHOWIAK: That's the down side. That's the down side of doing it this way. We added a core measure. Maybe to absorb some of that expense, we didn't go down that path. I don't --

MEMBER APOSTOLAKIS: I have two questions. You said that if you calculate the risk achievement work of BiMAC, it's huge. I'm a bit confused. How do you calculate overall for something that you have not quantified?

BiMAC is there as a defense-in-depth measure for bounding things, right?

MR. SEEMAN: It has no meaning.

MEMBER APOSTOLAKIS: The second question

is I understand how you got on the left there how you're trying to bound things, which, you know, we have been doing this for decades.

But then ROAAM, the R in ROAAM stands for risk. So I don't understand how the methodology that is risk-oriented is used in a bounding analysis. Is there a trick there I don't see?

MR. WACHOWIAK: Yes. The trick is the way that I organized this. The ROAAM review is looking at those bounding things. But the ROAAM process is the entire page. So it's deciding which things are probabilistic and which things are deterministic is part of the ROAAM process.

MEMBER APOSTOLAKIS: Okay. So it should have been on the title?

MR. WACHOWIAK: Okay. Yes. But I was looking here at the specific --

MEMBER APOSTOLAKIS: You put risk and --

MR. WACHOWIAK: The box there is the specific review that we did. It's not the ROAAM process. The ROAAM process --

CHAIRMAN CORRADINI: I guess I don't want to get into nitpicking, but back 25 years ago for the containment loads working group, the cartoon would look very similar.

Back in '83, when NRC staff was trying to essentially understand all of this, it kind of came down to, in fact, they invented some computer model that I don't -- I think it was called event tree by Vance Bier at Sandia, which said certain things are systems. And you would then do essentially a success criteria branch.

MR. WACHOWIAK: Right.

CHAIRMAN CORRADINI: Certain things are physical processes, which we think we know, we don't really know, we have some physical feel for. And you would take it down this path, where you would have to come up with ranges of initial and boundary conditions and then see how that evolves the accident.

So I am struggling a bit because that cartoon really hasn't changed in some sense, at least in my mind, for about 25 years. What makes this --

MEMBER APOSTOLAKIS: Why should it change, Mike?

CHAIRMAN CORRADINI: I don't think it should, but you said, you started this whole thing off saying, this is unique. And I'm struggling to think that --

MR. WACHOWIAK: Okay. Maybe it's not unique. It's different than what is currently being done for level 2 in --

CHAIRMAN CORRADINI: Okay.

MR. WACHOWIAK: Maybe it's unique to me because --

CHAIRMAN CORRADINI: That's fine. That's fine.

MR. WACHOWIAK: -- I wasn't around 25 years ago.

(Laughter.)

DR. KRESS: Neither was Mike.

MR. WACHOWIAK: Okay. I deserve that. I deserve it.

CHAIRMAN CORRADINI: But you are saying current operating plants won't look at it this way.

MR. WACHOWIAK: Right. And if you go into the ABWR level 2 assessment, it doesn't look at it this way. It tries to assign split fractions to every phenomenon.

CHAIRMAN CORRADINI: Okay.

MR. WACHOWIAK: And sometimes is it high versus low? Okay. High versus low, 90 percent, 10 percent. Do we just not know? Fifty/fifty. And it tries to assign a split fraction to everything. And what you end up is you lose the tails of the distributions that way. They end up going away in the quantification.

MEMBER APOSTOLAKIS: That's where they use the expert opinion elicitation process.

MR. WACHOWIAK: Right.

MEMBER APOSTOLAKIS: They didn't just say it. Anyway, we understand.

MR. WACHOWIAK: Okay.

MEMBER BROWN: Can I ask a question since I am ignorant? Somebody talked about why if you have the BiMAC you wouldn't have as additional defense-in-depth the original concrete?

CHAIRMAN CORRADINI: An analysis of it.

MEMBER BROWN: An analysis. Were you leaning towards if you're going to have the BiMAC, you still ought to have the concrete anyway or is there --

MEMBER SHACK: I was asking a question for information at this point.

MEMBER BROWN: Well, I mean, we are trading one for the other. You've got concrete. I don't know whether everybody knows, but I presume there was some analysis because being ignorant, I can ask this kind of a question, what type of response we would have expected back with the ABWR based on some analysis or test that we did back then, 15 years ago or whatever. And now we've got the BiMAC, which is supposedly better that concrete. Yet, the report -- pardon?

MR. WACHOWIAK: I was trying to think if I had --

MEMBER BROWN: Yes. Well, the --

CHAIRMAN CORRADINI: Actually, he's going down the path which I want you to finish this, which is if you answer this to the staff, if the ESBWR looked like an ABWR in performance, where there was no BiMAC, you have what you consider a bounding calculation of how it would perform.

MEMBER BROWN: I lost that, Mike.

MR. WACHOWIAK: You have an --

MEMBER BROWN: You said you submitted to the staff --

MR. WACHOWIAK: -- an accepted method of calculation of how it would perform.

MEMBER BROWN: The concrete or the BiMAC?

MR. WACHOWIAK: The concrete.

MEMBER BROWN: Okay. So that's --

MR. WACHOWIAK: And so since you are new on this, the --

MEMBER BROWN: Really new.

MR. WACHOWIAK: -- relatively new on this Committee, I don't have the slide on here. We have used it before. It kind of shows where the BiMAC is. In the ABWR, there is a block, if you will, of sacrificial concrete that is the low-gas concrete that you are talking about that is meant to be ablated by the core. And that area or that volume is being replaced with the BiMAC.

So when we did the analysis, we looked at just what the basemat would be, which is the limestone. Well, actually, we looked at both. We looked at both there: the limestone and basaltic concrete.

And we can -- I don't know -- at the break or maybe for tomorrow look up some of these results, but --

MEMBER SHACK: That would be good.

MR. WACHOWIAK: But what I remember from this is that the ablation rate with the low-gas concrete was higher. And we got to a basemat failure faster, but less gas was generated. But in both cases, we generated enough gas to overpressurize the containment requiring venting.

CHAIRMAN CORRADINI: Within 24 hours?

MR. WACHOWIAK: That's the part I don't remember.

CHAIRMAN CORRADINI: That's the critical part I'm curious about. Okay. Thank you. Because Charlie's question, actually, is what I eventually wanted to ask when you had mentioned that you had submitted something to the staff.

MR. WACHOWIAK: And from way back when -- and we'll look this up. My recollection is that we were okay for 24 hours. It was after 24 hours that you ended up needing to either vent or you would go through the thickness of the basemat or the lower drywell.

While that meets the regulations, you can have the intact barrier for 24 hours. And our thought is that there is really nothing you can do about it, though. So then what?

Okay. So you can make it 24 hours and then 24 in the first 25th hour, you have a problem.

That's maybe you can do things with sheltering/evacuation off site there, but why not go through and put in something like the BiMAC that can essentially eliminate the need for having to go down that path?

That was what our thinking was. And, as such, we didn't necessarily put or we didn't actually put it into the base analysis because the analysis of the BiMAC basically got us to the scenario where the release due to BiMAC failure was already a low enough frequency that we didn't need to pursue that branch further.

MEMBER BROWN: In terms of the BiMAC relative to concrete, old stuff versus new stuff, the reports talk about tests that you have run. And there are some results, which I guess are supposed to be presented at some point.

Were there tests run on concrete? So we don't have a comparison of some similar type of testing regimen in terms of the performance of old stuff versus what you had.

DR. KRESS: There is a large database on tests run on concrete with melt that was done in the past, mostly at Sandia but at other places.

MEMBER BROWN: In a manner which tried to simulate the melt similar to what they talked about in the report of electric heating burning everything up or what have you?

DR. KRESS: Yes.

MEMBER BROWN: Okay.

MR. WACHOWIAK: And we are going to rely on those older tests, rather than repeating the specifics.

MEMBER BROWN: I wasn't advocating doing that. I just wondered what was there.

CHAIRMAN CORRADINI: We'll get back to this later. I guess the only lingering question in my mind is, is the ABWR analysis under the conditions there is no BiMAC boundary? That is, is there something about the BiMAC design that doesn't focus the transient loading on the basemat such that you could actually get to by some means, at this point by some means, earlier failure because of some transient effect on the BiMAC, where you focus the heat and get it down to the basemat quicker?

MR. WACHOWIAK: In our estimation, the answer to that should be no, but that's also part of the detailed design, how we design that sacrificial layer, which is --

MEMBER SHACK: TBD?

MR. WACHOWIAK: Which is TBD. We are in the process of doing that now. We have recently determined the space that we have for that layer is now in --

MEMBER APOSTOLAKIS: Excuse me. I see you have a slide on the BiMAC. Could that discussion take place then so --

MR. WACHOWIAK: Yes, sir. I'm sorry.

MEMBER APOSTOLAKIS: Your slide 7 --

CHAIRMAN CORRADINI: Keep on going.

MEMBER APOSTOLAKIS: -- has layers developed.

MR. WACHOWIAK: I was trying to remember if I had that in there or not.

CHAIRMAN CORRADINI: Which? Slide 7? Also number 8.

MEMBER APOSTOLAKIS: Also number 8.

MR. WACHOWIAK: I was just going on precedent from last time, where we spent 45 minutes on the first slide.

(Laughter.)

CHAIRMAN CORRADINI: At least you didn't

mention epistemic and aleatory, George. We could have been on this thing for another 45 minutes.

MEMBER APOSTOLAKIS: It's all epistemic here. You guys don't --

CHAIRMAN CORRADINI: Well, they treat the epistemic in one way and the aleatory in another.

MEMBER APOSTOLAKIS: Let's go.

(Laughter.)

CHAIRMAN CORRADINI: Onward.

MR. WACHOWIAK: So let me move on on some of the specific things that we have discussed: hydrogen generation and control. The issues that we have there are hydrogen detonation and then overpressurization due to the additional noncondensible gases.

So in terms of detonation, basically we followed what 50.44 says is that you can have in order to contain it. So we inert the containment during operation with nitrogen. There is a band of allowed oxygen that is fairly small during operation.

We do have time periods when the containment does not have the inert atmosphere. And that is right just prior to and just following a refueling outage. So the way we treated that in the severe accident analysis and in the PRA was we said: Okay. There is no inerting of the containment during that time frame. We'll not claim any performance of the containment whatsoever during that time frame. So it's a bomb-being scenario.

So every sequence that goes to core damage in the one day prior to fuel, like a fuel reload outage and one day following that, we add into the containment bypass sequence. Certainly it's not that that's bound and you can't be more than bypass.

Once again, it makes it difficult to understand or get a characterization of what the importance of things is during that one day and what the procedure should be because we have assumed no performance of the containment. So that's a limitation of what we're doing. Once again, as we get to this discussion later this afternoon, we think that that is okay for design certification and to determine what design features we need to add to the plan.

The overpressurization is another aspect of this. Basically what we have done there is we have looked at the ultimate strength of the containment.

There is a calculation that's presented in chapter 19(c) of the DCD. And it talks about what the strength of the containment is.

And we do have an analysis that says how much gas is added by reacting all of the zirconium surrounding the fuel pellets. It would be like 100 percent of the reactant.

We compare those two. And I think that's on the next page. The pressure achieved by reacting all the zirconium, even though we don't -- none of our codes predict that we react that much, but all of it is at the bottom end.

MEMBER APOSTOLAKIS: Can you use the cursor? Yes.

MEMBER SHACK: Use the friendly hand.

MR. WACHOWIAK: The friendly hand. Down here it's -- I believe that's .906 was the pressure that we calculate megapascal gauge. It's in DCD, rev. 5.

See, the friendly hand goes away if we leave it.

CHAIRMAN CORRADINI: Sorry.

MR. WACHOWIAK: It's okay.

CHAIRMAN CORRADINI: The friendly laser

is.

MEMBER BROWN: Megapascal and psig.

MR. WACHOWIAK: Here it's --

MEMBER BROWN: Hold it. What's a mega? I'm an English guy.

CHAIRMAN CORRADINI: Ask him. Ten atmospheres.

MR. WACHOWIAK: 1.45 times 10^{-4} is the factor for --

(Laughter.)

CHAIRMAN CORRADINI: Okay, Charlie?

MR. WACHOWIAK: One megapascal is approximately 10 atmospheres.

CHAIRMAN CORRADINI: Correct. That's right.

MEMBER BROWN: A hundred and fifty psig? It's 140 psi?

CHAIRMAN CORRADINI: One hundred forty-five but close enough.

MEMBER BROWN: 14.7 psi for atmosphere, right, if I remember that number? I call it 147, though. So one megapascal is? Tell me that again. I lost it already.

MR. WACHOWIAK: A hundred fifty psig.

MEMBER BROWN: Okay. Ten atmospheres, roughly, megapascal. Okay. I'll remember that until this afternoon maybe.

MR. WACHOWIAK: And we discussed in the DCD what these various things are. The drywell head leakage happens to be the weak point in the steady state analysis at 500 degrees.

Once again, that's probably bounding as well because that drywell head is under water. And it's not necessarily going to be that at that temperature. It may be somewhat lower than that.

CHAIRMAN CORRADINI: So can I ask about the blue curve? All of these are static loads from chapter 21?

MR. WACHOWIAK: Yes.

CHAIRMAN CORRADINI: So there is an analysis in chapter 21 about a dynamic load from an ex-vessel steam explosion. That is not encapsulated in the blue curve?

MR. WACHOWIAK: No.

CHAIRMAN CORRADINI: Okay.

MR. WACHOWIAK: But, once again, this -- and we'll talk about that when we get to the ex-vessel portion.

CHAIRMAN CORRADINI: I just wanted to make sure what was in the blue curve. I'm happy.

MR. WACHOWIAK: Okay. Yes. This is the static load because it's essentially looked at, what happens to get to the overpressurization.

CHAIRMAN CORRADINI: All right. Thank you.

MEMBER BROWN: What is the pressure containment design?

MR. WACHOWIAK: The design pressure is --

MEMBER BROWN: Forty-something?

MR. WACHOWIAK: Approximately 45.

MEMBER BROWN: Okay.

MR. WACHOWIAK: It's also a megapascal number, but --

MEMBER BLEY: About a third.

MEMBER BROWN: I was going to say it's way down.

MEMBER APOSTOLAKIS: The top line says it's .31 megapascal, right? Is that what it means?

MR. WACHOWIAK: Here?

MEMBER APOSTOLAKIS: Yes.

MEMBER BROWN: That's the skin.

MR. WACHOWIAK: Yes, yes.

MEMBER BROWN: Anything that happens -- am I reading this wrong? Anything that happens overpressurizes.

MEMBER APOSTOLAKIS: It's .31 megapascals design.

MEMBER BROWN: Anything that happens overpressurizes. Is that what --

MEMBER SHACK: No, no. Severe accident, design basis.

MEMBER BROWN: Yes. Any of the severe accidents overpressurized.

MR. WACHOWIAK: What this is saying is if you overpressurize past the design, you need to get to approximately three times the design before the containment will start to yield. So the containment won't fail until three times --

MEMBER BROWN: The design pressure.

MR. WACHOWIAK: -- design pressure.

MEMBER APOSTOLAKIS: And why is that?

CHAIRMAN CORRADINI: So that is 135 approximately.

MEMBER APOSTOLAKIS: Could you explain that to me?

MR. WACHOWIAK: The design?

MEMBER APOSTOLAKIS: Why is it three and not four?

MR. DUBE: I think the *x*-scale is off by one. The origin should be one, trying to do the division safety, the risk assessment.

MEMBER APOSTOLAKIS: The origin should be one, which means what, that it is zero? Then you should have gotten it into the left? These are --

MR. WACHOWIAK: I think that the scale is okay. The factor on the design pressure is less important for this PRA than what the actual pressure is.

MEMBER APOSTOLAKIS: I want to understand why there is a design value. We go several times higher. We start seeing a failure. I don't understand.

CHAIRMAN CORRADINI: You start to see what?

MEMBER APOSTOLAKIS: Some probability of failure.

DR. KRESS: That's because the ASME codes have a lot of factors of safety built into them. And the design conforms to the ASME code. There are a lot of factors of safety built into it.

MEMBER BROWN: They are taking the factors of safety out.

MR. WACHOWIAK: That is the way I --

MEMBER BROWN: Best estimate calculation.

MEMBER BROWN: The design value is 45 if you factor -- am I saying this right?

DR. KRESS: Yes.

MEMBER BROWN: You put in factors of safety?

DR. KRESS: Yes.

MEMBER BROWN: If I give you best estimate, it's three or four times that.

MEMBER BLEY: Tom, if I recall right, back some years ago, Sandia tried to blow up some vessels. And that's when we found out how much overdesigned they were.

DR. KRESS: Yes. They actually --

MEMBER BLEY: You had to really pump it way up before it --

CHAIRMAN CORRADINI: That's a fairly typical result from the Sandia tests.

MR. WACHOWIAK: Some of the things to get your head around this to make it easier to see where some of these are is that we're looking at yield here at one in the design. We meet everything on stress limits plus margin. So that's nowhere near yield. So that's probably where most of the origin comes into play.

MEMBER APOSTOLAKIS: In the Japanese earthquake, we were told here that the actual horizontal ground acceleration was two and a half to three times the safe shutdown earthquake. And the damage was minor. It seems to be consistent with this, but there is a factor of about two to three. So that's good. That's another defense-in-depth.

CHAIRMAN CORRADINI: Thank God for those mechanical engineers. Let's keep on going.

MR. WACHOWIAK: I saw a hand go up in the back. It went back down.

So in the PRA report, we don't discuss a lot about hydrogen control, but there is that section on the containment fragility that encompasses that. That will get to the placement of the BiMAC. What we're looking at is ex-vessel core debris coolability.

Some of the current plants that are operating and some of the proposed new designs look at in-vessel core debris coolability so that if they're raising the lower head, you can cool it from the outside.

Once again, we have chosen not to take that position for a couple of reasons. One, the BWR lower head is filled with penetrations for the CRD tubes. And if we want to take credit for those as staying in place with molten debris, we would have to have some mechanism, fairly robust mechanism, of holding those tubes in from the bottom.

Due to maintenance concerns on the plant, it is one issue. We don't have that. Basically they're hanging from the lower head. So that takes us away from being able to credit ex-vessel cooling in this particular area.

The other thing is, though, as we get to the steam explosion part, the ESBWR is the design of the lower drywell where the pedestal has essentially communication to the outside. We don't want to be in a situation where we have a partially flooded containment when you get to the situation where maybe the core would come through the vessel.

So where it started out as yes, it's going to be hard to design an outage if we have all of this other structural material in the lower drywell, we have to maintain these CRD mechanisms, it started out that way going away from the in-vessel retention option. It turns out that it probably would have been extremely difficult to actually implement that in severe accident procedure space because of the competing mechanisms of steam explosion versus keeping the lower head cool.

CHAIRMAN CORRADINI: But that is no different of a conclusion than ABWR came to, right?

MR. WACHOWIAK: Yes, that is part of the conclusion of ABWR. But ABWR is slightly different in that the pedestal wall itself, the outside of the pedestal wall is the suppression pool; whereas, in ESBWR, the outside of the pedestal wall is the environment. So it's a little bit of a different impact having been damaged.

CHAIRMAN CORRADINI: Thank you. I'd forgotten.

MEMBER BROWN: Can you explain that pedestal wall stuff when you get to the pictures?

MR. WACHOWIAK: I can.

MEMBER BROWN: I have no idea what the pedestal is in here. I mean, there are no words that say.

MEMBER APOSTOLAKIS: Let's go to the figure. I would like to understand your questions earlier in the context of the figure. Would you mind repeating that? Are you ready to go to the figure?

MR. WACHOWIAK: I'm almost there.

MEMBER APOSTOLAKIS: Okay.

MR. WACHOWIAK: So, once again, to address this basemat melt penetration issue, we have the large spreading area, just like ABWR. It's the same, essentially the same, spreading area. We still have to flood the drywell just like that system. We happen to have a more passive system for flooding the lower drywell, but that is modeled based on a fault tree.

We know how to model systems. We have the large spreading area. Like mentioned earlier, at the time we licensed the ABWR, everybody was sure that the latest tests were going to show that water on top of the debris was coolable. Well, it didn't quite go that way for us. So we took a different approach and added the BiMAC.

But once we add the BiMAC, though, we have to look at failure modes in the BiMAC. We look at local burnout, water depletion, local melt-through. And to address these things, we addressed them different ways.

The local burnout was addressed during the confirmatory testing. The water depletion, once again that is a systematic thing. So we have a PCCS fault tree model. And then the local melt-through is addressed in the design of the sacrificial layer, which is still ongoing.

Now to try to get into the pictures.

MEMBER APOSTOLAKIS: Good.

MR. WACHOWIAK: Let me go back up to the front picture here.

MEMBER APOSTOLAKIS: That's an interesting acronym there.

MR. WACHOWIAK: BiMAC?

MEMBER APOSTOLAKIS: Yes.

MR. WACHOWIAK: Okay.

MEMBER APOSTOLAKIS: Nobody remembers that?

MR. WACHOWIAK: Basemat internal melt arrest and coolability.

MEMBER APOSTOLAKIS: I knew you knew.

MR. WACHOWIAK: The experiments in the mat because it wasn't just panel. It was just melt arrest.

MEMBER APOSTOLAKIS: Okay.

MR. WACHOWIAK: So, just to point out, as I was saying earlier, this is the area that we're looking at here, is the lower drywell pedestal area, reactor vessels up above that. It's sitting on the basemat. And these rooms on the outside here are in the reactor building.

These are the pedestal walls that we're talking about here. The floor is the basemat of the reactor. This is all underground, by the way. And these rooms here are outside of the containment. So the pedestal wall is up against the reactor buildings.

CHAIRMAN CORRADINI: In difference to the ABWR, where we would have found the suppression pool out there?

MR. WACHOWIAK: Our suppression pool is raised so that it's above the core in this design, rather than down on the basemat.

MEMBER APOSTOLAKIS: Very good.

MR. WACHOWIAK: So when we go back to this picture, these walls are the pedestal walls I was just talking about. This floor here should be extended across and throughout here. It's the basemat.

CHAIRMAN CORRADINI: And then, as we were talking about, would the sacrificial layer be still TBD relative to dimension? Has the basemat floor been scoped as to what it's going to be in terms of penetration, depth, thickness?

MR. WACHOWIAK: Yes. That's already established. Do you remember what it was?

MR. SEEMAN: I believe it was six meters.

MR. WACHOWIAK: Six meters? And that was already established in the design basically for the structural portion of the building. What we were allowed to play in was this area here that's approximately one and a half meters above the --

CHAIRMAN CORRADINI: And the material for the basemat is specified or flexible relative to the concrete type?

MR. WACHOWIAK: I believe it's flexible.

CHAIRMAN CORRADINI: Okay.

MEMBER APOSTOLAKIS: Say that again.

MR. WACHOWIAK: In the design --

CHAIRMAN CORRADINI: The type of concrete, there's various --

MEMBER BROWN: You mean the gray stuff?

CHAIRMAN CORRADINI: The gray stuff. Yes, the gray stuff.

MR. WACHOWIAK: Yes because of the gray marble out here.

MEMBER BROWN: Not the BiMAC thing itself, the device? That's a basemat. The other stuff is the protector for the basemat, right?

MR. WACHOWIAK: So let me go over what some of the things are here. We have water tanks that are way up here. They're way up in the containment. And we have pipes that go down to a distributor.

And then the BiMAC itself -- and I think I have this on the next sheet -- is a two-dimensional cone. So it's like this except it's covering a circular area.

And those pipes go out. And then they transition to a standpipe. The standpipes, of course, are much lower as you go out along the diameter. And the standpipes are higher as you get near the edge. And, in fact, as you get near the edge, some of the horizontal do need more than one standpipe in order to completely cover the wall.

MEMBER BROWN: Why do you want all of the core to pool into one little puddle, as opposed to being more distributed? That was not a good idea in the old days.

MR. WACHOWIAK: Okay. This is somewhat exaggerated in terms of the inclination.

CHAIRMAN CORRADINI: He can't speak about it.

MR. WACHOWIAK: Which?

MEMBER BROWN: You can calculate it on the next page if you want to.

MR. WACHOWIAK: It's showing what our concept was. The experiments show that the optimum or that the range of angle for having the right thermal dynamic behavior is in the range of zero to 20 degrees. Approximately ten degrees is what we set up our concept based on. Is that on the next page?

MEMBER BROWN: Yes.

MR. WACHOWIAK: Once again, all values are preliminary. And, in fact, they are all different now. We won't get into what they specifically are. So it's a very low, low angle. And it's 100 square meter floor area.

This shows where that the layer basically hugs the pipes. In fact, that was in the original concept, we thought that we would do this this way. In fact, we will be filling in most of that area with the concrete. And we'll let the core itself decide what the right final dimension is.

CHAIRMAN CORRADINI: Can you repeat what you just said, Rick? I didn't understand it. I'm sorry.

MR. WACHOWIAK: This layer initially will probably not be set up so that it's in a dish sort of arrangement. It will probably be just like a flat floor.

MEMBER BROWN: That degree, ten degrees, will not be ten degrees. It's the pipes.

MR. WACHOWIAK: The ten degrees is the pipes underneath the floor.

MEMBER BROWN: Okay.

MR. WACHOWIAK: But the floor itself will seem --

MEMBER BROWN: That's the brown stuff on top of the pipes.

MR. WACHOWIAK: And the actual sloping of the floor will be based on getting water into the sump, just like in a normal lower drywell.

MEMBER APOSTOLAKIS: So that will be another --

MR. WACHOWIAK: We have channels in the floor to get water into the sumps and things like that. But for BiMAC performance itself, we don't need to have that slope.

So your question, why do we want to pull it to the middle? We don't. This was an initial concept of how it might be arranged, but it is likely to be just a flat floor underneath there. But the pipes need to be sloped because the pipes, we need to establish the flow patterns that --

MEMBER BROWN: So you are saying that brown layer is going to be thicker in the middle and thin around the edges?

MR. WACHOWIAK: Yes.

MEMBER BROWN: I put it in simplified --

MR. WACHOWIAK: Thicker in the middle, thin around the edges. That's probably the best way of putting it right now.

MEMBER BROWN: And what is the little grated thing on top of that? Is that a --

MR. WACHOWIAK: It's a floor so we can walk on it. We're not expecting to --

MEMBER BROWN: Is it an open floor? I mean, that's --

MR. WACHOWIAK: We haven't decided yet. It's at least going to be grating, but it will probably be grating with some kind of a sheet metal on it so that you're not dropping stuff through there.

But, once again, that has nothing to do with the performance of the BiMAC.

MEMBER BROWN: I understand that. I just wanted to know what it was. That's all.

MR. WACHOWIAK: And the specific materials here, you know, we had presented this zirconium refractory material in earlier designs. Actually, it's now based on what we have looked at in the experiments. We find that we have a much greater choice of things that we can use. And we're working on what that specific material is. It's not been --

CHAIRMAN CORRADINI: Based on what? I'm sorry. You said based on what?

MR. WACHOWIAK: After we finished optimizing the dimensions here, what we found is that we have greater choices of materials given the dimensions that we'll finally end up with on the piping.

CHAIRMAN CORRADINI: Thank you.

MEMBER APOSTOLAKIS: So what kinds of tests have you performed?

CHAIRMAN CORRADINI: They are going to get to that.

MEMBER APOSTOLAKIS: Oh. You will get that later? Okay.

MR. WACHOWIAK: Yes. I'll get you there. Just to illustrate here --

MEMBER SHACK: Before you get there, let me just ask the question about -- you know, you're very concerned about ablation of that layer, but the thermal shock itself never seems to be discussed as to whether it will spall and crack. There's no testing of that.

And, again, I'm not familiar with the literature on this. Could you address that particular mode of failure, which isn't really discussed anywhere?

CHAIRMAN CORRADINI: Can I append something to this? In chapter 21 and in the BiMAC experimental report, it makes great pains of saying the best estimate is that metallic will come down first, but it was bounded by 100 percent of the oxidic.

Metallic doesn't behave the same way in thermal shock as oxidic. So that's what I think is the concern here.

MR. WACHOWIAK: Do we have an RAI on that specific thing or is that --

MR. SEEMAN: That is on the RAI.

MR. WACHOWIAK: We have an RAI on that. And we basically got that about a week ago, and we haven't responded to that yet. But we'll be responding to that in the RAI.

CHAIRMAN CORRADINI: So if we are not going to discuss anything further here, just to go one step further, this is where I guess I am asking the question about the ABWR calculation being a bound to the BiMAC performance because if this is designed in such a fashion that I spall, I get right to the tubes. I burn through the tubes. Now I've got a concentrated focus and a totally different erosion pattern than if I had it as the ABWR expected it to be nicely spread out. That's what's got me asking the question.

MR. WACHOWIAK: Okay. There are two

things associated with that. The first one is that we show these things here. And they're somewhat misleading in your mind. It's more of a flat floor --

CHAIRMAN CORRADINI: Yes. That I got.

MR. WACHOWIAK: -- than what you're thinking. The calculation that we did that compared to the ABWR took into account the shape of the pipes so that the volume of the melt, if you will, had that characteristic. The thickness of the melt was associated with the double-inverted ungulate that we have here.

DR. KRESS: I have a conflict of interest on this, but I would like to ask a question of fact. On your picture, the line on the left is identified as a deluge line.

MR. WACHOWIAK: Yes.

DR. KRESS: Is that incorrect? That's a feed line to the BiMAC pipes. The deluge is separate?

MR. WACHOWIAK: No. We called them all deluge.

DR. KRESS: Called them all deluge?

MR. WACHOWIAK: Yes. And some of them

will go directly into the BiMAC channel. And some will go into the lower drywell area --

DR. KRESS: You call them all deluge, right. Yes.

MR. WACHOWIAK: -- directly into the sump because we also want the sump filled with water to protect in case something gets spilled over into the sump so we don't have --

DR. KRESS: There are three of these lines that feed the pipes?

MR. WACHOWIAK: Twelve lines.

DR. KRESS: Twelve lines feed?

MR. WACHOWIAK: There are 12 lines total because we have four --

DR. KRESS: Six feed the pipes, and six go directly on top?

MR. WACHOWIAK: Essentially. And we could change that if we -- that's not cast in stone yet of how many go to which places, but what we initially decided was that we needed about half to go directly to the BiMAC. And the other half can go to protecting, you know, just spilling onto other things that we want protected.

DR. KRESS: Well, lines that feed the

BiMAC tubes, do they go to the center distributor? You have a distributor running in that direction.

MR. WACHOWIAK: Do you have that?

CHAIRMAN CORRADINI: I think it's the next slide.

MEMBER BROWN: Do you have a slide that shows that?

CHAIRMAN CORRADINI: Tom is getting to a question that I had, too. I was --

DR. KRESS: This shows two of them, two downcomers, one on each end. You said there were six. I was trying to figure out how they --

MR. WACHOWIAK: Long-term, these are the long-term feed for natural circulation. So the water pool is above the core. Water would be going into these tubes to the distributor and out.

DR. KRESS: I understood you to say there are six of those lines.

MEMBER APOSTOLAKIS: Twelve.

MR. WACHOWIAK: And then the concept here on this cartoon, right? This isn't a design drawing here but a cartoon; that these deluge lines would be fed down to this distributor. So six of those smaller lines would go down there initially.

DR. KRESS: Oh, the blue is also feeding the distributor?

MR. WACHOWIAK: The blue is the one that comes from the pools up on the top.

CHAIRMAN CORRADINI: Okay. So let's now get into really colors. So the yellow is for natural circulation?

MR. WACHOWIAK: Yes.

CHAIRMAN CORRADINI: The dark blue, there are 12 or 6 of them?

MR. WACHOWIAK: That would go into here? We're estimating that should be about six of them.

CHAIRMAN CORRADINI: And there are another six that would discharge on top of the melt or on top?

MR. WACHOWIAK: On top of the melt or in the sump or things that we think need to have additional protection, like the sump, is a way that if you get material in there, you could focus the heat onto the pedestal wall and down through the basemat.

So what we want to do is we want to make sure that the sump is filled so that the BiMAC pipe is here and then the sump behind the pipe is also filled with water so that there is more protection from getting material there.

If there are other things down in here that we think we want to have some short-term protection, which we don't know right now since we don't know all of what is down there, we could direct that deluge onto those specific things so that it is a water-covered thing when the melt is coming out versus just dry and good impact, --

CHAIRMAN CORRADINI: So I don't know how you want to --

MR. WACHOWIAK: -- flexibility that we have.

CHAIRMAN CORRADINI: That's fine. There's a question over here. I'm sorry, George.

MEMBER APOSTOLAKIS: Yes. I am still trying to understand the answer to Tom's question. So there is this dark blue line from the GDCS.

MR. WACHOWIAK: GDCS.

MEMBER APOSTOLAKIS: GDCS. How many dark blue lines do you have? Six?

MR. WACHOWIAK: Associated with this piece here, it will likely be six.

MEMBER APOSTOLAKIS: So where would the

second one be?

MR. WACHOWIAK: It could be seven.

MEMBER APOSTOLAKIS: I want to know what the second one would be. I am missing something.

MR. WACHOWIAK: They would just be --

MEMBER APOSTOLAKIS: Around.

MR. WACHOWIAK: -- just around.

MEMBER APOSTOLAKIS: Okay. Around.

MR. WACHOWIAK: Like the ABWR, they just come down the lower drywell, and they are open pipes to here. So it would be a setup similar to that.

MEMBER APOSTOLAKIS: And if we go to the next slide, then, each one will have its own distributor and so on.

MEMBER BROWN: No. It's an open line he said. It just dumps water down into the --

MEMBER APOSTOLAKIS: Oh, okay.

MR. WACHOWIAK: Into the distributor.

MEMBER APOSTOLAKIS: All right.

MR. WACHOWIAK: Into the common distributor for all of the pipes.

MEMBER APOSTOLAKIS: Okay. Okay.

DR. KRESS: Now, in the long term as this thing progresses, that khaki-colored stuff will disappear?

MR. WACHOWIAK: The khaki-colored stuff will disappear.

CHAIRMAN CORRADINI: Sacrificial layer.

DR. KRESS: It won't be part of the operation?

MEMBER SHACK: It will come to an equilibrium.

MR. WACHOWIAK: It will come to an equilibrium. There will be some layer and some crust and then material above it, core material above it. So this where it may start to be a floor will end up in some shape that is determined by the heat transfer characteristics of the melt.

So the melt will bring that into equilibrium. The key is that it needs to be thick enough so that the equilibrium doesn't fall into the blue pipe.

DR. KRESS: And you have determined what that crust thickness will be?

MR. WACHOWIAK: Yes. And that was what was on the previous page that as long as we have 20 centimeters, we're going to be protected. That's more of a minimum value here.

MEMBER BROWN: That's a start. That's the way it's built.

MEMBER SHACK: Yes. That is not your equilibrium value.

MR. WACHOWIAK: That would be the starting value, but, in all likelihood, it's going to be different than this because this was 20 centimeters of using zirconium oxide.

CHAIRMAN CORRADINI: So let me get back to my question again, which maybe is another RAI. This is essentially just like the AP1000 except ex-vessel. Your heat flux is going to be concentrated at that turn point, right? And so that's to me the crucial thing. And that's crucial based on what the melt composition is at that turn point.

MR. WACHOWIAK: Yes.

CHAIRMAN CORRADINI: And so I'm still back to the original statement in the BiMAC report and in chapter 21 which says things are bounded by 100 percent of the melt oxidic, but the guesstimate, the best estimate is metallic melt coming down.

And so if I have metallic melt coming down, even particularly that I've now got a flat floor, and I direct that metallic melt to that corner, I'm going to have one interestingly high heat flux there.

And I'm curious. You've gotten to the curve that I am interested in, which is that red line is based on some theoretical calculation. The blue line is the test results, which says we're hunky-dory because we're underneath the red line.

I'm still struggling with how much I trust the red line.

MR. WACHOWIAK: Okay. The blue line was done based on the initial calculations, not the test.

CHAIRMAN CORRADINI: Oh, I'm sorry.

MR. WACHOWIAK: I believe the test was looking at that.

CHAIRMAN CORRADINI: Right, knuckle or whatever you want to call this thing. I'm sorry. I should remember this, and I don't. I apologize.

MR. WACHOWIAK: Yes. Well, maybe you should. This is one of those things that you guys like to use, all this non-dimensional stuff.

The blue line is the pipe that is --

MEMBER APOSTOLAKIS: "You guys." Which guys are we?

(Laughter.)

MR. WACHOWIAK: I know what he's saying. Academia. If we told the construction guys to go out and build this non-dimensional thing --

(Laughter.)

MR. WACHOWIAK: So the black line is a pipe that is essentially all horizontal. There is not much to the vertical section of it. And, as a matter of fact, we think that the melt is probably not even going to get to the vertical section of that piece of pipe because it's out on the diameters. You know, the BiMAC itself, the volume can hold, what, three or four cores. So we don't think it's going to go all the way out to the sides.

CHAIRMAN CORRADINI: That's if it's a cone.

MR. WACHOWIAK: Right. So this one here, there's nothing at that knuckle. But this one if it cones at the ends near where the entry to the channel is, that's what this channel is meant to represent. And this is the horizontal piece. This is the vertical piece and the knuckle right there where there would be this issue that you are talking about.

CHAIRMAN CORRADINI: I'll stop. But what

I'm worried about is that pinch point and that you're going to get enough boiling to essentially shut the natural circulation down flow. And the whole thing will essentially then choke off, right, just stop flow because if I have any sort of CHF or enough boiling, I'll essentially stop any sort of down flow because now I'm bringing the pressure drop.

The two-phase pressure drop is moving, getting larger and larger and moving back up the pipe so that I don't have enough natural circulation head to drive it.

MR. WACHOWIAK: And I think that was what the experiment was meant to investigate.

CHAIRMAN CORRADINI: Yes. Okay.

DR. KRESS: The blue line is a CFD calculation?

MR. WACHOWIAK: Yes, I think that's right.

DR. KRESS: Do you know what code they used for that?

MR. WACHOWIAK: It wasn't something I looked up before I came on.

DR. KRESS: Two-dimensional or three-dimensional?

MR. WACHOWIAK: We did two-dimensional and three-dimensional cases. I think the M cases are the three-dimensional results. There's a table in chapter 21 that looks at different things. There's a batch of those cases that were done with the three-dimensional code versus the two-dimensional.

DR. KRESS: Do you know what correlations you used to calculate the red line?

MR. WACHOWIAK: I can look those up. I don't know those. We can maybe look inside chapter 21 when we get to a break.

DR. KRESS: So obviously two different correlations.

MR. WACHOWIAK: Yes.

DR. KRESS: One for a flat plate and one for vertical.

MR. WACHOWIAK: Well, one for a minimally inclined plate and one for a vertical.

CHAIRMAN CORRADINI: But where Tom I thought was going is there is a fuzziness to the blue line and there is a fuzziness to the redline. I'm worried about the intersection of the fuzziness. That's where I'm still troubled at. I assume that's what.

MR. WACHOWIAK: And that was what the experiments were supposed to address because, you know, clearly this is where we have the least amount of market, is right at that fuzzy intersection.

DR. KRESS: This is all nucleate boiling. None of it is film boiling, of course.

MR. WACHOWIAK: It's essentially nucleate boiling, especially on the vertical parts. There are some. We looked at some SLUG flow in --

DR. KRESS: Lot of void --

MR. WACHOWIAK: -- the horizontal sections, but, once again, we didn't get to there as long as we had subcooling at the inlet. But it could go somewhat past nucleate boiling into the SLUG regime and still perform this way.

DR. KRESS: Okay.

MEMBER ABDEL-KHALIK: If the tubes are different, how would that affect the flow distribution in that header?

MR. WACHOWIAK: That was another one of the objectives of the experiment, to look at an array of tubes. So one of the scaled experiments had a quarter BiMAC, if you will. And we looked at local heat flux on heat flux differences across the different tubes. And we'd have results presented for that.

And I believe we have an RAI also on some of those results, that some of the tubes had reverse flow, I think is what you saw in the bore head. Is that right?

So that because of some of these asymmetric issues, that there were different flow patterns that were established, and we're looking into that right now.

DR. KRESS: Was there any concern about parallel flow stability when you have lots of parallel pipes with different heat fluxes on them?

MR. WACHOWIAK: Parallel flow stability.

CHAIRMAN CORRADINI: You got some. What you were saying, that you had set up a situation where certain pipes were going this way. You get this almost like an oscillatory.

MR. WACHOWIAK: Yes. And I think that's what some of the questions that we have -- there were some reverse flow situations shown in the experiments. And we have been asked to explain those.

DR. KRESS: I was more concerned about

some flows. You have the same pressure drop basically across these two. Some flows would get it at pressured off if you're in film boiling. Some of them will give you that pressured off if you're in nucleate boiling but a different flow rate.

So that sometimes give you -- you never know when you're going to be in one or the other because it's a probabilistic thing that decides.

MR. WACHOWIAK: It's a good question.

DR. KRESS: But you didn't see any of that in the test at all?

MR. WACHOWIAK: We didn't see that.

DR. KRESS: Not the question. Were each of the tubes instrumented so you could get the flow rate through each of the tubes?

MR. WACHOWIAK: I believe that that is the case.

CHAIRMAN CORRADINI: That was true. There is a picture of this magnetic flow meter where they are tracking flow rate per tube.

DR. KRESS: Per tube?

CHAIRMAN CORRADINI: Yes.

DR. KRESS: And void fraction?

CHAIRMAN CORRADINI: I think so because

there was a void measurement. There were integral void measurements.

DR. KRESS: Oh, magnetic flow meters --

CHAIRMAN CORRADINI: Right.

DR. KRESS: -- are weird when you have void fractions.

MEMBER ABDEL-KHALIK: I believe Tom is asking about leatherneck-type flow and stability.

DR. KRESS: Yes, absolutely.

MEMBER ABDEL-KHALIK: And that question is, you know, we're talking about void fractions greater than the onset of significant voids, which is about five percent void fraction. And that's a region where we would be concerned about OFI-type problems in parallel pipe systems. Has that been looked at?

MR. WACHOWIAK: Where I think we -- I don't know the answer to that specific question. It hasn't been posed yet. One of the things that we did find is that all of our initial calculations that we did assumed that there would be saturated water at the inlet to the downcomer. And it turns out that we are probably going to have some subcooling, four or five degrees of subcooling, at the inlet, almost only because of the height of the water pool that is going to be there.

Many of these things that we were worried about go away when we have the initial subcooling. We maintain almost a nucleate regime all the way through the pipe when we have the initial subcooling.

So if that specific question that you have can be found in one of the questions that we already have or somehow if you can get that to the staff and send that to us, we could answer that question specifically. But it's beyond what I'm prepared to discuss.

MEMBER ABDEL-KHALIK: Okay. I think that would be an interesting problem to look at. Regardless of how much subcooling you have at the inlet, you have subcooled boiling. The amount of voiding you have in the piping is probably greater than OSV, which is five percent void fraction. And typically OFI happens at the same point that the OSV.

So five percent void fraction I would start worrying about flow instability in parallel piping systems.

MR. WACHOWIAK: Okay. And we have it on the heat flux range there, but what Dr. Theophanus was saying, where he thought he was going to get into a problem, this is on the vertical or in the horizontal tubes now, is about a 70 percent of what fraction is where he would get backpressure issues now. This question about stability is a different question, and I don't know that we answered that question.

DR. KRESS: If you failed one of the tubes, would you be injecting water into the melt?

CHAIRMAN CORRADINI: We would call it the Con. Ed. approach.

DR. KRESS: That's where it comes from?

MR. WACHOWIAK: I don't know that we expect the melt to get all the way down to the tubes. We still expect there to be some layer of material --

DR. KRESS: Some crust and material there?

MR. WACHOWIAK: -- in crust in between that. So we wouldn't be looking at injecting water directly into the melt. Now, that's if everything works. But if a tube dries out, you know, if it's one tube, would we be able to get a local ablation right at that one point to drop down in the tube?

That seems intuitively hard for me to come to the point where if we failed one tube, that we would get instant or a direct flow or a direct melt path to the basemat. A band of tubes, though, I could see that.

If we failed the tube, I don't think we would be thinking at --

DR. KRESS: Very little about an ex-vessel steam explosion under those conditions.

MR. WACHOWIAK: Okay.

DR. KRESS: That happened to one of the German designs is the reason I brought it up.

MR. WACHOWIAK: I guess I would like to see how that came about. Long term I think there's less of an issue because it's not as -- even though I'm saying that there are a few degrees of subcooling, we're at or near saturation in the initial pours, where you have the big subcooling, where that might be a larger concern. I hadn't thought about that.

MEMBER BROWN: Can you go back to slide seven.

MR. WACHOWIAK: I'm going the wrong way. Seven.

MEMBER BROWN: You mentioned earlier the water comes down the drainage pipes, goes down the distributor, flows up, and then it kind of dribbles down into where all the melting stuff is. Is that what I see?

MR. WACHOWIAK: Dribbles is -- okay. Initially you could --

MEMBER BROWN: If you've got a pipe coming up and you've got it open and the water comes up and flows --

MR. WACHOWIAK: It flows out of the top. Eventually, though, the amount of water is such that that pool will be about 17 meters deep by the time we're done. So yes, it dribbles, but it's a pretty good dribble.

MEMBER BROWN: You are not depending on the tubes, then, for cooling any more at that point? I mean, obviously if you've got --

MR. WACHOWIAK: If we have the melt on the pipes basically establishing a flow pattern through there, so the pipes are somewhat inclined, heat the pipes up, the water comes out, the water has to be replaced. It's a natural circulation flow pattern in the --

MEMBER BROWN: So it's high enough that it will refill the --

MR. WACHOWIAK: Oh, yes.

MEMBER BROWN: -- deluge and then come back through there?

MR. WACHOWIAK: It's not through the deluge lines. That's those --

MEMBER BROWN: There's another set of lines?

MEMBER SHACK: The downcomer lines.

MR. WACHOWIAK: Well, where are they?

MEMBER BROWN: Yes, I remember.

MR. WACHOWIAK: That's the yellow lines.

MEMBER BROWN: Okay. So, in other words, they're down within the level of the water.

MR. WACHOWIAK: Yes. They're up higher than where the core would be, but they're within the level of where the pool is going to be.

MEMBER BROWN: So the initial problem, whatever it is, that causes all the core in the material to settle down there, you have blocked that pipe where it starts dribbling out. That would be an issue, is that correct?

MR. WACHOWIAK: Yes, that would be an

issue. And so a couple of things that we're doing with this is the exit pipes and these inlet pipes are all way up against the wall. The core itself where the melt is is here. And we have done essentially a probabilistic analysis of where the pile of core debris might come out if we failed one of the edge CRD tubes and found that we have significant space between the wall and where the edge of that --

MEMBER BROWN: So nothing would blow out towards that and then come down the wall and plug it into --

MR. WACHOWIAK: Right. We looked at what kind of protection we would need for these pipes and also for the sump, which the design of the sump in this isn't just a square sump that sits off to the side. It's actually something that is molded into the wall just for that concern that you have raised.

MEMBER APOSTOLAKIS: What happens to all this heat flow? Water comes out. It goes on top?

MR. WACHOWIAK: Yes.

MEMBER APOSTOLAKIS: Same thing?

MR. WACHOWIAK: And the heat?

MEMBER APOSTOLAKIS: Yes.

MR. WACHOWIAK: The heat is removed by

the PCCS, passive containment cooling system.

MEMBER APOSTOLAKIS: Okay.

MR. WACHOWIAK: Any steam that is generated here will be condensed in the PCCS, which then feeds back to the GDCS pools, which then will be fed back down by these lines.

DR. KRESS: When you look at that picture, it looks like the liner is very well-covered. But those are cylinders. They touch at one point on the wall and one point on each other, which is not as well covered as it looks, it seems to me like.

MR. WACHOWIAK: Right. That's what I mentioned early on in this, that on some of these, what we call near-edge tubes, there are going to be two or three vertical pipes connected to that so that we do have full coverage on the wall.

CHAIRMAN CORRADINI: So that will branch. People have been asking about once it is there. Can you walk me through the logic of how this thing starts up?

MR. WACHOWIAK: Right.

CHAIRMAN CORRADINI: I'm still way back at the transient.

MEMBER BLEY: And maybe back up one picture as you walk through this.

MR. WACHOWIAK: I should just put random numbers down here. Okay.

CHAIRMAN CORRADINI: So at time zero, some CRD because of events that we're going to take up after lunch gets us a core melt in the lower plenum and a CRD breaks or leaks or a weldment opens up or something.

MR. WACHOWIAK: Yes, or the vessel will creak rupture at one of those.

CHAIRMAN CORRADINI: Right. So one of these dudes starts flowing out. So with that as the starting point, can you kind of talk me through how this is initiated and the timing of what is supposed to happen when?

MR. WACHOWIAK: Okay.

MEMBER BLEY: And I guess from what you have told us, that material is now expected to be a flat surface, not --

MR. WACHOWIAK: Essentially flat. It won't be perfectly flat but essentially flat. So somewhere in this part of the cylinder -- you know, this is several, ten meters across. And the vessel itself is seven meters across.

So the CRD tubes are around this area. We would have melt that comes out. In actuality, it would probably drip down the CRD tubes. And you wouldn't actually get a lot until a significant amount came out. But let's say that it's not candling down the CRD tubes. That's not really the right term.

So it comes down. And it would first come into contact with the floor. Right now we know it's at least a grating, but it's probably going to have some sort of a sheet metal on top of the floor.

The melt will just go through that sheet metal like it's nothing there. It's not going to provide any type of protection. We don't expect it to. The only thing that we would expect this to protect is if the CRD itself fell down, we would expect the grating to stop it from acting like a spear and coming down and breaking the concrete.

CHAIRMAN CORRADINI: Nor will the grating preferentially send it to the wall.

MR. WACHOWIAK: No.

CHAIRMAN CORRADINI: Or slash it there or or. That would be my --

MEMBER BLEY: Why do you think that? But go ahead.

MR. WACHOWIAK: The estimate is that it's a thin metal layer and that the super heat in the melt material would just act like it's not there.

MEMBER SHACK: But one of your recent addenda says you think you could be making that somewhat beefier.

MR. WACHOWIAK: Melt right through it, yes.

MEMBER APOSTOLAKIS: What kind of temperatures are you talking about?

MR. WACHOWIAK: Three thousand, 4,000.

MEMBER APOSTOLAKIS: F?

MR. WACHOWIAK: Yes, I think. Yes. We have melted the core. And then we have had to remelt it in the bottom of the vessel so that we fail the vessel. And then it's going out after it's been remelted in the bottom of the vessel. So it's not just fuel pellets falling out or anything like that.

MEMBER APOSTOLAKIS: Yes. Okay. So --

MEMBER SHACK: I thought your recent comment was, though, you were thinking of beefing up that floor presumably to more protection against falling thingie bobs.

MR. WACHOWIAK: Right. "Falling thingie bobs" is probably the best term that I've heard for that so far. But, even if we did that, it still wouldn't be anything that would protect or that would stop --

MEMBER SHACK: Stop hot core melt.

MR. WACHOWIAK: -- molten core melt.

MEMBER SHACK: I mean, not putting a ceramic layer there.

MR. WACHOWIAK: The only thing is we just don't want things to fall directly onto the concrete and have some sort of mechanical damage because of the concentrated impact.

Once again, we don't expect that to happen either because these CRDs are all connected by wires and zooms and everything else. They're probably not going to fall straight down anyway. They're probably going to be hanging by their wires and everything else anyway because there are hydraulic lines, water lines that go to their scrambler rods. Plus, each one of the motors has, you know, miles of cable connected to it, too.

So while that's an issue, theoretical

issue, I think, in practicality, what we will see is there is no way those can --

MEMBER BROWN: Why wouldn't the heat of the core melt just destroy that stuff, just like it does the grating?

MR. WACHOWIAK: It will.

MEMBER BROWN: Okay. So if it comes --

MR. WACHOWIAK: But the initial thoughts were, "Well, okay. We opened this hole. And this thing that is hanging down will just fall." Well, the thing that is hanging down there will probably fall into the tree forest of CRD tubes.

And then the wires will melt, and the tubes will melt and fall. You know, it won't be a direct spear coming down, but it will be some sort of a progression of material falling down from the top. But that's kind of off from what we were getting at here.

As the material is coming down, we are heating the air space of the lower drywell. And I'll get to why that is important in a minute. We would be heating the air space. And then as the material starts to collect on the floor, there is a net, an array of thermal couples either on top of the floor or embedded in the floor.

CHAIRMAN CORRADINI: TBD?

MR. WACHOWIAK: It's probably going to be a combination of both. The array or spacing of those is not TBD. We've got that in the design of how many there are and where they are located.

But let's just say that in every given region, there are two thermal couples that are there and that when the prescribed number of adjacent regions had indication that there is increased temperature there or lack of continuity because if the melt melts the thermal couple wire, we are going to assume that it was the melt that caused that.

So if we get the right array and we have done a heat transfer calculation to detect what that array is, then the system that actuates these valves here will send the signal to those. Right now they are squib valves, essentially two-inch squib valves, similar to what we use in standby liquid control systems today.

That system would actuate those squib values or send a signal to actuate those squib valves. But just prior to or just outside of the wire coming into these, there is a temperature switch. The air temperature in the lower drywell needs to be above the saturated temperature given no core melt, which is 575-600 degrees K? F?

CHAIRMAN CORRADINI: F.

MR. WACHOWIAK: F, F. So if the air temperature is hot enough to set those temperature switches, then the squib valves will actually fire and will start putting water down into the --

CHAIRMAN CORRADINI: So can I just repeat up to this point what you have said? So it's a combination of there are two things that have got to occur. Those sensors are going to have to see something above something like 600 F. And there will be some sort of logic in terms of either measure temperature or lack of continuity of embedded thermal couples.

And you need both of those. You need both of those to essentially register to allow the squib valves to fire.

MR. WACHOWIAK: Yes.

MEMBER APOSTOLAKIS: Why both?

MR. WACHOWIAK: The reason we have the temperature switches there is because we are really worried. Okay. We are worried about them going off when we don't want them to.

MEMBER APOSTOLAKIS: I was just curious.

MR. WACHOWIAK: And, remember, we are dealing in severe accident space here. And it's a much better day at the nuclear plant if we prevent the severe accident than if we have to deal with the severe accident. So we really want that water to be in the GDCS tanks to be able to go into the core, rather than somewhere for some reason going into the lower drywell before we need it.

MEMBER APOSTOLAKIS: Accidentally.

MR. WACHOWIAK: So that's the reason why you have to have the confirmatory high temperature in the gas space.

MEMBER APOSTOLAKIS: Okay.

MR. WACHOWIAK: And, once again, that is similar to the ABWR. The ABWR deluge system is completely actuated by air space temperature.

DR. KRESS: Why didn't the GDCS water go into the core in the first place?

MR. WACHOWIAK: Because the valves that lead from the GDCS tanks to the core failed in the closed position or the two digital control systems that control those valves failed.

And I was going to get to this point. The control system that actuates this is a third diverse control system from everything else that we had been operating.

MEMBER BLEY: Diverse power?

MR. WACHOWIAK: Diverse power, diverse platform. It's not a programmable system. It's a system with its own batteries.

CHAIRMAN CORRADINI: We will come back to this because I can see the PRA types are getting actually excited again.

MEMBER ABDEL-KHALIK: Would a common mode failure of the squib valves also affect this? The same common mode failure that would prevent the water from getting into the vessel would prevent the water from going into the BiMAC?

MR. WACHOWIAK: If we used a common squib valve or common squib valve charge there, then yes. But we're specifying that that has to be diverse.

One of the reasons why we have 12 lines coming down here, rather than just 4 lines coming down, like out of each of the GECS pipes, is we want to use a completely different squib valve here than what we're using for the inject lines. So while those are specifically designed squib valves for that purpose of injection, these are more similar to squib valves used in nuclear applications used today.

So we're concerned with that. We're specifying that it needs to be a diverse valve so that we don't have that common mode failure. That would eliminate any benefit from having this in the first place. It would be to get that common mode failure.

CHAIRMAN CORRADINI: Keep on going.

DR. KRESS: There is no problem between the race between the melt getting down to the tubes and the timing of turning on those squib valves, is there?

MR. WACHOWIAK: That all depends on our final configuration of the layer here, but, you know, we've got tens of minutes to deal with.

DR. KRESS: Before the melt gets to the tubes?

MR. WACHOWIAK: Before the melt gets to the tubes. And that was when we were still looking at a 20-centimeter layer. So I think we've got even more time now that we have done our optimization.

DR. KRESS: Have you dealt with that

transient period calculationally to see what the actual thermal effect is on the tubes and the sacrificial layers? I guess this has been asked before.

CHAIRMAN CORRADINI: No, but you are exactly where I was going to ask the question. So keep on going.

DR. KRESS: Well, that's the question. Have you dealt with that transient period to be sure there's not a way for that melt to get there faster or for the thermal effect to get there faster?

MR. WACHOWIAK: I'll have to go back through the report and see if that was addressed in there.

CHAIRMAN CORRADINI: We didn't see it. I looked for this in particular. And so let me say it a different way, but it is really Tom's question, which is so you said you have got these temperature things somewhere in the concrete or in the sacrificial layer or above the layer. And you've got this double-check on the air temperature. And now they both say yeah, something is amiss. Fire these buggers off. Let the water in.

Now the water is coming in. I am trying

to figure out how much melt is there and what is the composition of the melt where it fires or does it not matter. And you have done calculations to show it's all metallic and there is a hell of a lot of it and we're okay or it's all oxidic and there's a hell of a lot of it and we're okay or there's not a whole lot of either and I dump a lot of water in there, now a hell of a lot of it comes in and we're okay.

And I've been looking for all three of those possibilities. And I have to admit I've not seen it anywhere. And that's the source of my -- and it kind of goes back to Tom's point.

MEMBER ABDEL-KHALIK: Now, before those valves activate, the pipes are presumably filled with nitrogen. Is that correct?

MR. WACHOWIAK: That's what I would expect, yes. It's --

MEMBER ABDEL-KHALIK: Is that a better arrangement than if the pipes were to be kept always full of water?

MR. WACHOWIAK: The issue that we have if we keep the pipes full of water by putting the valves down here, you know, if we start with a full pipe with a valve down here, we run into the issue that the melt eject may impact the valves. The environment for the valves is adverse.

So what we have elected to do was we put the valves up and on the deck, up top, so that they are not affected whatsoever by the melt material itself. So that was a trade-off that we had to look at.

Are we more worried about how fast the water gets there or more worried about the valves being able to survive in a severe accident environment? We chose making the valves' higher reliability in a severe accident environment.

So we are taking the hit on the timing there, but we don't think that the timing is going to be that great. I think the time from when the water starts going through the pipe to when it gets into the BiMAC is going to be a fairly short period compared to how we detect the actual amount of melt on the floor. I think that is going to take longer to get thermal couples registered at each of the cells that we need to activate that.

MEMBER ABDEL-KHALIK: I'm just concerned in this case, sort of following up on what Tom's question is, about if the pipes are already very hot so that the wall temperature is above the minimum film boiling temperature and you're trying to gravity-feed these pipes, the water is not going to get in there.

MR. WACHOWIAK: I think that is one of our RAIs that we're working on right now. And the initial look at that was that we don't think that they're going to be that hot when the water gets there.

MR. SEEMAN: There would be enough material that has no test to go through.

MR. WACHOWIAK: But that is one of the staff's questions that they've asked us to provide a response on.

MEMBER BROWN: Are you worried that they couldn't --

MR. WACHOWIAK: Apparently they couldn't find it either.

MEMBER BROWN: Are you worried about the valves being damaged by the stuff that comes down or just the environment at the high temperature --

MR. WACHOWIAK: It would be --

MEMBER BROWN: -- caused them not to operate?

MR. WACHOWIAK: It would be both.

MEMBER BROWN: You've already said that you're not going to have this material get out to the wall where it is going to plug the pipes. And now you're saying, well, we're worried about it getting out and damaging the squib. Did I miss something there?

MR. WACHOWIAK: The main --

MEMBER BROWN: Am I mischaracterizing that?

MR. WACHOWIAK: Yes. The main part was the thermal environment that is there.

MEMBER BROWN: Okay. So the internals of the valve would be such, hot enough, that they couldn't open whatever --

MR. WACHOWIAK: Right. Because we're expecting the gas space here to be up over 600 degrees. So, you know, it's going to be not a very nice environment for valves down there. Plus, they're splashing and things like that, too. If you get small amounts of material and things, that could also be a problem.

MEMBER BLEY: Have the squib valves been tested in a 600-degree environment?

MR. WACHOWIAK: Once again, we're moving them out of the 600-degree environment so that we don't have to do that.

MEMBER BLEY: They're far enough that they --

MR. WACHOWIAK: But the equipment in the drywell, my understanding is that the equipment in the drywell, all needs to be qualified to like a 575-degree temperature. That's what we do for the ICS valves and other valves in the drywell.

CHAIRMAN CORRADINI: So just to repeat, Rick, to let you go, so did we miss it? I didn't look for it. I gave the three possibilities. But it's back to Tom's original question. Was there a transient analysis somewhere that we missed?

Because I didn't see it; that is, the start-up, everything you just walked us through and all the possible branches of how this thing actually gets to the steady state that the tests have been done at. Am I missing something?

MR. WACHOWIAK: I think that is the genesis of your question, right, Ed?

CHAIRMAN CORRADINI: My question is, so the staff can answer it in light of this, is there an

RAI that asks to describe the analysis of the start-up of this, the start-up transient, since we get to the steady state?

Because it's very clear this has been documented when you get to the steady state, how it performs. I'm still trying to get from the point of actuation to the point of steady state.

MR. FULLER: Okay.

CHAIRMAN CORRADINI: Has there been an RAI asking how this happens?

MR. FULLER: Not yet.

MEMBER APOSTOLAKIS: You have to go to the microphone. Ed, can you go to the microphone and say it again and who you are?

MR. FULLER: Yes. This is Ed Fuller from the staff.

To answer Professor Corradini's question, no, we have not asked that question yet.

CHAIRMAN CORRADINI: Okay.

MR. WACHOWIAK: So I would expect that this afternoon.

(Laughter.)

MR. WACHOWIAK: And I know we have talked about that before, and I think --

CHAIRMAN CORRADINI: That's fine. I think Tom has characterized it best in that we are trying to put in our minds how this thing starts up. And we might have five different incorrect versions of it. So we want to get clear how you guys view it and how it is supposed to operate.

MEMBER BLEY: Just a simple question for me. That picture you had you don't have to go back to it. Those overflow pipes that dump water, are they essentially level with the floor? That's what it looks like with the sacrificial floor. They are not much above it if they are above it.

MR. WACHOWIAK: Do you know what the --

MR. SEEMAN: I thought that was that 1.5. It would be like two meters. So I believe it is.

MEMBER BLEY: So it's right down there near it.

MEMBER APOSTOLAKIS: Didn't you say that eventually you were going to have 17 meters?

MR. WACHOWIAK: Of water.

MEMBER SHACK: But they only just make this above any potential depth of the melt.

CHAIRMAN CORRADINI: Yes. Dennis' point is the overflow line. So once you start natural circulation, where does it flow back down?

MEMBER BROWN: It is the right-hand pipe that kept going back out, that little cutout that he's got there in the dark blue, this one here. The yellow pipe is where it goes back.

CHAIRMAN CORRADINI: Right.

MR. WACHOWIAK: And then how high that is, that's what Dennis is --

MEMBER BLEY: I was going to ask both, yes. Where does it dump out, and then where does it come back?

MR. WACHOWIAK: That would likely be somewhat higher than the water pipes.

MEMBER APOSTOLAKIS: So it would be what, two meters, you said? And then it starts filling up with water, right?

MR. SEEMAN: Right.

MEMBER APOSTOLAKIS: So how does that water come out? From the two-meter pipe?

CHAIRMAN CORRADINI: From the little guys, it boils out. From the yellow one, it flows back down.

MR. WACHOWIAK: This is not necessarily to scale. This would be a much bigger pipe.

MEMBER BLEY: You said that only two or three meters.

MEMBER APOSTOLAKIS: Yes.

MEMBER BROWN: So it gets covered before the natural circulation gets started. So it's all full of air, and then the water fills up. And then we're going to get it started through the empty pipes?

MEMBER APOSTOLAKIS: It's covered by water.

MR. WACHOWIAK: It's all under water, though. The water itself -- so the BiMAC is in this little flat area down here that you can't even see. And the water level essentially will be here.

MEMBER BLEY: Up even with the pool?

MR. WACHOWIAK: About even with the top of the suppression.

MEMBER BLEY: And the downcomer wouldn't be up real high, where it's likely to be the coolest? It will be just partway up?

MR. WACHOWIAK: It will be partway up because, remember, it can't be -- we don't want it to be in the way of servicing the CRDs and things there. We wanted that all to be out of the way. We want it to be under the grading once again so that people aren't dropping stuff in there during the outages. You know, that would not be a good thing.

MEMBER BLEY: On this picture, the grading is kind of that thing that looks like the top of a capstan there, right under the CRDMs?

MR. WACHOWIAK: Underneath the thing, the two white dots, I guess.

MEMBER BLEY: Okay.

MR. WACHOWIAK: Way down at the bottom.

MEMBER BLEY: Oh. Way down there. Okay.

MEMBER BROWN: So a downcomer is just a pipe that water fills up. It's open at the top. It's open at the bottom. When the water builds up in the place, it then starts coming back down because it's hot water. But the pipe hasn't been filled up to get started. It's not going to fill from the bottom.

MR. WACHOWIAK: When we fill the water in with these things --

MEMBER BROWN: Is it?

MR. WACHOWIAK: Here this is open to that channel so the water will go, will fill in here, and will also fill up here. So the water level here and here and here will all be the same.

MEMBER BROWN: Well, you show the downcomer pipe as being above the grading level on figure 8. That's why I was asking the question. See it?

MR. WACHOWIAK: Okay.

MEMBER BROWN: It's I don't know how ever many meters it is above the grading level. And then it's open up at the top. And pretty soon the water builds up. And it's got to come back down that pipe. Does that get started okay?

DR. KRESS: That is part of the transient.

MR. WACHOWIAK: That is part of the transient question.

MEMBER BROWN: All right.

MEMBER APOSTOLAKIS: So what is the natural circulation part at that stage? I mean, the water has already --

MR. WACHOWIAK: The right three-dimensional --

MEMBER APOSTOLAKIS: The transient --

MR. WACHOWIAK: The natural circulation pattern will be out through this pipe --

MEMBER APOSTOLAKIS: Right.

MR. WACHOWIAK: -- and then into the channel pool itself.

MEMBER APOSTOLAKIS: Right.

MR. WACHOWIAK: And then the pool would be coming back in.

MEMBER APOSTOLAKIS: In the other picture, the previous picture, it would come down from where, from the deluge?

MEMBER BROWN: No. The left-hand one is where the initial water goes down.

MEMBER APOSTOLAKIS: The initial water.

MEMBER BROWN: But the right-hand one is the downcomer pipe.

MR. WACHOWIAK: This is just --

MEMBER APOSTOLAKIS: Oh, for the right.

MEMBER BROWN: But that's a downcomer. Isn't that representing a downcomer?

MR. WACHOWIAK: It's coming from the same place. They come from GDCS.

MEMBER STETKAR: It's the GDCS pools, which get condensate back from the PCCS heat exchangers, which flow back down the lines.

MR. WACHOWIAK: Anything that steams out

will come back that way. But the water from in the pool will also circulate.

MEMBER APOSTOLAKIS: So how does that happen?

MR. WACHOWIAK: It is hard to show with these two-dimensional pictures because we don't have the right slice to answer your question, I think.

DR. KRESS: On the next picture, when you initially turned on the first deluge lines to go into the pool, the blue line, what keeps the water from going back up to yellow, instead of through the tubes?

MR. WACHOWIAK: Nothing.

DR. KRESS: Some would, right?

MR. WACHOWIAK: Some would. That's why I was saying that the water level in here and the water level in these would be the same. There's nothing that's going to prevent it from going up through here, which gets back to the question, what is the temperature on this when it starts so that we'll get an even distribution of water through all those pipes?

DR. KRESS: Including the yellow pipes?

MR. WACHOWIAK: Yes.

MEMBER BLEY: For Charlie's question, if I understand this right, the downcomer actually feeds into the distributor? Is that what it does or does it dump into the bottom of the pool?

MR. WACHOWIAK: The downcomer feeds into the distributor. That's correct.

MEMBER BLEY: Down and under or through the pipes.

MEMBER BROWN: Okay. So it feeds just like the initial feed?

MR. WACHOWIAK: Yes.

MEMBER BROWN: So that the downcomer has to then go -- in order to do the natural circulation, it has to go back out through the pipes and then out through these little things, where it dribbles, not really dribbles, dribbles outward?

MR. WACHOWIAK: Yes.

MEMBER APOSTOLAKIS: I'll come back to this transient business. The water starts rising. It's one meter, two meters, three meters. Tell me what happens. I mean, it keeps going up or at some point starts coming down.

CHAIRMAN CORRADINI: They are not going to tell you just yet. They're going to get back to us on that.

MEMBER APOSTOLAKIS: What?

CHAIRMAN CORRADINI: They are not going to tell us just yet. They're going to get back to us on that.

MEMBER APOSTOLAKIS: Okay. Good.

CHAIRMAN CORRADINI: Is that fair?

MR. WACHOWIAK: Yes.

CHAIRMAN CORRADINI: Okay.

DR. KRESS: And tell me what you do in natural convection. Is this hot water coming out? Is it assumed mix with everything? And then you've got a colander of water to feed down. That's a misnomer. If you've got bad distribution or bad mixing, that calculation doesn't work. But that's usually the way you calculate it.

MEMBER APOSTOLAKIS: But I also want to understand as the level rises, at which point does it go to pipes and come --

DR. KRESS: It just gives you more driving force to drive stuff through the line in the calculation the way it's calculated.

CHAIRMAN CORRADINI: In chapter 21 and in the BiMAC test report, they give one figure on what they expect the heat flux distribution. I guess I do agree with this one part, which is that downcomer or the center pipe is going to see much less heat flux. So the natural point is it is going to want to boil up the small pipes and get fed by the large pipe because of the maldistribution of heat flux to the big pipes, which are the small pipes.

But I think George's point, I think George's point, is as you're filling up, how does the thing get to steady state again? So we're back to the how do we get to steady state question.

MR. WACHOWIAK: And I think some of the things that we will be looking at here is as it first starts to dribble over, if you will, it is putting water on top of the melt. And that is all going to boil away.

Until we establish a good crust on the top, we are not going to be filling up that whole pipe. It's going to be boiling, going to PCCS, condensing in PCCS, and coming back down the deluge lines.

So early on the flow path is going to be through the whole containment --

MEMBER APOSTOLAKIS: Right.

MR. WACHOWIAK: -- until we establish a good crust on top of the core. And then it's going to start filling up into the --

MEMBER APOSTOLAKIS: That's where I'm not sure I understand.

CHAIRMAN CORRADINI: So let me ask this one question. There were spreading experiments back in 1988 and '89 at ISPRA about core melt spreading and if it stays where you think it's going to -- if it spreads evenly or it goes where you think it is going to go.

Have you assessed those to convince yourself that if you have something that is asymmetrically coming down -- I'm back to transient; I'm sorry, I can't get off of it -- that something comes down, as you said, not at the wall because the wall is way far away from where the first CRD, it starts piling up here, that it's not going to simply stay piled up and focus an attack on the basemat there?

MR. WACHOWIAK: And we'll have to get back to you on that. I know we looked at that thing early on when we were trying to decide what to do and when we were deciding if we were going to put the

BiMAC in.

I know that we had a whole bunch of those analyses that we looked at, but I don't know that that earlier material made it into the final document.

MEMBER APOSTOLAKIS: When are they coming before the full Committee?

CHAIRMAN CORRADINI: They? These? They?

MEMBER APOSTOLAKIS: They.

CHAIRMAN CORRADINI: These they? October. October. Right at this moment, that's the plan.

MEMBER APOSTOLAKIS: In a month and a few weeks. So you will have the answers then? You are writing a letter?

CHAIRMAN CORRADINI: Well, we have never held off an -- it's an interim letter. We've never held off an interim letter if we have open questions. They will appear as conclusions and notes to the staff.

MEMBER APOSTOLAKIS: No, no, no. When we say, "Welcome back" to you, when will that happen?

CHAIRMAN CORRADINI: For them?

MEMBER APOSTOLAKIS: Yes.

CHAIRMAN CORRADINI: I don't think by October.

MEMBER APOSTOLAKIS: But during the full Committee presentation, I mean, if you have already done it --

CHAIRMAN CORRADINI: Let me just try to help this out. So if they can answer some of the RAIs and staff will come in and present and we feel comfortable, then that will be included in the interim letter.

If this still is in the path where they are trying to answer the RAIs, we have to decide, will we write an interim letter on chapters 19 and 21, listing some things that are still open that we're concerned about.

MEMBER APOSTOLAKIS: Is that your understanding?

MR. WACHOWIAK: Yes.

DR. KRESS: I know this is just a diagram, but if you look at that smallest tube at the top --

MR. WACHOWIAK: Yes.

DR. KRESS: -- it looks like there's a part of the liner that is not protected.

MR. WACHOWIAK: That's because of this cartoon. It's not shown.

DR. KRESS: It's just a --

MR. WACHOWIAK: The idea is that when this pipe comes out, we would have --

DR. KRESS: We would actually have --

MR. WACHOWIAK: -- coverage of tubes all across the all.

DR. KRESS: And actually having coverage.

MR. WACHOWIAK: Yes. We have looked at 3-D modeling of this thing. And we can arrange it so that some of these have to be branched into more than one.

DR. KRESS: Have you considered any issues about thermal warping of those tubes due to the temperature distribution? Maybe they got offset or something and uncover part of the liner?

MR. WACHOWIAK: We're not expecting those tubes themselves to get that hot. It's still going to be the expectation is that all of these tubes are filled with water and are in a --

DR. KRESS: I was concerned about the temperature distribution on a lot of them, rather than actual temperature.

MR. WACHOWIAK: Yes. And I think what our experiment showed is that the bulk temperature in those tubes is remaining all right around saturation. So if we're talking about between subcooled --

DR. KRESS: Okay. You wouldn't have any --

MR. WACHOWIAK: -- and saturation, you know, that type of temperature, but the extremely high temperatures, I don't think we are expecting to see in the tube themselves because they're built for it.

CHAIRMAN CORRADINI: We've got to keep on going. I would like to take a break in a few minutes. Do you have a natural break point you want to get to?

MEMBER ABDEL-KHALIK: Could you stop at that slide?

MR. WACHOWIAK: Which one?

MEMBER ABDEL-KHALIK: Twelve.

MR. WACHOWIAK: Got it.

MEMBER ABDEL-KHALIK: Now, the implication here is that CHF is the limiting heat flux, but OFI can happen at a lot lower heat flux than CHF. And if that happens, some of the tubes will actually dry out.

MR. WACHOWIAK: Okay.

MEMBER ABDEL-KHALIK: So has that been done? Has that analysis been made?

MR. WACHOWIAK: I guess I don't know the answer to that question whether in determining that CHF was the right parameter to use here, that that analysis was done and then not included in the report or if it was not done.

So I don't know the answer to your question. So if we can get that question, then I think we can have it answered.

MEMBER ABDEL-KHALIK: The question is simply, we want to know what the OFI limit is for this set of piping.

MR. WACHOWIAK: Okay.

CHAIRMAN CORRADINI: Can I help or modify the questions? I would expect -- I think you said it. Maybe I missed it. I really couldn't understand this part of the BiMAC report. I tried. With all the color coding and everything, I just couldn't get it.

They probably had instabilities in their actual measurements. And I'm curious how they discerned when they had it and when they didn't because I think Said's point is well-taken that since they're looking at the red line, compared to the blue or the black line, they probably crossed the boundary where they were actually getting counterflow behavior. And I'm curious. Were they able to detect it?

MR. WACHOWIAK: Right.

CHAIRMAN CORRADINI: That's another way of asking the same sort of question, yes.

MEMBER ABDEL-KHALIK: I mean, the fact that you reached saturation temperature does not preclude the possibility of having leatherneck-type instability.

MR. WACHOWIAK: Okay. I think that's a good question. We should be able to answer that. Okay. Now is a good time for a break because I think this one might take a little bit.

CHAIRMAN CORRADINI: So just to make sure, we are not going to come back to the BiMAC at this point?

MR. WACHOWIAK: No. We are pushing on.

CHAIRMAN CORRADINI: We are pushing on. Okay. Go ahead, Said.

MEMBER ABDEL-KHALIK: Aren't they going to talk about their testing or --

CHAIRMAN CORRADINI: I think we might drag them back to that, but --

MEMBER ABDEL-KHALIK: Drag us back to the testing, but in that, we will need to be close on what we go into, the proprietary or not. But I'm going to have --

CHAIRMAN CORRADINI: On the testing?

MEMBER ABDEL-KHALIK: On the testing.

CHAIRMAN CORRADINI: Maybe, then, we might hold off on that. So let's take a break until a quarter of.

(Whereupon, the foregoing matter went off the record at 10:25 a.m. and went back on the record at 10:44 a.m.)

CHAIRMAN CORRADINI: Let's get started again. So the question is to the members is that Rick is going to go on to other issues. Do we have questions that are in open session about the experiments?

And if not, if we are going to get to details about dimensions and angles and such in that, we should hold off and bring that up later.

MR. WACHOWIAK: Yes.

CHAIRMAN CORRADINI: So we'll move on at this point through your presentation.

MR. WACHOWIAK: All right. A couple of things that came up in the last thing we were able to take a look at on the break. Glen found something in the report on the instability.

MR. SEEMAN: Leatherneck flow instability is discussed on page 23 of the test report. And that discusses that it wasn't possible to reach that in flow instability at the experimental levels that were used in the test.

MR. WACHOWIAK: At the heat flux levels that were used, you couldn't get there. He looked for it and couldn't get to it. So that's discussed.

MEMBER ABDEL-KHALIK: But does that exclude it from the expected conditions?

MEMBER BLEY: How did those heat flux levels compare with what we might see?

MR. SEEMAN: They were bounding. The heat flux levels in the test were bounding compared to expected, the heat fluxes in the BiMAC.

DR. KRESS: It was calculated by CFD, a whole lot of decay heat and a lot of melt.

MR. SEEMAN: Right.

DR. KRESS: Decay heat was for six hours after shutdown?

MR. SEEMAN: Right. That was the --

DR. KRESS: How did you arrive at that particular value?

MR. WACHOWIAK: We looked at the core damage sequences. And essentially the significant sequences were all six hours or later before we had melt go to the vessel.

DR. KRESS: The dominant core melt sequences?

MR. WACHOWIAK: The significant ones.

DR. KRESS: The significant ones.

MR. WACHOWIAK: It's a little more than dominant. It was --

MEMBER ABDEL-KHALIK: But I guess I would like to see more about how the experiments were scaled to determine whether or not the statement that you made that the heat flux that you used in the experiment is bounding for the actual system is relevant.

MR. WACHOWIAK: Okay. Right. Because that was in the scaled experiment. That was in the scaled experiment.

MEMBER ABDEL-KHALIK: Right, right, right.

CHAIRMAN CORRADINI: The one-half, one-quarter, right?

MR. WACHOWIAK: Yes, quarter --

CHAIRMAN CORRADINI: I'm sorry. Quarter of it at one-half scale. Excuse me.

MR. SEEMAN: That is an RAI to discuss scaling. We have an RAI on that scaling.

MEMBER ABDEL-KHALIK: Are we going to get to this later on in a closed session where they talk about the experiments and --

MR. SEEMAN: We want to. We will.

MEMBER ABDEL-KHALIK: Okay. Thank you.

MR. WACHOWIAK: All right. The other thing that maybe I'll bring up later since the question about dribbling out of the pipes came from somebody else --

MEMBER ABDEL-KHALIK: Just keep on going.

MR. WACHOWIAK: We'll keep going. All right. So the next area that we want to look at is the high-pressure melt eject scenarios. The issue here is direct containment heating and then the local failures of the liners.

In the direct containment heating, the way we address that, one way, is we looked at bounding parameters for the high-pressure melt eject and then looked at the dynamic response of the pressure suppression containment to see if we could withstand that scenario.

DR. KRESS: This is using the ROAAM process? You used the ROAAM process to do this?

MR. WACHOWIAK: Yes, yes, which is basically establishing the theoretical basis and then doing an expert elicitation, I guess, or review on that.

The local liner failures, we looked at that. And, once again, we can't preclude local liner failures in the high-pressure melt eject, but in the way that our containment liner is constructed, which is different than what some of the other plants have done in the past.

We don't have a freestanding shell with concrete outside of it. Each of the plates are actually anchored into the concrete. So there is no flow path out around the liner if we get a small hole. It's got to go through the entire container itself. And we have sensitivities associated with that.

So this is one place in the report where it gets difficult to understand what it was we were trying to get at mainly because of the way we presented it.

Regime III is the expected regime. Okay? This is basically what we expect to happen. And it's not highlighted in the report. What we expect to happen isn't what's shown because we don't think that we're going to have any interesting phenomena there.

CHAIRMAN CORRADINI: I'm sorry. Can you just remind us really briefly? We would get into this only if we had a failure of? Can you just remind me? I'm sorry.

MR. WACHOWIAK: Depressurization.

CHAIRMAN CORRADINI: And that would be by the squib, again by another set of depressurization valves?

MR. WACHOWIAK: We have depressurization valves --

CHAIRMAN CORRADINI: Right.

MR. WACHOWIAK: -- that could provide it.

We have traditional safety relief valves that could also provide depressurization. And then we also have the isolation condenser system, which if it goes into operation will also provide depressurization. So all three of those systems would need to fail before we get into high-pressure melt eject.

And I think -- I am trying to remember now. In our latest results. That is a fairly small percentage of the total core damage frequency falls into this range.

CHAIRMAN CORRADINI: Okay. Sorry. Thank you.

MR. WACHOWIAK: So regime II is where we spent most of our time looking at, finding bounding parameters to address the way that we would load the containment from a high-pressure melt eject.

What we have shown in the end with these results is that the peak pressures in the containment are well within the ultimate pressure that we talked about earlier. We get about .6 megapascals, 6 bars, 70 pounds in the dynamic peak because basically the pressure suppression containment is designed to handle those sorts of dynamic pressurization.

The way that we calculated this -- and

it's described in the report -- is we have essentially a closed-form solution that looks at the load or that looks at the pressurization in the containment, which was parked against the IET tests from way back when on the pressure suppression containments.

Then regime I, which we call hypothetical, should be regime H, but it's regime 1, hypothetical. We push the parameters on the model to see what it would take to fail the containment. And in the end, we found that we could get up to the place where containment would fail, but we would have to use input parameters, like the timing of the melt release or the amount of the melt or the rate of ablation of the vessel, those sorts of things that were outside of anything that we had seen in the thermal data.

So we call that the hypothetical regime. It was mainly calculated so that we could demonstrate that our methods were capable of calculating a failure of the containment, even though this is our bounding calc. It's not failing containment. And in the actual cases that we ran associated with the significant core melt sequences, we don't even get anywhere near the bounding case.

MEMBER BLEY: Just to tie a couple of things together that you said before, if you actually had this scenario where you failed all of your depressurization systems, --

MR. WACHOWIAK: Yes.

MEMBER BLEY: -- to get to this point, what is the earliest core melt you might get out of a scenario like that? Do you remember it?

MR. WACHOWIAK: Do you have it?

MR. SEEMAN: I am not sure the earliest, but I should have a pretty good --

MEMBER BLEY: Rough time.

MR. WACHOWIAK: Yes. It is a few hours, but --

MEMBER BLEY: Okay. So a scenario like this wasn't considered a significant scenario because the probability, the frequency of it is very low because your experiments were done, you said, with a six-hour decay heat because the significant scenarios all had greater than six-hour --

MR. WACHOWIAK: Yes.

MEMBER BLEY: -- take time to melt. So this one would be earlier than that, but it doesn't fit in that category of significant if I am understanding you correctly.

MR. SEEMAN: That was six hours.

MEMBER BLEY: This one was --

MR. WACHOWIAK: They were the earliest ones. That's where we based the six hours on.

MR. SEEMAN: Right.

MEMBER BLEY: Okay.

DR. KRESS: Are these map?

MR. WACHOWIAK: Yes.

MEMBER ABDEL-KHALIK: What phenomenon would have such a short time constant that would give you that peak at two seconds?

MR. WACHOWIAK: If we deposited the entire core into the drywell within just a couple of seconds, we would end up having to start with a CRD tube that came out. And that four-inch hole would need to ablate into a one-meter-wide hole within like, I think it was, a couple of seconds was the parameters that we got to iterate those types of pressurization.

DR. KRESS: The containment is inerted during this?

MR. WACHOWIAK: Yes.

DR. KRESS: So you don't have to worry about hydrogen iteration?

MR. WACHOWIAK: Yes.

CHAIRMAN CORRADINI: I think you want to take a step back. I think Said is asking, let's say you have a hole, let's say you have the melt, let's say you have a temperature. What is the mechanism that is pumping up the pressure inside containment to these?

MEMBER ABDEL-KHALIK: Right and then --

MR. WACHOWIAK: Okay. I'm sorry.

MEMBER ABDEL-KHALIK: Right, right.

MR. WACHOWIAK: The way that the high-pressure melt eject, the DCH scenario, goes is you start with the core material jets. You get a jet of core material out of the hole. And it's followed by a high-pressure steam jet. Okay?

And the high-pressure steam jet fragments and mixes with the core material as it's on the floor and it drives that up the sides of the walls of the lower drywell and disperses into the atmosphere on the containment.

And as it's dispersing, the surface area of the material in the melt is able to interact with all of the gas that's in the --

MEMBER ABDEL-KHALIK: What I am trying to understand, --

MR. WACHOWIAK: Okay.

MEMBER ABDEL-KHALIK: -- all of the things that you talked about sort of tend to drive the pressure up. So we're on the pressurized leg of this curve. What brought it down for that short period of time?

MEMBER BLEY: The dip in the curve.

MEMBER ABDEL-KHALIK: Right.

MR. WACHOWIAK: This part here.

MEMBER ABDEL-KHALIK: Right. Or on the other case, what you call the nominal thing, --

MR. WACHOWIAK: Here.

MEMBER ABDEL-KHALIK: -- what physical phenomenon dominates during this time period that causes the pressure to turn around?

MR. WACHOWIAK: Vent clearing. The pressure suppression containment is set up so that if the water in the vents, covering the vents, pressure goes up, it pushes that water down when the vent's clear and the steam goes and we start involving the suppression pool air space. And then they recover it. It becomes more of a -- not all events participate in the --

DR. KRESS: In order to make this calculation, you need surface area or drop size distribution. Does that come out of expert opinion or is that pulled out of experiments on --

MR. WACHOWIAK: I would have to go back and look at where we got that, but it's probably a combination of expert opinion and experiments because I don't know that we have seen very many of these DCH events.

CHAIRMAN CORRADINI: I would guess it's the tuning of the Sandia experiments.

DR. KRESS: Sandia experiments.

MR. WACHOWIAK: But I wouldn't exclude expert elicitation in that as well because this is one of these phenomena where that --

MEMBER BLEY: If you did, you would hope that is colored by knowledge of the Sandia experiments.

MR. WACHOWIAK: Okay.

DR. KRESS: So the ROAAM process basically tells you how much melt and what picture it is?

MR. WACHOWIAK: Yes.

DR. KRESS: That maybe feeds out of the primary vessel?

CHAIRMAN CORRADINI: I guess I am not worried about this given all the ways you depressurize, but I do think that this one part I guess we need to understand. So when you say, "expert opinion" versus tuning, who are the experts you are talking about? Was it a staff insight at GE that got together and set the distribution curse for the ROAAM calculation or was it the Santa Barbara folks?

MR. WACHOWIAK: Santa Barbara folks set that up. And then we took that report and had it reviewed by basically nine experts. And their comments are included in the report.

CHAIRMAN CORRADINI: And that's in 21? Did I miss that?

MR. WACHOWIAK: In 21.

CHAIRMAN CORRADINI: Okay.

MR. WACHOWIAK: Their letters, correspondence is in there. And the people who reviewed it are in there.

CHAIRMAN CORRADINI: Thank you. Thank

you. Move on.

MR. WACHOWIAK: Okay. This is a simple demonstration of how we decide these things in our process, whether or not we're going to include something in the containment event tree. The load from the DCH that we calculated is this line here. Okay?

And the containment fragility that we presented before, this is an earlier version of it. Those two lines or two curves don't intersect in any significant way. So this allows us to call energetic failure due to DCH physically unreasonable for our containment.

And we don't treat it explicitly in the main calculation for the level 2. We do have a sensitivity that we have looked at. Well, what if we are wrong? What does it do to us in the level 3? So this is a fairly simple, straightforward example of how we apply that to come up with physically unreasonable.

Now, the next one is the fuel coolant interaction that would generate a steam explosion. We looked at ex-vessel steam explosions. That's the issue that we have here. And the failure modes are damaging the pedestal wall, which would get us a release to the environment.

We find that if we had a very deep subcooled pool of water in the lower drywell, that that becomes an issue. Another issue is physically damaging the BiMAC pipes themselves because they can be crushed, if you will, by an impulse load. And we also find that deep subcooled pools will affect BiMAC pipes.

I didn't put very deep down because the loading on the pipes, at least in the current evaluation, pipes are more fragile than the lower drywell or at the wall.

The way we address this is that we minimize the amount of water in the lower drywell prior to the vessel breach. And the question came up, do we want to have this BiMAC pre-flooded or almost pre-flooded? And this is the area where we looked at that trade-off and decided that we don't want to have that set up that way.

CHAIRMAN CORRADINI: So just to repeat because I do remember you had covered this before. When you say "deep," it's still below the equipment hatch?

MR. WACHOWIAK: Yes. Very deep is above the equipment hatch. Deep still is up to the equipment hatch.

CHAIRMAN CORRADINI: Which is still? I'm trying to remember. Is that about three meters?

MR. WACHOWIAK: 2.2 meters is the equipment hatch.

CHAIRMAN CORRADINI: 2.2. And in these calculations, I'm trying to -- I lost my Chapter 21 somewhere in here. In your calculations, you looked at asymmetric loading of the pedestal. I was most concerned with the pour rate and the temperature where it occurred relative to the wall.

MR. WACHOWIAK: Yes. I think in the report, you can see we did two or three different locations with respect to the wall. We did a center and then a couple of off-center. But, once again, when we calculated the effect on the wall, we didn't -- the wall section itself got the whole impulse.

Off-center developed what the impulse would be. And then the calculation on the wall was a symmetric wall.

CHAIRMAN CORRADINI: Okay.

DR. KRESS: Did you use a particular FCI

code for this model?

MR. WACHOWIAK: Of course.

DR. KRESS: Texas?

CHAIRMAN CORRADINI: No, please.

DR. KRESS: The thing developed in Wisconsin?

MR. WACHOWIAK: I don't remember which code we used to develop the FCI loads.

DR. KRESS: There is a model in MAAP.

CHAIRMAN CORRADINI: No. It's the PM alpha SPROS.

MR. WACHOWIAK: And then LSI for the wall response.

CHAIRMAN CORRADINI: Was it coupled or was it -- so there was a pressure source term, and then it was fed to essentially a finite element response of the wall?

MR. WACHOWIAK: Yes.

CHAIRMAN CORRADINI: Okay. And cracking was the impulse? What was the failure that the little dashed line in terms of the pedestal wall failure there? Is that cracking of the wall or what was the mechanism?

MR. WACHOWIAK: No. It was reaching the

strain limits on the rebar.

CHAIRMAN CORRADINI: Okay.

MR. WACHOWIAK: So yes. We cracked the concrete well before we would this front integrity of the rebar.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. WACHOWIAK: And that's shown in the -- you have to get the color version of the report to really see what is going on there. And then also be aware that the boundary condition of the pedestal wall was not -- the anchorage at the bottom wasn't realistic.

So that first node that you would see there for the strain in the rebar is not necessarily what we would expect. It's just because of the boundary condition that was used.

DR. KRESS: In terms of the upper bound load calculation, does that have anything to do with how much metallic melt is assumed to be in with the core melt?

MR. WACHOWIAK: Right. And there are several cases that are in the report that we looked at different compositions of the melt and different core rates and things like that. And this box here is meant to envelope all of those cases.

DR. KRESS: The specific cases that follow.

MR. WACHOWIAK: There would be different cases along there. So what we find is that if we've got a one to two-meter subcooled pool and we have the upper bound load, we start seeing from the LS DINA calculations that somewhere between 400 and 600 kilopascal seconds is where we failed the rebar.

So for these types of pools, we're not expecting to fail the pedestal. But what we see is that in that same set of pools, this bounds out what the impulse to the floor is. We do see that, at least with the BiMAC pipes that we use in this calculation, that we start to see their incipient failure rate within the loads that are generated by those one to two-meter deep pools.

So what we say is if we get more than .7 meters of water, this isn't a PRA now. If we start with more than .7 meters of water in the lower drywell. When the floor is expected to come out, then we'll assume that the containment is either going to fail by a pedestal failure or fail because the BiMAC is -- the pipes are going to be damaged.

DR. KRESS: Does the amount of subcooling matter there? If it were saturated, would you get a different depth?

MR. WACHOWIAK: Yes. We wouldn't see very much at all. In what the calculation shows, if it's saturated, we don't see any impulse, essentially the melt --

DR. KRESS: It just gets --

MR. WACHOWIAK: -- calculates itself. And it's --

DR. KRESS: So if you're in a subcooling, did you assume --

MR. WACHOWIAK: Fifty degrees.

DR. KRESS: Fifty degrees?

MR. WACHOWIAK: In the calc, so quite a bit of subcooling. We're not even sure we're going to get to that. Now, once again, we didn't try to calculate the subcooling in the pools. We thought that was beyond our state of knowledge as to know specifically what the temperature was in that water in the drywell. So there --

MEMBER BROWN: Is subcooling better or worse?

MR. WACHOWIAK: Subcooling makes it

worse.

DR. KRESS: Yes. You get real energetic explosions the more subcooling you have.

MEMBER BROWN: Okay. That's for the ex-vessel?

MR. WACHOWIAK: Yes.

MEMBER BROWN: Okay.

CHAIRMAN CORRADINI: And so I guess then it gets back to your point. So every one of this curve, the red curve, which is the load from the high level, what was the subcooling in the core rate? Do you remember? I'm sorry I'm looking at --

MR. WACHOWIAK: I don't know the core rate. The subcooling was 50 degrees K.

CHAIRMAN CORRADINI: 50 degrees K?

MR. WACHOWIAK: I remember that one. I don't remember what --

CHAIRMAN CORRADINI: Okay. All right. And then for the blue, it's more like 10-20 degrees K?

MR. WACHOWIAK: Okay.

CHAIRMAN CORRADINI: Okay.

MEMBER BROWN: Fifty degrees Kelvin, right? That's what you --

MR. WACHOWIAK: Yes.

MEMBER BROWN: Okay. So that's such a large number for subcooling. In this case, that's conservative, I guess? Is that? Tom? Anybody?

DR. KRESS: Yes. It's a pretty low -- it's a pretty good subcooling, yes.

MEMBER BROWN: And you wouldn't expect that much under this scenario?

MR. WACHOWIAK: The water itself is -- there are two ways that water can get into the lower drywell essentially in these cases, is that it came out of the reactor. So it was already started out at saturated at 1,000 pounds when it came out of the reactor. So 50 degrees subcooling would be pretty good subcooling in the lower drywell.

The other cases where it's condensed on the wall --

MEMBER BROWN: It would be pretty conservative is what you --

MR. WACHOWIAK: Yes.

MEMBER BROWN: It wouldn't get to that.

MR. WACHOWIAK: It wouldn't get to that point. And the other place, though, is condensation on the wall that would run down into the lower drywell. And we're thinking that that's going to be fairly close to saturation because of that mechanism for getting the water down there. So 50 degrees subcooling we think was bounding.

But, once again, once we got to the -- we didn't really use that. We didn't try to calculate what the temperature was. We just said if our calculation shows that the water is there, we're going to assume that it's subcooled and that we'll have the steam explosion.

We didn't try to cut it that fine because that gets beyond what we think that we actually can know at this point in time.

CHAIRMAN CORRADINI: So, just to repeat because you have heard of this, where would be the failure of the tube? It would be in the buried tube, in the tube along the wall, that blue line, the intersection of the red line, which is the load versus the deformation. That's where.

MR. WACHOWIAK: Fairy tube.

CHAIRMAN CORRADINI: Fairy tube.

MR. WACHOWIAK: And I don't believe we took into account any of the floor material on top of the tube. It was just the strength of the pipes themselves that was considered here.

CHAIRMAN CORRADINI: Okay. So let me ask, then, my question. It would seem to me the tube that I would most worry about was the exposed tube on the wall that's connected to the water, not the buried tube underneath the concrete.

Again, I've got this in my head. I've got 12 feeder tubes, 6 of which go to the top of the water, 6 of which go below. And it's those tubes, those six tubes, that feed the header that then boil back up that worry me the most because they're exposed to the water where I have a drop of melt, which I have an explosion which crushes those tubes.

I thought that was the blue line. That's not the blue line?

MR. WACHOWIAK: The pictures that are in the report show the horizontal tubes. So I guess we'll have to take that bask as a question to see how we address the -- now, once again, remember that the vertical tubes for the most part are going to be buried in some sort of a material.

CHAIRMAN CORRADINI: But at some point they have to pop out so water can pop in. So that's the point I'm worried about is I've got these feeder tubes to the downcomer and I'm worried about them being crimped off by some further explosion.

MR. WACHOWIAK: Right.

CHAIRMAN CORRADINI: Yes.

MR. WACHOWIAK: I understand the feeder tubes. The sidewall tubes, you know, if they're there and they're buried most of the way --

CHAIRMAN CORRADINI: I'm there.

MR. WACHOWIAK: -- the impulse isn't going to be doing anything to those --

CHAIRMAN CORRADINI: Yes. I'm with you.

MR. WACHOWIAK: -- the large downcomer tubes. That's a good question. And I don't know that we address that in the report. We will look to see if it's in there.

Once again, that can be addressed, though, too, since it's not everything. Since it's a localized area, we can do things to minimize the impulse on that pipe in the detailed design.

CHAIRMAN CORRADINI: There are experiments run by AECL for their pressure tube. They're what they call an MFMI event. They actually have gotten data on that. So you might want to look. There is actual experimental data literally looking for this sort of effect on a pressure source outside of an array of tubes in a water chamber.

DR. KRESS: The horizontal tubes, do they fail in tension due to just mashing on them?

MR. WACHOWIAK: Pressing, yes.

DR. KRESS: The sides fail in tension because of the --

MR. WACHOWIAK: Yes. I think that's the -- in the report, it shows where the strains are calculated in the pipes. Yes, that crushing is the mechanism.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. WACHOWIAK: Okay. Now we'll move on to containment overpressurization in the long term. We've gotten through these short, energetic things, what could happen to the containment in the long term.

We have systems that mitigate this. This is getting back to more traditional PRA. We have a passive containment cooling system, that if it's steam that's carrying the heat, we can condense that steam and move the heat outside the containment.

Implicit in that is the vacuum breakers that they provide that seal between the drywell and the wetwell. I know that at least most of this Committee has had many presentations on the vacuum breaker.

So I don't intend to go over any of that stuff now. Just we took credit for the vacuum breakers.

CHAIRMAN CORRADINI: We don't have our skeptic consultant with us anyway. So let's move on.

MR. WACHOWIAK: If the vacuum breakers and the backup valves fail, then we assume the containment will overpressurize. That's how that's done using the fault tree systems in the PRA.

We have an active RHR system that we also take credit for in the PRA. And then we do have venting. Once again, in our PRA, venting is still considered to be a large release.

The only thing that the venting does is it changes the way that the source term is addressed in the level 3. So all venting is, at least in the design PRA, considered to be a large release and factored into that containment performance.

We treated these using a fault tree/event tree method. And it's linked. Level 1, level 2 are linked directly. We talked about that in June.

CHAIRMAN CORRADINI: So at this point, I think unless the members -- I'm going to jump in here. Unless the members are in disagreement, this might be the point to close it if there are questions about the heat transfer experiments.

MEMBER BROWN: The BiMAC.

CHAIRMAN CORRADINI: The BiMAC. Going back to the BiMAC heat transfers, which have a lot of design detail, we'll have to close the session. Is that all right? Now we'll look to the designated federal officer to tell me how I do that. How do I do that?

MR. VANDER MOLLEN: You call a short recess. And we ask everyone who is not either --

CHAIRMAN CORRADINI: Do we check IDs?

MR. VANDER MOLLEN: Well, we're not far from it. People who may stay are either staff members, who go to jail if they say something of proprietary stuff; or the applicant; and anyone who has executed a proprietary agreement with the applicant. And I am going to defer to the GEH personnel to tell me if there is anybody who is unauthorized to be here.

CHAIRMAN CORRADINI: Okay. So are there

any open session questions at this point about the severe accident management discussion that Rick has provided?

(No response.)

CHAIRMAN CORRADINI: If not, let's take a short, very short -- don't leave the room except for a quick bathroom -- break. 11:25 we'll come back. All right?

(Whereupon, the foregoing matter went off the record at 11:15 a.m., to reconvene in closed session, and reconvened in open session as follows at 11:42 a.m.)

CHAIRMAN CORRADINI: Go ahead, Ed. We're in open session.

EVALUATION OF SEVERE ACCIDENTS

MR. FULLER: What I am doing here today is a continuation of what you heard in June from Mark Caruso going through the review of chapter 19. The severe accident evaluations piece that General Electric prepared is in section 19.3 of the second tier document of the DCD.

In our review, we followed the standard review plan. And we used section 19.2 to denote severe accident evaluation. So I just wanted to make sure you understand that so you're not confused later. The purpose of this presentation is to actually review that and prepare the SER.

I am going through three topics just to show you without even going through in any detail the applicable regulations that we use and just show you the SER technical topics, which are nothing more than major section heads in section 19.2, and to just briefly discuss the very few significant open items that we have got.

Next slide, Rocky. We have got a number of regulatory requirements on severe accidents that are in 10 CFR 52.

MR. FOSTER: Ed, if we could possibly move along on this slide because we presented this on June 3rd?

MR. FULLER: There was one I added, though, pertaining to the severe accident mitigation design alternatives that relates to the NEPA as well as to our actual FSAR review.

CHAIRMAN CORRADINI: This is out of the 10 CFR 51.55, Ed?

MR. FULLER: That's correct.

CHAIRMAN CORRADINI: Okay. I just wanted

to point that out. Everything else in this slide is the same as what appeared in the package.

MEMBER APOSTOLAKIS: What does the "use of PRA" mean, "Regulatory Guidance. Policy statements on severe accidents and use of PRA"?

MR. FULLER: Where?

MEMBER APOSTOLAKIS: Right under "Regulatory Guidance."

MR. FOSTER: The first bullet underneath the second one.

MR. FULLER: Oh, the policy statements that appear back in the early '90s.

MEMBER APOSTOLAKIS: Oh, that means use PRA to the extent supported by the state-of-the-art, --

MR. FULLER: Yes. Next slide.

MEMBER APOSTOLAKIS: -- which is a pretty general blanket statement.

MR. FULLER: Okay. Now let's get into the course. We are supposed to evaluate severe accident prevention and severe accident mitigation features. And so the first two sections of an SER give our evaluation.

We had no open items on severe accident

prevention. We had a couple on severe accident mitigation, which I will get to. And we had a couple on containment performance capability and one on accident management and nothing on, no open items on, severe accident mitigation design alternatives.

Note here that I have actually put on the slide that document that I referred to earlier today to aid in your finding it. Okay? You want to look at the SAMDA submittal.

MEMBER APOSTOLAKIS: So let me understand that. Let's go back since you want to show me. 19.2.6. So we expect the applicant to show a number of ways for mitigating the severe accident, what this means.

MR. FULLER: What he has to do here is -- obviously when you are producing a design, an advanced design, to be certified, there are a lot of features for mitigating severe accidents that are not in existing plants.

In addition, the NEPA requires you to look at other severe accident mitigation alternatives and do a cost-benefit on whether or not they is a case for including them. And so the applicant has to go through the process.

And this particular report, this NEDO report, is GEH's document to comply with this. And, needless to say, they didn't find anything that was in addition to what they have already got that was cost-beneficial.

MEMBER APOSTOLAKIS: So there was no evaluation of an alternative to the BiMAC?

MR. FULLER: No.

MEMBER APOSTOLAKIS: Was there an evaluation of an alternative to anything? You said no I think when --

MR. FULLER: Not to the BiMAC. Is the answer --

MEMBER APOSTOLAKIS: Or to anything else.

MR. FULLER: Yes, there was some, but I can't really specify what they are, you know, right today. I would have to get the report and go over it with you. I am sorry that you guys never got the report to review, but it's been out for a year.

MEMBER ABDEL-KHALIK: Can the applicant answer that question? What alternatives were evaluated?

MR. MILLER: This is Gary Miller, GEH.

I think the scope of that was to evaluate alternatives above and beyond what was currently in the ESBWR design. So we screened alternatives that were based on an industry search, other SAMDA evaluations from other plants.

We used that. We used ABWR SAMDA evaluation, anything we could to generate a list of potential alternatives that are not currently in the ESBWR design. And then we screened those based on their merits.

MR. FULLER: Okay. Let's go to the next slide. The first significant open item has to do with the BiMAC performance test report. We asked a whole lot of RAIs on the BiMAC during the course of the review. Quite a few of them got resolved, but a number of them; in particular, the two listed here, resolution awaited the results of the BiMAC tests and the review of the documentation of them.

We got that report in the May time frame. We did a very quick, intense review and generated 27 RAIs. And, as a result of this discussion this morning, maybe a couple of more will be generated.

So this is an ongoing open item. The review focused on several major areas: adequacy of the test facility, scaling and its applicability to the ESBWR, the range of test data as compared to what one might expect in severe accident loadings, the adequacy of the theoretical predictions as compared to the data and implications of the design on operational ESBWR safety.

And we found that the test facility generally adequately scaled prototypic conditions, but we do have an RAI on scaling basis of the multi-channel tests.

Regarding the range of measured test data, we focused on the perceived lack of relevant tests for near-edge tubes. We wanted to see a better treatment of the range of heat fluxes chosen for the tests. And there were some other issues that RAIs are written on.

Comparing theoretical predictions against the data, our contractor did a little assessment for the single-tube tests. And it seems like the predictions are supporting the measurements.

And, finally, the implications on ESBWR operational safety, we have some RAIs on thermal load boundary conditions; the use of CFD simulations to obtain boundary conditions; and, taking cue from Dr. Powers, who is not here today, asked questions on the structural integrity of zirconia; and we also asked about the effects of crusts on heat loads and some other issues as well. So that captures the vast majority of the 27 RAIs that are in those 4 areas.

Next slide. Another significant --

CHAIRMAN CORRADINI: Can I interrupt you just to ask one thing? So when you are doing these calculations under the third sub-bullet, "Adequacy of the theoretical," what was being used?

MR. FULLER: It is a model that Dr. Khatib-Rahbar has put in place many years ago. Can I ask Mohsen to address that?

DR. KHATIB-RAHBAR: All right. This is a very simple one-dimensional pressure drop calculation essentially for low pressures, where you're driving the flow through this, the head you're providing by the liquid column. And it's basically coming out of the tubes. And you're just finding the stability of the range of that.

CHAIRMAN CORRADINI: So this is given a heat load, you're doing a natural circulation?

DR. KHATIB-RAHBAR: Precisely.

CHAIRMAN CORRADINI: So did you guys --

DR. KHATIB-RAHBAR: This is the same

thing which was done by General Electric, by the way, as well.

CHAIRMAN CORRADINI: Okay. But did you guys look at the prediction of the heat flux distribution in comparison to what GEH was proposing or --

DR. KHATIB-RAHBAR: Distribution? Do you mean axially or distribution you mean in terms of what?

CHAIRMAN CORRADINI: Along the tube length and along the wall.

DR. KHATIB-RAHBAR: Yes, we did that. We actually used a non-uniform heat distribution along the pipes because it's a single tube case. So for a single tube, the heat flux along the pipe, which tried to simulate the same thing, which was done in a GE --

CHAIRMAN CORRADINI: Right. That I'm with, but I guess I'm asking something slightly different. I'm saying you were using their input. Did you check their heat flux distribution? In other words, they're saying they expect the heat flux distribution of some shape. Did you recheck that?

DR. KHATIB-RAHBAR: No, no. The GE heat

flux distribution is based on the CFD analysis.

CHAIRMAN CORRADINI: Okay. Which they have done.

DR. KHATIB-RAHBAR: Which they have done. We have not done a molten core analysis.

CHAIRMAN CORRADINI: Okay. That was I guess my question.

DR. KHATIB-RAHBAR: This is just a single tube.

CHAIRMAN CORRADINI: Okay.

DR. KHATIB-RAHBAR: It's heat flux-driven analysis.

CHAIRMAN CORRADINI: Okay. Thank you.

MEMBER ABDEL-KHALIK: But this analysis is for a single tube, whether it's uniformly or non-uniformly heated. And you do a sequence of steady state calculations --

DR. KHATIB-RAHBAR: Precisely.

MEMBER ABDEL-KHALIK: -- to find the '05 --

DR. KHATIB-RAHBAR: Precisely. Yes, yes.

MEMBER ABDEL-KHALIK: But there is no calculation whereby you have a group of pipes that are not geometrically identical --

DR. KHATIB-RAHBAR: Correct.

MEMBER ABDEL-KHALIK: -- that are in parallel.

DR. KHATIB-RAHBAR: That's correct. Had we done a single tube analysis only, the issue of how we challenge stability is not considered if that is what you are concerned about.

In those, I think there are some discussions in the GE report that they talk about that I think in passing, but that is something we have not addressed. You are absolutely correct.

It is just a single tube, pressure drop analysis.

MEMBER ABDEL-KHALIK: Steady state. Steady state.

DR. KHATIB-RAHBAR: Precisely. But it is a steady state problem, though.

MEMBER ABDEL-KHALIK: Right, right, a sequence of steady states.

DR. KHATIB-RAHBAR: And that's where the problem is.

MEMBER ABDEL-KHALIK: Right, right.

MR. FULLER: Let's go to the next slide, please. There was another significant open item that is now cleared up on vacuum breaker performance. We were concerned about vacuum breaker leakage. And GEH has provided information on isolation valves on the drywell side of the drywell-wetwell interface to show that, in addition the vacuum breakers, you had the isolation valves, which would close in appropriate ways to reduce the probability of vacuum breaker leakage and loss of pressures suppression capability.

CHAIRMAN CORRADINI: Just to be sure, it's on the drywell side or on the wetwell side?

MR. FULLER: I'm sorry. No. It's on the drywell side.

CHAIRMAN CORRADINI: Okay.

MR. FULLER: Maybe GE can elaborate a little bit.

CHAIRMAN CORRADINI: I remember it being on the wetwell side, but, again, I could be goofy. This is not the forum.

MR. WACHOWIAK: State the question again.

CHAIRMAN CORRADINI: Where is the isolation valve: on the drywell side or the wetwell side of the vacuum?

MR. WACHOWIAK: The isolation valves are on the wetwell side of the vacuum breaker.

MR. FULLER: I'm not sure about the drawing, then.

MR. WACHOWIAK: But they're in the drywell.

MR. FULLER: Oh, yes. I'm sorry. I meant to say they were -- yes, they were in the drywell between the structure between the tube and the vacuum breakers themselves.

MR. WACHOWIAK: Except it goes into the vacuum breaker.

MR. FULLER: Okay. Right.

CHAIRMAN CORRADINI: I don't want to knock you off base. Keep on going.

MR. FULLER: Next slide. Here is another case of an open item that was in existence when we prepared the SER with open items, which has since been resolved, having to do with the liner strain exceeding Level-C limits under 100 percent metal/water reaction conditions.

And temperature boundary conditions for the drywell head was set incorrectly. And apparently that has been corrected. Jim Xu of the staff is here, who did this particular part of the review, in case you have any questions.

Okay. Hearing none, let's go to the next slide. The final open item has to do with accident management, not in the way GE was talking about accident management earlier in terms of the very low-probability, potential high-consequence events and the BiMAC but more in terms of how they're in the process of developing their severe accident management guidelines because we can do all of the review of severe accident evaluations we want, but the real reason for doing this is to make sure that the plants have in place procedures and training to handle these accidents if they have them.

So looking downstream to the actual COL licensees and holders, they will have to have good accident management procedures in place.

Given that, we believe that it is important that before we give a COL, that we understand for these new kinds of reactors, that we need to understand what the technical basis is, particularly relative to that for the existing plants.

So we have been asking RAIs and back and forth between COL applicants and GE in this case. And we're trying to get them to the point where they will give us the information we need in an appropriate manner.

So there have been a number of supplements to this basic accident management RAI. And the latest one, which GE has just gotten, basically comes down and asks, what is your technical basis for ESBWR accident management? And we're hoping we get a decent reply this time.

CHAIRMAN CORRADINI: I am not sure I appreciate everything you just said. Can you kind of try a different way?

MEMBER APOSTOLAKIS: I am confused. Is this an issue of a design certification or of COL?

MR. FULLER: It is an issue of COL. However, if you go back into history, you find that when the industry formulated severe accident management guidelines, it did it through a pretty structured process that began by having EPRI develop the technical basis for dealing with all of these severe accident phenomena and how you start bringing them towards procedures. And NEI was involved, and owners' groups were involved.

So what happened was at a certain point, that technical basis got transferred to the various owners' groups. And they developed the plant-specific guidance or specific to their kinds of plants, which, in turn, were developed into the plant-specific guidelines. Okay?

And there are no actual regulations on this, but there is an agreement between the NEI and the NRC, which basically led to industry initiative, if you will, that all of the plants agreed to comply with. And it's summarized in NEI 91-04, which includes some correspondence between the NRC and the NEI at the time.

And so we're taking this as precedent to go forward with the new plants because we want to make sure that the same kinds of processes are in place for the new plants.

MEMBER APOSTOLAKIS: I understand that, but why now and not at the COL?

MR. FULLER: Because take, for example, ESBWR.

MR. OESTERLE: Ed, let me jump in here for a second. This is Eric Oesterle from the staff. I am going to start at the endpoint with the COL applicants or the feature licensees.

With respect to the NRC issuing them a

license, they have to demonstrate to us that they are the ultimate responsible authority for implementing the operational programs, the operational procedures, including operating procedures, emergency procedures, severe accident guidelines and procedures.

So it is the COL applicant that has the burden of responsibility from the staff point of view to provide that information to us. However, the technical basis for developing all of those procedures and guidelines really rests with the design certification applicant.

So there is going to be a lot of dialogue and interaction between the COL applicants and the applicants for design certification so that the COL applicants can provide us, the staff, with these procedures for review.

It is all part of what we consider operational programs that we look at under chapter 13. And it has connections to various other portions of the COL application.

Now, the reason the burden of responsibility is on the COL is because they will ultimately operate the plant, not GEH. They're the designers of the plant. And, yet, they have a tremendous amount of input into these procedures that the COL applicant is responsible for.

MEMBER APOSTOLAKIS: We've done all this at the COL.

MR. FOSTER: We could have, but we gave the option to GE. Okay. Talk with the COL applicants and determine when you want to provide it, but we need it before we go through licensing.

MR. FULLER: Let me explain why. Particularly for a plant like ESBWR, there's a lot of -- what we perceive is a plant is not going to behave the same in many ways as the existing plants because we've got severe accident mitigation features.

Timings are going to be different. And strategies will likely be different in any cases. And if we don't get those identified now and give somebody a COL and then find out later that we didn't understand the technical basis, then it's hard to resolve after the fact. So we want it done before we give COLs.

And it makes sense to have the designer involved because they have done all of the severe accident work already to understand their plant.

MR. OESTERLE: Just one more data point

for this discussion again. This is Eric Oesterle from the staff.

After we develop all of these technical bases, then we have to establish regulations. Well, the regulations with respect to design certification state that once you receive a certification of the design, that design has finality under the regulations with the exception of the operational aspects for that design. That does not have finality. That finality rests with the COL license holder.

Although the technical basis provides the foundation for all of these discussions and the regulations, that is one of the other very important reasons why it is up to the COL applicant to do this.

MR. FULLER: Okay. That concludes my presentation. Any more questions?

CHAIRMAN CORRADINI: Members?

(No response.)

CHAIRMAN CORRADINI: Okay. Let's adjourn for lunch. Let's break for lunch. 1:00 o'clock.

MEMBER APOSTOLAKIS: No.

CHAIRMAN CORRADINI: Please.

(Whereupon, the closed session was concluded at 12:08

p.m.)

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

(1:01 p.m.)

CHAIRMAN CORRADINI: On time at 1:05. Let's resume for our afternoon session.

INTRODUCTION

MR. WACHOWIAK: All right. So this next session, which is expected to go today and then --

CHAIRMAN CORRADINI: All tomorrow.

MR. WACHOWIAK: -- all tomorrow --

CHAIRMAN CORRADINI: But we want to pace ourselves. We don't want to get behind.

MR. WACHOWIAK: Okay.

CHAIRMAN CORRADINI: And you're not going to present very much.

MR. WACHOWIAK: My intention is not to have a lot of presentation. I have a few slides up front to put things in context. Then we'll go because I want to make sure. There were some questions before on what it was you were reviewing and what is the purpose of all of this stuff. And I just want to make sure that we all understand what we have today, what we are going to have in the future, and where that is going to be.

So go ahead. Everybody saw that picture

before. I've had that 100 times.

CHAIRMAN CORRADINI: Sure.

MR. WACHOWIAK: This is our team that we have here today. You know me, Rick. Gary Miller you've met before. He's principal engineer in the PRA area; Glen, who was up here earlier this morning, one of our PRA engineers. Jonathan is a PRA engineer and Justin a PRA engineer.

Lou Lanese is somewhere. You've seen Lou. Oh, there he is back in the back. He's our regulatory affairs contact, make sure that we don't have to go to jail like these guys do.

(Laughter.)

CHAIRMAN CORRADINI: So he's your designated federal jail-server?

(Laughter.)

MR. WACHOWIAK: And also I didn't have up on the board Brandon Schaffer. He's a project engineer for the ESBWR design cert. So he's our link to management at this point.

Going down through the list, down the next thing, here's what I think we're doing. Okay? What you guys want to do is get an understanding of the technical quality of the PRA. Okay? And where we were left before, you had some open questions and you wanted to look at some more detailed things. And this is our forum or our opportunity for doing that. Okay?

Look at the completeness that we have. And then we really want to investigate the details of what is going on in the PRA. Okay?

PRESENTATION OF SELECTED PRA ACCIDENT SEQUENCES

MR. WACHOWIAK: And the way we are going to do this is we have got four sequences that you suggested we amended. And we'll use those for the context for this. But those sequences are an entry point into this. It's not that you were interested in those particular sequences. Okay?

Go down to the next one. I just have a couple of things here that talk about the quality and scope of the PRA and then put it in the context for the design certification.

The first is a partial quote from reg guide 1.200. And you really need to look at any PRA that you do in the context of how you're going to use it.

MEMBER ABDEL-KHALIK: I'm sorry, but we do not have copies of these slides.

MR. WACHOWIAK: You don't? This was the last one that I sent to Lynn yesterday morning. Did she not get copies out?

MEMBER ABDEL-KHALIK: She said there's nothing in the box.

MR. WACHOWIAK: We'll have to get -- there are only a few slides here. We'll have to get copies of this. Apparently they didn't make it in the car on the way here.

MR. VANDER MOLLEN: We'll need them for the record.

MR. WACHOWIAK: I have got them on here. I've got the .pdf file on here. We had printed hard copies before they left, but apparently they didn't make it in the box. So I apologize for that.

So we want to look at the PRA in context of what it is we're doing with the PRA. Okay? So in the past I think there is some thought that there is a plant PRA that's general and can be used for anything.

In general, that is right. There is a framework that is there. But you always have to tailor the PRA to what it is you're going to use it for. In our case here with the design, we were using the PRA to support the design certification application. Okay?

ISG, which has just come out on the PRAs for combined construction operating licenses, basically says that ASME capability category I is the metric that we're looking for, which is a PRA that can discern, can find vulnerabilities and can discern importances at the system/train level.

So many of the -- if we get to a point where we're going into more details than what we have, it's because this application of the PRA wasn't intended to do that.

On to the next one.

MEMBER APOSTOLAKIS: Let me. Harold, do we have this ISG?

MR. VANDER MOLLEN: Apparently not.

MR. WACHOWIAK: I got it off your Web site.

MEMBER APOSTOLAKIS: Oh, that's on the Web site.

MEMBER BLEY: It has not come to us directly.

MEMBER APOSTOLAKIS: ISGs in general do not come for approval, but I would like to have a copy.

MR. FOSTER: It should be available on the public Web site.

MR. WACHOWIAK: That's where I got it.

MEMBER APOSTOLAKIS: We never go to the public Web site.

MEMBER ABDEL-KHALIK: Back to the comment that you just made, and it's at the top. So you did not go through a process by which you identified single-point vulnerabilities for your design.

MR. WACHOWIAK: Yes, I think we did go through that. In the process of building the PRA, we were looking for single-point vulnerabilities all along the way. And the reason why you don't see a lot of that in the final analysis is because when we found them, we eliminated the single-point vulnerabilities. That wasn't allowed to stay in the design.

So you don't see things like that. You don't see a specific search for that in the final analysis because we were removing those as we went along.

MEMBER ABDEL-KHALIK: Yes, I can understand that, but, you know --

MR. WACHOWIAK: Our point was to identify vulnerabilities and eliminate them. That's one of the uses of the design PRA. We have that flexibility now since we don't have a piece of hardware that we have to change.

MEMBER APOSTOLAKIS: I remember we had the long discussion last time on the evolution of PRA. If this design is certified, this PRA exists to support this design, that doesn't mean when the COL time comes up later, we cannot revisit the PRA and update it and all of that.

MR. WACHOWIAK: If you had my slides, you would see that is my next slide.

MEMBER APOSTOLAKIS: Okay. Let me continue the thought.

MR. WACHOWIAK: Okay.

MEMBER APOSTOLAKIS: Regulatory guide 1.200 also makes a big deal out of a peer review. There is no such requirement here, is there?

MR. WACHOWIAK: No, there is not. And you will also see that in the ISG, that for this particular PRA, there isn't a peer review. And there are several reasons for that. One reason is that the staff is actually reviewing the PRA versus the ones specifically addressed in reg guide 1.200. The peer review is somewhat of a surrogate for a staff review. And I think that's even in the words of reg guide 1.200 now.

MEMBER APOSTOLAKIS: But it could be here, too. It could be a surrogate here as well.

MR. WACHOWIAK: It could be. We run into --

MEMBER APOSTOLAKIS: Anyway, they don't require it.

MR. WACHOWIAK: It's not required. We run into some difficulties, especially with a new design in doing a full, thorough peer review, because those peer reviews tend to -- we try to make them happen in a few-week time frame.

And if you have a brand new design that no one has looked at before, it's hard to find peers and get them up to speed in a few-week period; whereas, I think it's taken the staff a year to get up to speed on everything they need to know about the ESBWR design in order to do a good review.

So at this stage, too, it's difficult to do that type of peer view, but we do have the additional. And we have done some limited things that I think we have talked about a lot before. We have gone through the standards, ASME standards, and the NEI peer review process and internally done an assessment of our models against all the requirements of the RAI that we sent our response in that showed that comparison.

MEMBER BLEY: Rick, excuse me. I know this is your turn, but so I don't forget it later, I would like to ask the staff if they agree that the review they are doing now is at least equivalent to the kind of review reg guide 1.200 would have had an outsider do.

MR. CARUSO: Well, I don't think the level resources that we have had to do this are equivalent to a peer review team that has a number of people with different expertise, but I would say, you know, I guess we have had more time than a peer review team would have. So maybe in that sense, it comes out to be equal.

I think the one thing that I wish could have been better was I think because the PRA is evolving, you know, the most significant and detailed review we did was of the first one.

Many of the questions, as I mentioned

last time when we were here, there were, you know, 250, 300, 400 questions. Many of those questions were addressed by modifying the PRA. And there were additional modifications that weren't based on those questions.

So we sort of had a moving target. We have not had the resources to go back every time we have gotten rev. 2 to go back and do the level of detail of review that we did on rev. 1.

MEMBER BLEY: Do you foresee a point at which that will be able to happen that you will actually get that final thorough review?

MR. CARUSO: Well, I think we feel like what we have done so far in terms of the rev. 1 and looking at the responses and doing additional reviews and the questions that we asked about technical quality and the work that GE has done, their own self-assessment, and looking at their quality of procedures, that we feel that we have done enough to be able to judge the PRA in terms of its application in this context.

MEMBER BLEY: Thanks.

MR. WACHOWIAK: And just to tie this up a little bit, having just within the past few months participated on a peer review for an operating plant, I think the level of depth that the staff has gotten into is equivalent to what a peer review team would look at and in some cases would go even deeper.

MEMBER BLEY: Okay.

MR. WACHOWIAK: Now, in a peer review when there is a finding or a comment, that gets transmitted to the utility. And then the utility resolves that and it doesn't ever go back to the review team, where in this case, where we had those issues, the resolution went back to the reviewers. And the reviewers reviewed the resolution. So in that sense, it's more thorough than a peer review.

MEMBER APOSTOLAKIS: Let's explore a little bit of the words in this context, presumably the design certification.

MR. WACHOWIAK: Yes.

MEMBER APOSTOLAKIS: I am wondering whether that context is different from any other context in the sense that basically what you want to make sure is that your sequences are meaningful, right, the accident sequences, the event trees, and fault trees are meaningful, but also that the numbers are meaningful because you are arguing that when you do the focused PRA, your core damage frequency is well below the focus.

So both things matter. The sequences, which presumably are used to identify single-point vulnerabilities or other kinds of vulnerabilities, may affect the design. But the numbers matter, too.

Of course, this PRA will not be as detailed as a PRA for an operating facility because you don't have certain kinds of information.

So is that what you guys understand as well by the words "in this context," that we have to make sure that at least what we have is correct in the terms of the sequences and the cut sets but also that the numbers are not really of secondary importance? The numbers also could be reasonable.

MR. CARUSO: Mark Caruso with the staff.

I agree with that. I think we have looked at the numbers a great deal. We have looked especially at common cause failures. You know, we used operational data where it was appropriate, where we were looking at pumps and we were looking at motor-operated valves.

MEMBER APOSTOLAKIS: As long as we have this common understanding. That's all I wanted to make sure of, that we're not missing anything.

MR. WACHOWIAK: Yes. And/or determining that we don't have vulnerability is one thing and for determining that we meet the goals with a full PRA and with the focused PRA. Those sorts of things are completely doable with what we have.

MEMBER APOSTOLAKIS: Okay.

MR. WACHOWIAK: If we're going to go and try to determine allowed outage time for tech specs for certain equipment --

MEMBER APOSTOLAKIS: No, no.

MR. WACHOWIAK: -- we don't have that kind of information.

MEMBER APOSTOLAKIS: No, absolutely not. No. That's what I meant, that within the limitations of what we have, --

MR. WACHOWIAK: Right.

MEMBER APOSTOLAKIS: -- both the vent analysis and the quantitative analysis --

MR. WACHOWIAK: Right.

MEMBER APOSTOLAKIS: -- matter.

MR. WACHOWIAK: Okay.

MEMBER APOSTOLAKIS: So that's good enough.

MR. CARUSO: I might just add that I believe that some of the other vendors -- and I won't mention any names -- that are coming in for design certification I believe are going to bundle together risk-informed tech spec application in 50.59 application. That's part.

I think that we will get into this issue in much detail at that time.

MEMBER APOSTOLAKIS: We will revisit the context at that time.

MR. CARUSO: Yes, right.

MEMBER APOSTOLAKIS: At this point this is all we --

MR. WACHOWIAK: Let's go to the next slide because after we go and that is what our objectives are --

MR. OESTERLE: Well, I think hang on just a second. Eric Oesterle from the staff. I just wanted to butt in with an important clarification.

And this is my interpretation of what the question also asks is that at this point I am not aware of any staff position that would indicate that the staff's review of the applicant's PRA can be considered the peer review as described in the reg.

guide.

MEMBER APOSTOLAKIS: Yes, you are right. There isn't such a statement there. But we are just asking to figure out where the people stand.

MR. OESTERLE: Right.

MEMBER APOSTOLAKIS: I personally would not say it's --

MR. WACHOWIAK: Go back to the previous one?

DR. KRESS: Can I see it just again? I am interested in just what your definition might be of a vulnerability. You know, when they did the plant vulnerabilities for the operating plants, they kind of thought of it as a CDF greater than 10^{-4}. If it got greater than that, they thought of it as a vulnerability.

I don't think that would apply to your plant. So I was wondering what you considered may be a vulnerability if your CDF was greater than your target by a certain amount or --

MR. WACHOWIAK: The main thing that we were looking for for vulnerabilities was things like single point failures, where if you had an initiating event, like a transient initiating event and some single failure that would lead you to core damage, lead you to core damage, would be vulnerability, things that are associated with the normal operating state.

Now, we have a few things in shutdown. I think everybody is aware that if you have a pipe break in shutdown, if we don't get the lower drywell hatch closed within a certain time frame before the water starts coming through the door, then you are significantly on the way to a core damage event. It's very difficult to respond perfectly to that situation.

That is probably as close to a vulnerability as we have. We had to put some constraints on the applicants, the COL applicants, so that they commit to certain procedural things to address that particular thing.

But those are the kinds of things that we're looking for. If we have something where there's an initiating event and some small number of failures will take you to core damage, we don't want that to happen.

Now, there's the common cause failure things that get there. But we have to look at what the specific common cause failures are. If it's a common cause failure of eight things, that's not a single point failure. Nobody needs to --

MEMBER APOSTOLAKIS: So what you are saying is the event sequences are the first thing you look at and then the probability.

MR. WACHOWIAK: Right.

MEMBER APOSTOLAKIS: Because if you say it's eight things that must fail, I don't care. I mean, it's not a --

MR. WACHOWIAK: It's not a vulnerability, yes.

MEMBER APOSTOLAKIS: Well, that made sense. There is no specific definition of what a vulnerability --

MR. WACHOWIAK: Yes.

MEMBER APOSTOLAKIS: You remember in the IPEEE days, every single licensee said, "We have identified no vulnerabilities," next paragraph, "These are the changes we made to the project."

(Laughter.)

MR. WACHOWIAK: No vulnerabilities after the changes.

So let's go to the next one here. I

think this is my last point I want to make. Part 52 was recently revised. This statement was added to Part 50, which requires the owners of the plant to do a fully standard, compliant PRA prior to fuel load.

So, no matter what anybody does with any of their design cert PRAs, this is a requirement by law that they have to do that. And then, as you see on the other statements that go --

MEMBER APOSTOLAKIS: Right.

MR. WACHOWIAK: -- farther on down, it is now required by law that they update that every four years. So two pieces to this. One, the design PRA will have to be updated. And the second piece is that it is required to be compliant with the standards that are endorsed at the time when they do the update.

So if we have some piece of this PRA that we couldn't do because we didn't have the information at this stage of the design and that's something that's required by the standard, well, when this PRA is done, that is going to need to be included in there or they wouldn't be compliant with the standard.

On to the next one, I think. I just said that. That was the update requirement that is in there. And I think that's it. Right? Oh, no. Not quite it. I had to put in a conclusion. I'm not allow to do these conclusions. We discussed this already.

So do we want to start with one particular sequence?

MEMBER APOSTOLAKIS: I don't know.

CHAIRMAN CORRADINI: I think that was the plan.

MEMBER STETKAR: Let me start. Sequence descriptions.

CHAIRMAN CORRADINI: I guess Mr. Stetkar has a suggestion.

MEMBER STETKAR: Only because we talked about the severe accident situation, a lot about the BiMAC, and things like that, what I would like to do is start a little bit from the back end. We could put it in the context of the specific sequence if we want to, but some of the general questions apply more globally.

So now I warn you this is going to get real detailed real fast. So --

CHAIRMAN CORRADINI: Do you want to have

them at least --

MEMBER STETKAR: This is not a sequence. Please don't. You know, there are some bigger picture issues here than nitpicky details of individual sequences. The sequences are good context in case we want to get them into a specific path through the event model.

Let me ask you a specific question. GDCS deluge valves. You have 12 valves. There's a top event in the level 2 event tree called BI_SP. Look it up. The success criteria for BI_SP says, "I win if any six deluge valves open," period.

Now, what is the basis, A, for that general success criteria? And, B, how does the PRA differentiate between the deluge valves that supply the BiMAC cooling tubes versus the deluge valves that dump into the lower drywell, two questions? Answers, please.

MR. WACHOWIAK: Okay.

MEMBER BROWN: That was crisp.

MEMBER STETKAR: I said we are going to get real detailed real fast --

MEMBER BROWN: Not hard to understand at all.

MEMBER STETKAR: -- because what I am trying to do is follow up on definitions of success criteria. Are they consistent with the design as we understand it? And how are they implemented in the PRA?

MEMBER BROWN: Right.

MEMBER STETKAR: And how were those reviewed during this review?

MEMBER APOSTOLAKIS: So let me understand the question.

MEMBER STETKAR: Because I haven't seen a question about this.

MEMBER APOSTOLAKIS: So you say there were eight?

MEMBER STETKAR: There are 12 deluge valves. The PRA success criteria says, "I win if any six open."

MEMBER APOSTOLAKIS: Okay.

MEMBER STETKAR: What's the basis for six, not seven, not nine, not three, six? That's a technical basis. And because certain deluge valves go to different places, I can win if six deluge valves only go to the BiMAC tubes. I can win if six deluge valves only go to the lower drywell. I can win if three and three, five and one, two and two, and two and four.

I want to know what the basis for the six was and how does the PRA differentiate where I am actually getting the water because right now, A, it doesn't differentiate. And, B, I don't know the basis for the six in the beginning. And this is really important because if we don't have successful deluge, it is a bad day in the containment.

MR. WACHOWIAK: It was already a bad day.

(Laughter.)

MEMBER STETKAR: It's a worse day. It's a worse day outside. There you go.

MR. WACHOWIAK: I think you get it, right?

MEMBER STETKAR: I get it. So those are the questions. What's the basis for six?

MR. WACHOWIAK: Okay. The basis for six I think came from Theo. And what he said was that we need to have about a certain I guess flow area of pipe available from the tanks down into the BiMAC. And originally when we had just four valves, our success criteria would have been any two. When we have decided that we want to expand it out to more than just four valves, we retained the value of half of the valves.

Now, here is where I think we got a little behind in the PRA versus what the implementation is in the design is that the PRA does not take into account that half are not going into the common header in the tubes. They're going to other places. So that's something that we're going to need to go back and look at.

But, given that, even if we make it that it's got to be whatever the success criteria turn out to be, I don't think that we'll end up with differences in the numbers because of the limitations --

MEMBER STETKAR: That's speculation about where we're headed. I'm just looking at, do the model and the success criteria support what we know about the design today? And what I know about the design today is that. And the PRA does not support that.

MR. WACHOWIAK: That's right.

MEMBER STETKAR: That's a simple statement. I don't care speculation about what the success criteria may be. I don't care speculation about what the numbers may be. It's does the PRA accurately model the plant as we know it today?

MR. WACHOWIAK: And where we are. And that particular one --

MEMBER STETKAR: Doesn't. Okay. So that's one point.

MR. WACHOWIAK: We're out of sync.

MEMBER STETKAR: Okay. That's a point.

MR. WACHOWIAK: And because one of the things that happens in doing the design PRAs, we get the information. We put it into our success criteria in the PRA. The designers also get the information.

MEMBER STETKAR: That's an interesting thing, but we're on the ACRS and we're at the ultimate tail end of that entire process. You know, you see it before anybody else does. The staff sees it after you do. We see it after the staff. Why are we finding it? Why are we finding it and not the staff and not you?

MR. WACHOWIAK: I know why the staff isn't finding it.

MEMBER APOSTOLAKIS: Why?

MR. WACHOWIAK: Because that model wasn't in the previous revs. of the PRA. This rev. 3 is the first time we've actually had this.

MEMBER STETKAR: That's not true. I found it in rev. 2.

MR. WACHOWIAK: We had the --

MEMBER STETKAR: I made sure that it didn't change in rev. 3.

MEMBER BLEY: Which is where we started our review.

MEMBER STETKAR: This is where we started on rev. 2.

MR. WACHOWIAK: Okay. I thought --

MEMBER APOSTOLAKIS: Okay. We established that what you said is true. Which sequences would be affected by this?

MEMBER STETKAR: All sequences.

MEMBER APOSTOLAKIS: All sequences.

MEMBER STETKAR: All sequences that go to core damage. That's why I didn't want to talk about a specific sequence.

MEMBER APOSTOLAKIS: Yes. I understand that.

MEMBER STETKAR: It's functional success criteria.

MEMBER APOSTOLAKIS: Okay.

MEMBER STETKAR: That's to get water in for debris coolability.

MR. WACHOWIAK: In the initial PRA for the BiMAC system itself since we didn't have even close to the design, it was conceptual design, we initially set reliability criteria for the BiMAC itself that said that that system needed to perform independent of the other systems in the plant that were associated with any sequences where we used, core damage sequences. And it would need to have a reliability or unreliability of 10^{-3} or lower.

And I don't know that we don't have that requirement anymore. And so this is one of these things where when we loop back through there, we would make sure that however we set up this system, whether it's 12 valves or whether we need to have those arranged differently, it still needs to meet that reliability criteria in order for us to meet our goals for the containment.

So you found one of probably many things where it is not done.

MEMBER STETKAR: Let me ask. Let me ask. This is another generic one. So it's not sequence-specific. Vacuum breakers. In top event, there's a -- this again is in the level 2 containment models. There is a top event called DS-TOPBV. It's for the operation of the vacuum breakers.

The success criteria for that top event, if I understand the fault tree correctly, is that at least one of the three vacuum breakers must open to equalize pressures and that two of the three vacuum breakers must successfully re-close. That's the fault tree logic.

My question is, since, as I understand it, if you have a leak rate more than about the square equivalent area of 14 $centimeters^2$, you may have a problem.

Let's say all three vacuum breakers successfully open so it meets at least one of three opened and one of them stays completely open and the isolation valve does not close. Doesn't that fail the containment?

CHAIRMAN CORRADINI: Can you repeat that, John? I'm sorry.

MEMBER STETKAR: If all three vacuum breakers open successfully and one of them remains open, does not re-close, and its isolation valve does not close because it's got an isolation valve on it

-- so I have an open vacuum breaker path.

CHAIRMAN CORRADINI: Manhole cover is --

MEMBER STETKAR: Manhole cover and its isolation valve are still open. Does that not fail containment according to the success criteria that I understand for bypass scenarios?

MR. WACHOWIAK: Which top event were --

MEMBER STETKAR: It's called DS, dog Sam -- I don't understand the military stuff -- -TOPBV. And the success criteria require any one of three to open.

So you fail if all three fail to open. You also fail if any two fail to close, which means one could have remained fully open. You do not fail if one remains fully open. Isn't that really failure?

MR. HOWE: In the long term, there is actually another tab, which is DL-TOPBV, which requires all three vacuum breakers to be leak-tight. This function right here is primarily just for steam suppressions, that initial kind of pressure transient. And then for long-term containment integrity, we require all three to be leak-tight.

MEMBER STETKAR: Okay. I may have missed

that.

MR. WACHOWIAK: Yes. The function of this one is like the vacuum breakers in the existing plants. It's to make the pressure suppression system work.

MEMBER STETKAR: Now, is there no way that you go to -- I don't have the event tree up here in front of me because I've got too many files. If you give me a chance, I can bring up the event tree and look at it. I mean, this is the way this is going to have to go before --

MR. HOWE: Right. To get to long-term success, we have to go through the other top, which requires all --

MEMBER STETKAR: That's why I -- what header is that under on the event tree?

MR. HOWE: It would be under the W2.

MEMBER STETKAR: W2?

MR. HOWE: Yes, one of those that is going to be DL-TOPBV. There is an example up here. It's a part of that W2 node.

MEMBER STETKAR: Okay. The long-term stuff is under W2. So it's only questioned. And the short-term stuff is under W1?

MR. HOWE: That's right.

MEMBER STETKAR: Okay.

MR. WACHOWIAK: And then the steam suppression is under VB in this containment event tree. So we've got three different things that are associated with that. The VB node is whether the containment is going to fail early. The W1 node, I believe that's the active RHR system. And the W2 is the passive decay heat removal system.

MEMBER STETKAR: And W2 has the long-term. Okay. I didn't get as far as W2 because I was interpreting BV as all functional failures that disabled containment cooling. So it's not.

MR. HOWE: Right. Actually, that DL top is also under W1. It's really kind of used as a support to the PCCS.

MEMBER STETKAR: What's the top called? DL something?

MR. HOWE: DL-TOPBV.

MEMBER STETKAR: DL-TOPBV?

MR. HOWE: Yes.

MEMBER STETKAR: Thank you.

MR. HOWE: That's it.

MEMBER STETKAR: Now, since we're talking about kind of level 1/level 2 interface, now we kind of have to walk through. It's not a specific sequence, but I was concerned about -- the general topic is GDCS deluge again now.

MR. WACHOWIAK: Okay.

MEMBER STETKAR: Suppose you have successful GDCS injection so that the DPVs all open, all the GDCS pools dump into the vessel, and then you go to core melt.

MR. WACHOWIAK: You won't.

MEMBER STETKAR: Yes, you will. FDW-0033 has indeed cut sets. And there are ways that you can go to melt because you have late makeup failure. This is a late low-pressure melt scenario. It is possible.

CHAIRMAN CORRADINI: So somehow the water doesn't make it back from the PCCS back to the GDCS? Is that --

MEMBER STETKAR: The only thing I understand is what I look at in the risk model. So there are requirements that for late makeup, I either need active makeup from some of the active systems or I need to have equalizing or I need to have dumped at least two of the GDCS pools in there.

And there are combinations that indeed fail that. I don't want to talk about frequencies. I am just talking about functions here. There are sequences. There are cut sets, sequences, whatever you want to call them, where I can in this plant have successful low-pressure injection via the GDCS pools. And I can dump them all in there and, yet, still go to late low-pressure damage, core damage.

CHAIRMAN CORRADINI: So, just to help me along, can GEH explain? It's got to be a failure of the PCCS to deliver the water back to the GDCS. That's the only way to get that physically.

MR. WACHOWIAK: Not really.

(Laughter.)

MR. WACHOWIAK: There are ways to get there.

MEMBER STETKAR: Okay. Fine.

MR. WACHOWIAK: They end up being low. What we could talk about --

MEMBER STETKAR: They are low-frequency, but I want to get back to right now I am talking about functions and success criteria because I may be confused.

The situation I was thinking about is

suppose you are in this situation. So all the GDCS pools have dumped. The DPVs are open because that's a most likely -- in the real world, that's a most likely situation. And then you go to core melt. And I get high temperature down in the lower drywell. And all of my GDCS dump valves dutifully open. Where does the water go?

I mean, how do I know that now the entire inventory of water that is coming back into the GDCS pools is going to know that it needs to go down in the lower drywell and feed the BiMAC, rather than going into the vessel, which is also depressurized and just circulating in the upper drywell space? That is where the DPVs dump.

MR. WACHOWIAK: So there are a few things with this sequence set. The lines that come off of the -- that go from the tanks to the BiMAC are the same lines as the GDCS.

MEMBER STETKAR: Yes.

MR. WACHOWIAK: So some of it would still go, could still go to the vessel. But I think when you guys talk about the --

MEMBER STETKAR: It depends where the pressures are, though. I mean, you know, if the pressure is higher in the lower drywell, the water is --

CHAIRMAN CORRADINI: But how can the pressure be higher in the lower drywell? The lower drywell and the upper drywell are connected by about ten square meters of area. So they can't be different.

MEMBER STETKAR: That's why I wanted to find out whether the pressures would be the same or whether I can get a lower drywell bypass condition going on.

MR. WACHOWIAK: I think that that's an interesting question, but I believe that we handled it in a different way, though. Those particular sequences where we have already dumped the GDCS pools and those -- I believe we have those marked as high water level in the lower drywell cases. No?

MEMBER STETKAR: Not this sequence. It goes to a CD-1 low level. Now I'll look at the specific sequence. It is this FDW-0033 sequence that we want to talk about --

MR. WACHOWIAK: That is a --

MEMBER STETKAR: -- mapped to a late, low-pressure, low-level in the drywell sequence.

MR. WACHOWIAK: Okay.

MEMBER STETKAR: So it's run through that. It's run through that part of the model.

MR. HOWE: Yes. For that specific sequence, we have successful early GDCS failure of late GDCS.

MEMBER STETKAR: Right.

MR. HOWE: Based on the success criteria that are defined, that means you have only had at most one of the three pools inject to that core. So even if you do get that core melt-through, you still have two other GDCS pools.

MEMBER STETKAR: The success criteria requires successful injection of one.

MR. HOWE: Right.

MEMBER STETKAR: Success could also occur if you had all three of them.

MR. HOWE: But the success criteria for the long term GDCS is two of three pools.

MEMBER STETKAR: That's right. That's right. The success criteria say that I can win if I have one inject initially. In fact, I can win in the short term if I have all three inject. And I can win in the short term if I had two of the three inject in the beginning.

MR. HOWE: Right.

MEMBER STETKAR: So I can win in both the short term and the long term if all three GDCS pools inject, right?

MR. HOWE: That's correct.

MEMBER STETKAR: And under those conditions, I've won in the short term. I could win in the long term, but there are other things that can still fail me in the long term.

MR. HOWE: Right.

MEMBER STETKAR: So, even though all three injected in the short term, at least two of those are necessary but not sufficient. You achieve success in the long term. So I can still fail in the long term having had all three inject in the short term. Is that correct?

MR. HOWE: Yes. And then that would be due to containment heat removal failure, which we have been as the class 2A and class 2B sequences. And those, we do not model mitigation of those sequences in the level 2. Those are soon to go to relief.

MEMBER STETKAR: I didn't see that,

though, because in the sequence mapping, at least in the tables that I read in the report, this particular sequence, the one --

MR. HOWE: Right. The feedwater --

MEMBER STETKAR: -- FDW-0033, in particular, so now if we're going to talk about -- for this one, I need the context. It's a more generic issue because there are other sequences that look like this. But if you want to talk about specific ones, this one indeed can satisfy all those conditions. And according to the documentation, if I understand the documentation correctly, it's mapped to a CD-1 --

MR. HOWE: Right.

MEMBER STETKAR: -- and, in particular, a low drywell level CD-1 because you differentiate the level in the drywell for the CD-1's.

MEMBER BLEY: Which is not guaranteed --

MEMBER STETKAR: Which is not guaranteed failure --

MR. HOWE: Right.

MEMBER STETKAR: -- because then you run that through that level 2 event tree.

MR. HOWE: Right.

MEMBER STETKAR: You know, that's linked to that level 2 event tree, where you have the success criteria that says you win if any six of the GDCS valves open up.

So my question first is it's kind of a two-part question. I wanted to understand whether my original concern about where does the water go is valid. And the second concern is if indeed the water can go into the lower drywell, that there isn't any pressure difference or some other phenomenon that would preclude that due to any six GDCS deluge valves opening. Does that success criterion apply under this condition or maybe do I need more deluge valves to open?

CHAIRMAN CORRADINI: I don't think -- you guys are in another space and dimension than I am, but if I dumped enough of that water by the way they have the design, you're going to have a very deep pool of many meters already in the lower cavity.

MEMBER STETKAR: No, it's not in the lower cavity. It's not down there. It's up there.

CHAIRMAN CORRADINI: It's not down there yet. It's not down there yet.

MR. WACHOWIAK: If you look at the

long-term success criteria, there are two things that can get you to success in the long term: if two or more pools inject or if one pool injects plus equalizing lines open.

So in your three-pool case, if three pools go in early, by definition, you have already won late because three pools win late. If two pools go in early, by definition, you have already won because two pools are sufficient to carry you through late.

If only one pool then goes in, you have to open an equalizing line to stay for the long term. And in that particular case, there's not enough water to get it all filled down in the lower drywell. So that's why it's low.

CHAIRMAN CORRADINI: Where does it end up then?

MR. WACHOWIAK: It ends up in the suppression pool because --

MEMBER STETKAR: You know, walk me through that. I'm sorry to stop you, but we'll get back to that. Walk me. Back up about three minutes or two minutes.

MR. WACHOWIAK: Right.

MEMBER STETKAR: And walk me back through.

MR. WACHOWIAK: So we have the --

MEMBER STETKAR: I think you're right.

MR. WACHOWIAK: We have the short-term and a long-term.

MEMBER STETKAR: Yes.

MR. WACHOWIAK: The short-term requires one pool.

MEMBER STETKAR: Right.

MR. WACHOWIAK: And the long-term requires either two pools or one pool and an equalizing line. So it makes the suppression pool talk to it. So if three pools work like you say --

MEMBER STETKAR: Oh, okay.

MR. WACHOWIAK: By definition, it makes you win on both short and long-term. If two pools inject, you win on short and long-term. If only one pool injects, then you will only win on short-term and you need additional equipment in the long-term. That's why we modeled it that way, was to --

CHAIRMAN CORRADINI: When you say, "win," you mean to avoid core damage?

MR. WACHOWIAK: To avoid core damage,

yes. And so what we have to ask is, does PCCS work to keep everything going?

CHAIRMAN CORRADINI: All right. So just to answer my question, then, John, just to finish it off then, if you dumped early with one pool but the equalizing line would work, you would go to core melt and all the water ends up in the suppression pool, instead of a lot of the water.

MR. WACHOWIAK: To get back to your point, we have six PCCS heat exchangers. And they're directed into the various GDCS pools. And the GDCS pools are, at least currently in the design, connected up at the top with -- when they fill the pools, you fill one. And it cascades to the other. So they're kind of all interconnected up at the upper water-level range.

So water that comes back from the PCCS heat exchangers goes into those pools. And if there's a pool that's open to the reactor, that will continue to go to the reactor. If, for some reason, the pool, the cascading lines that we talk about are -- you know, we don't know how those are going to be arranged right now.

You know, they could have high points.

They might not. We just don't know. There is no safety function for it. It's just a fill the pools. But let's say that those don't equalize so that all --

CHAIRMAN CORRADINI: I understand.

MR. WACHOWIAK: -- the pools don't cascade back to the one that's feeding the reactor. So we don't have that modeled that way yet. If those pools were to overflow, there's an overflow line on those pools that goes to the suppression pool.

So if there are six PCC heat exchangers distributed to three pools, two-thirds of the PCC condensate, the water that's coming up on steam out of the reactor, ends up flowing down to the suppression pool through those overflow lines. So over time you will deplete the water that is available for the closed circuit in the one pool.

Once again, now that we know how these lines are going to cascade those pools for normal refill, when we see the detailed design on that, we'll revisit that one to see if now in the long run one pool is enough for a success. But we don't have enough detail on those lines to make that decision at this point.

CHAIRMAN CORRADINI: Thank you. I'm satisfied.

MEMBER STETKAR: I am trying to think on the heat here. So bear with me.

CHAIRMAN CORRADINI: You have four guys.

MEMBER STETKAR: Yes. I really hate to do this.

MR. WACHOWIAK: You've got one back there.

CHAIRMAN CORRADINI: But you have Dennis.

MEMBER BLEY: Yes. But I haven't completely tracked this one.

MEMBER STETKAR: He's got other ones. But I'm thinking in failure space now. So I can fail if I have one pool injected successfully in the short term, one and only one, and the equalizing valves didn't open and all the other makeup supplies failed.

MR. WACHOWIAK: Right.

MEMBER STETKAR: So that I have one pool now that is not -- one pool went in and the other two are still available. The other two are still available because they did not go in initially, their injection valves didn't open or whatever.

Aren't the success criteria for the

number of GDCS -- now, under those conditions, under those conditions, so that I have injected one and let's say that the reason I didn't inject the other two is because none of the -- well, it can't be none of the injection valves opened, but their injection valves did not open.

I'll come back. The DPV valves did all open because they have to open to have any chance. So I've blown down the vessel to the upper drywell. Two pools did not go in. One pool did. That leaves me two pools full of water. The equalizing valves didn't open and none of my other makeup supplies.

So this sequence goes to core damage. It's another way of getting to the same sequence.

MR. WACHOWIAK: Right.

MEMBER STETKAR: It goes to what's called CD-1 low level in the drywell. The level 2 event tree that is linked to that sequence now dutifully asks, do at least 6 of the 12, 6 of the 12, GDCS dump valves open? And if they do, then I can win for containment heat removal because, by definition, I have enough water wherever it needs to go. That's the other part.

Now my question is, under these

conditions, first of all, physics, does the water really know, the water from those two pools now -- and I'll grant you you've got two pools -- does the water from those two pools really know that it needs to go into the lower drywell and not a good chunk into the vessel?

CHAIRMAN CORRADINI: How could it go in the vessel, though? You said that it failed to discharge. And that means the --

MEMBER STETKAR: It's been blowdown.

MR. WACHOWIAK: Right. But they failed --

CHAIRMAN CORRADINI: But they failed to open.

MR. WACHOWIAK: The valves, the lines that --

MEMBER STETKAR: Okay.

MR. WACHOWIAK: -- go from the pool to the vessel have failed.

MEMBER STETKAR: Good point. Good point. Good point. Yes, yes.

MR. WACHOWIAK: So branch line, when those valves open, then --

MEMBER STETKAR: I will eventually get to a case where none of this can happen.

MR. WACHOWIAK: And then we're back into the same issue with --

MEMBER STETKAR: But the success criteria -- well, there it's a little different on the six because I have effectively disabled three. There is no -- I am not sure where the water is going in that pool. So it might be instead of 6 of 12 in this case, it might be *m* of 9 with some distribution.

MR. WACHOWIAK: Right.

MEMBER STETKAR: But that gets back into the general success criteria.

MR. WACHOWIAK: We're going to need to sync that up that up with the arrangements for those valves.

MEMBER STETKAR: Thanks. I think I am starting to feel comfortable with this. I was getting concerned that we could have successful injection essentially of all the GDCS pools --

CHAIRMAN CORRADINI: The only way you're --

MEMBER STETKAR: -- and the water coming back to the pools not knowing whether it should go into the vessel and stay in the upper drywell and essentially in a circulatory mode up there because heat is still coming out.

DR. KRESS: The only way --

MEMBER STETKAR: Of course, it is getting down, you know, how did it know it needed to go down in the bottom?

CHAIRMAN CORRADINI: So just can I get this right? The only way John's worry would occur is if the first valve on those two pools didn't open, not the downstream valve, because you've got a valve upstream of the check valve that --

MR. WACHOWIAK: That's a manual valve.

CHAIRMAN CORRADINI: Is that a manual valve?

MEMBER STETKAR: I'll eventually get to that.

CHAIRMAN CORRADINI: Oh, okay.

MR. WACHOWIAK: That's the maintenance valves that I wanted to --

CHAIRMAN CORRADINI: So the only DPV valve is the one at the bottom of the loop seal. We'll get to that. Is that correct?

MR. WACHOWIAK: Yes.

CHAIRMAN CORRADINI: Okay. Thank you.

MEMBER STETKAR: We'll get to that valve, but that's a systems. I wanted to try to close some questions that I had in terms of linking success criteria across the level 1/level 2 models, --

MR. WACHOWIAK: Right.

MEMBER STETKAR: -- which is why I am starting on the deluge.

MR. WACHOWIAK: In all those systems, where there are multiple modes of a system that had different success criteria for the same system, they're the hard ones to link up between those types of models. You end up with something that looks like this long-term and short-term. It looks like there's an anomaly there.

MEMBER STETKAR: Well, yes. I mean, those are always difficult to link up. Well, that's the whole key is you have to walk through them. And I think part of the reasons that we wanted to have this type of discussion are sort of two-fold, number one, to answer our own questions because, you know, we have had limited exposure to all of this and very little time to try to examine some things, to do things like this, to understand that, yes, it sounds like it has been thought through and in cases where maybe it hasn't been thought through, to understand why those issues hadn't been raised previous times in the review process, somewhat your concern but also somewhat concern for the staff.

MR. CARUSO: This is Mark Caruso.

Rick and I had a conversation on this topic similar to yours not too long ago. And I found this short-term/long-term thing very confusing, too. If you go look at the design basis LOCAs, you will not find any that ever trigger the long-term.

In addition, there is water that the PRA is really taking credit for. And there is water from the SLICC system that will go in. There is water from the ICCS that will go.

But I agree with you. This is a confusing area.

MEMBER STETKAR: It's confusing. It takes a little bit of work to walk your way through it. And a public meeting trying to do things in real time is not the appropriate forum to do that. A year-long review of the PRA, understanding the design information and being able to actually look at the fault trees and walk your way through and the event trees and walk your way through the sequences certainly does seem a way to kind of look at these sort of issues.

So that's what I'm trying to understand, is if we, the ACRS, at the tail end of the process, having a couple of days to look at these things in real time can find things that may be deficiencies.

You know, I think we really want to understand why the longer, more in-depth review process hasn't done that, either your internal reviews and certainly why the staff hasn't raised them, as questions.

MEMBER APOSTOLAKIS: I would say, though, that because of the limited time, I think necessarily we are doing a spot-check.

MEMBER STETKAR: Oh, yes, obviously. Sure.

MEMBER APOSTOLAKIS: So the only question in my mind is if I find problems with the few things I am looking at, what can I conclude about the whole --

MEMBER STETKAR: That exactly is the whole issue --

MEMBER APOSTOLAKIS: Yes.

MEMBER STETKAR: -- because if you do a

few spot-checks, you would find no problems or very, very minor issues. You develop a sense of, you know, a warm feeling that essentially the processes work, that the internal reviews and whatever external reviews, if there were initial errors, that they have been found and corrected or maybe the models were perfect when you started.

But if doing focused spot-checks identifies problems, you're right. Maybe you have been lucky in your spot-checks. Maybe you have been just very, very fortunate to find, you know, the only issues. But that's where you have to be exceedingly lucky to do that.

MEMBER APOSTOLAKIS: By the way, who is present? Is it your staff that actually did the review here?

MR. CARUSO: Originally Nick Saltos did the Level I review. And then he moved to the PRA group. I came on board and looked at the responses to his RAIs and new things in the Rev. 2 model.

Ed has been I think on board and our contractors in the Level 2 stuff from day one.

MR. FULLER: Not from me from day one.

MR. CARUSO: I guess Bob Paulo started it out.

MR. WACHOWIAK: Nobody was here from day one except for Marie.

MR. CARUSO: Marie?

MR. WACHOWIAK: Marie.

MEMBER APOSTOLAKIS: Don, were you involved?

MR. DUBE: No.

MR. WACHOWIAK: This particular conversation of how those event trees were put together we had in the initial --

MEMBER APOSTOLAKIS: But Nick is not involved anymore?

MR. CARUSO: No.

MEMBER APOSTOLAKIS: Okay.

MEMBER STETKAR: Okay. But it's the standard bayonet the guy who isn't here. That's not --

MEMBER APOSTOLAKIS: No, no, no. I think we don't get into --

MEMBER STETKAR: That's right. We don't care who did it. It's --

MEMBER APOSTOLAKIS: It's performance-based.

MEMBER STETKAR: It's the review.

MEMBER APOSTOLAKIS: Performance-based.

MEMBER BLEY: I guess two quick things from me. Do you have any more general issues? I have one more general issue.

MEMBER STETKAR: Not general. I wanted to walk through that one sequence, but --

MEMBER BLEY: I think that will be good because the specifics I had will come up in any walk-through.

MEMBER STETKAR: And I have more specifics on --

MEMBER BLEY: But I have the one general, and I mentioned some of this last time. I just want to mention it again and see if you or if you could the staff at the same time have any thoughts on it.

In chapter 6 on human reliability, the good things I see are a statement that says, "Adequate treatment of human actions in the PRA is one of the keys to realistic understanding of accident sequences and their relative importance to overall risk." I guess I would certainly agree with that.

And you also point out that due to the

current status of the ESBWR documentation, the analysis of human actions carried out during the design phase is preliminary.

And that has to be true, but you then go on to say -- and maybe this isn't inconsistent. So I would like you to comment on the first part. And then I have a second question after that.

You go on to say for type A human actions "We review procedures related to tests" and all these things, but I don't think there are any procedures. And you go on to say for the type C's "A review of normal special failure emergency operating procedures." I don't think you have any of those.

So have you done some of that or is that all being saved for later? And if you're doing only the left-hand column kind of PRA, do you do these human reliability analyses or do you plan to?

If you can address that? Then I have some specific things that bothered me a lot on human reliability.

MR. WACHOWIAK: That's good. That's good. There should be things that bother you in there.

MEMBER BLEY: Fair enough.

MR. WACHOWIAK: I think the wording that we used, "review of procedures," what we are talking about there is typical maintenance-type procedures. There certainly are not any ESBWR-specific procedures at this point in time.

MEMBER BLEY: Right.

MR. WACHOWIAK: So we're looking at type A for restoring things to service. Typically in a nuclear plant the procedures would say that you have a full flow test or you have a checklist with a secondary check to make sure that you have things lined up properly and valve lineups and things like that.

Those are the kinds of things we looked at, were typical maintenance procedures for type A and probably could have worded that better to say that that was typical practices, rather than procedures.

Now, on the post-accident, once again I think it is more boilerplate-type language there because certainly, as Ed knows, we don't have emergency operating procedures or abnormal operating procedures, anything like that. That is in this loop that we're in with the human factors engineering.

We make our best guess at what human recoveries we would like to put into the model. And we using our tools calculate the time frame necessary to perform those actions and then assign screening values based on that. And then that list of human actions goes to the human factors engineering group, which then uses that as input to deciding what types of displays, controls, ergonomics that they need to put in to facilitate those types of actions.

And ultimately they will talk about what kind of procedures that they are going to generate for those. But certainly those actions become part of the system functional requirements of the system.

As we go through not in the design space because all this procedure development isn't happening in the design space, it's happening later, but in the later phases of the PRA, we will then take their information of how they have laid out those actions and try to attach some performance-shaping factors to what we already have in the PRA and go back through another loop and calculate and see if they still remain important actions if they indeed were important actions. And if they are, then the human factors will go and do additional things in their procedure development that they may not do for lower-significance items like that. And then it feeds back again for more performance shaping.

And in the end, when we have the training simulator developed because obviously we're going to have to train operators to operate this plant before it operates, we're going to have to train those. And then we can actually do some of the simulator observations and operator interviews and things that you would be used to in a full-blown HRA.

MEMBER BLEY: Okay.

MR. WACHOWIAK: We don't --

MEMBER BLEY: So some of this would come after the design cert?

MR. WACHOWIAK: It has to.

MEMBER BLEY: But before the COL is complete?

MR. WACHOWIAK: Yes.

MEMBER BLEY: Okay.

MR. WACHOWIAK: Well, no. The timing of all of this is that the COL doesn't necessarily need to be complete. Now, I know there are some questions out there on the emergency operating procedures and the COL, but in general the human factors engineering is a DAC item. And that would be completed and submitted to the NRC for review after the licenses are issued.

DAC are a special category of things yet to be done that have follow-up commitments. But human factors engineering falls into DAC. So it would be after the COL.

MR. OESTERLE: Yes. Eric Oesterle from the staff. That is exactly where I was going to discuss also because this dovetails right into DAC ITAAC. And this PRA, at least for me, is confusing enough. I was hoping that we wouldn't get there, but --

MEMBER APOSTOLAKIS: What's DAC?

MR. OESTERLE: Design acceptance criteria.

MR. WACHOWIAK: Design certification and COL applications contain the acceptance criteria for the design, rather than the design. And then there's a follow-up item to go in and verify that the design does meet all of the acceptance criteria for review.

MEMBER BLEY: I am still trying to get my handle. And all of the DAC and ITAAC things will be set up before the design is certified, will be written out, established?

MR. OESTERLE: Yes, that's correct. And, in fact, we're still going through that review process now to finalize the ITAAC for the ESBWR. And we have a meeting with GEH next week to continue the discussions about that.

And we'll be here October 21st to talk about chapter 14, a section of which includes a discussion on the selection criteria and methodology for identifying structure, systems, and components to put into ITAAC and then also to discuss the staff's review of the entire tier I document for ESBWR.

MEMBER BLEY: And we'll see ITAAC and DAC at the same time? Do they come together or are they going to be separate?

MR. OESTERLE: I like to talk about them as ITAAC, DAC as one thing.

MEMBER BLEY: Okay.

MR. OESTERLE: DAC are a special subset of ITAAC. And I call them design completion-related ITAAC. The vast majority of ITAAC are verification-type activities.

And once we get to the -- they get incorporated by reference by a COL application. And following issuance of the COL license, there are requirements for that licensee to successfully complete all of those ITAAC prior to being allowed to load fuel and to start up.

MEMBER BLEY: Back to the human reliability section in the PRA, there are a couple of things that I just don't agree with. And I want to put them on the table. And after I put them all out, if you want to talk about some of them, fine. If not, we'll worry about them some other time.

The first one is talking about type C post-initiating event, human actions. The nature of the passive ESBWR is such that post-initiator operator actions should not be such strong contributors to the risk profile as they are in current LWRs.

I don't know why that's here. It seems maybe wishful thinking. I think it is probably true for the errors of omission, but things like errors of commission are maybe common cause human-induced initiators I'm not fully convinced of that.

But it goes on, and then it talks about errors of commission a little bit. And it says -- let me see where to start this -- a commission error

-- and then some words that aren't really necessary -- is considered insignificant when the plant has emergency operating procedures.

And that kind of says we don't even have to think about it. And that is just plain inconsistent with experience and with some experiments that have been done, both at Halden and at Westinghouse once upon a time.

There is an NRC NUREG by Emily Roth and Lumau that ran a bunch of operators through simulators with fully vetted procedures. They were difficult scenarios. And people wandered from the procedures pretty well.

And the last thing along this same line is no dependencies are considered for human-related. And you haven't done all of this yet. I think this is in the future for human-related basic events due to type A and type C actions in the same minimal cut set due to highly differentiated time frames and the low combined probability.

In general, that is probably true, but in the experience base, you find some separated by even weeks, where the setup from one event, the effect on the person who is now involved in the second event, links over.

So I think while it's often true, there are cases where it is not true. And I sure hope when you get to that stage of the analysis, instead of just making a blanket statement, not thinking about them, you give it some real thought.

MEMBER APOSTOLAKIS: I agree with Dennis. I think this section really needs a good editing job.

Would you go back to a page that you had earlier on? That was a good example, too. I don't know. Where you raise human reliability analysis, can you start from page 1 and keep going down? No. Look at this. Stop. Stop. Stop.

By virtue of its capacity to combine human reliability with systems and component reliability, the probabilistic safe analysis provides an unsurpassable way of studying the --

MEMBER BLEY: Then you're better not dismiss them.

(Laughter.)

MEMBER APOSTOLAKIS: That guy was an enthusiast. Unsurpassable. You know, are you finished?

MEMBER BLEY: I am finished with this general area, yes.

MEMBER APOSTOLAKIS: Before you run into the detailed sequence, I have two minor points. Should I make them now?

MEMBER BLEY: Already said, what George said and what --

MEMBER APOSTOLAKIS: Sorry, sorry, sorry. Yes. Go.

MR. WACHOWIAK: Thought maybe you thought his questions were unsurpassable. While it is true that we did not address errors of commission and the words that we have in there saying that they aren't significant contributors, those I remember looking at. We got that from a reference. And I don't know what it is. Understand where you are now.

Errors of commission are in a couple of different areas. In the things that we looked at for the precursor types of type A errors, while they're all listed as errors of omission, those would also be the same types of things that an error of commission would cause. So the aspect is there looking for those things that would unset our acid traps for core melts, if you will, that take away the setup for the plant.

As I said, that entire list of pre-initiator operator actions have been given to the human factors engineering group. And that's one of their lists of things that they start with for setting up alarms and indications and things in the control room. So we try to address it that way.

Numerically right now I really have no idea how we would address errors of commission at this point without, you know --

MEMBER BLEY: There are some things you can look at. I won't mention them here. There is a variety of them.

When you are calculating core damage frequencies of 10^{-4}, then a human-induced common failure of 10^{-6} doesn't matter too much. When you are calculating 10^{-8}, the way you are going to break this plant somehow means something unusual has to happen.

The likelihood that it is a whole bunch of random things lining up seems pretty small to me when you have the chance of some activities by a human in the plant maybe defeating some of those. I think you've got to look really hard.

MR. WACHOWIAK: And we do have some

protection against that in the design. On the safety-related side for the automatically initiated actions, we don't allow, the digital I&C does not allow, the operators to interrupt any of those sequences. They go to completion before they're done.

So that's one of the things where I think we have seen in the past, where the automatic systems have initiated something and then the operator said, "Oh, I didn't want that to happen. Turn it off" --

MEMBER BLEY: We have certainly seen that.

MR. WACHOWIAK: -- or it's about to happen and they bypass the thing that is going to make it actuate. And we don't allow those types of actions. So that is one place where while it's not actually captured in words or in numbers in the PRA, that is one of the design philosophies that we have. So that helps move us towards the words that we used in the document.

Wasn't there one other? Oh, the difference in time as a screening value for saying that we don't have a dependence between actions. Yes. We'll have to look back at how we write that so that in the future when operator actions are looked at, that we don't use that as a blanket statement that just because of time, it should be screened. But our limited use of operator actions in this particular model, we looked at those kinds of actions to say, you know, it is separated in time, but it's running the fire pump here versus turning on the, backing up the depressurization valves over there and just --

MEMBER BLEY: I think that is a much better kind of argument than just the time lime because that is different mindsets getting involved. So I think --

MR. WACHOWIAK: I understand.

MEMBER BLEY: Yes.

MR. WACHOWIAK: And here remember with ESBWR, the difference in time is days in many of these cases.

MEMBER BLEY: But if the same guy happens to be back on shift, he can be linked.

MEMBER STETKAR: Or each one successively asks him, "Hey, what's wrong?"

MEMBER BLEY: Yes, exactly.

MEMBER STETKAR: And then I tell you

exactly what is wrong. And you tell him what is wrong. And he comes back. And I know what is wrong already because nothing has changed.

MEMBER BLEY: And those have happened.

MEMBER STETKAR: That's the kind of thing.

MR. WACHOWIAK: It's not just operators that are involved at that point because we have the emergency response organization and --

MEMBER BLEY: As long as we don't tell --

MEMBER APOSTOLAKIS: There is something here that confuses me a little bit.

MR. WACHOWIAK: Okay.

MEMBER APOSTOLAKIS: And I looked at the analysis of the isolation condenser. In table 4.2-6 --

MR. WACHOWIAK: Where are you, George?

MEMBER APOSTOLAKIS: Table 4.2-6.

MEMBER BLEY: In the isolation condenser section, --

MEMBER APOSTOLAKIS: Yes.

MEMBER BLEY: -- which is 4.2? Yes.

MEMBER APOSTOLAKIS: There is a top event. How is it easier for you to find it? Do you want a top event, that kind of thing? That's what you want?

MEMBER BLEY: I think we're going to get through the event -- go ahead. The fault trees, we've got a lot of questions on the fault trees.

MEMBER APOSTOLAKIS: B-32-2LOOPSFAIL. Do you find it?

MEMBER BLEY: Okay. On page 4.2-147.

MEMBER APOSTOLAKIS: The description. The description says, "Three heat exchangers loops, remove heat." Right?

MR. HOWE: Okay. Yes.

MEMBER APOSTOLAKIS: So this is a success, right?

MR. HOWE: Right. That's a success.

MEMBER APOSTOLAKIS: And how many have total? Four. So if two fail, you are in trouble. Now, if we go to the fault tree --

MR. CARUSO: Excuse me. Wasn't there an assumption that there is always one not operable?

MR. WACHOWIAK: No, not in the PRA.

MEMBER APOSTOLAKIS: There is a fault tree for all loops failing. Isn't there a fault tree for two loops failing somewhere in the --

MEMBER BLEY: Yes, page 213.

MEMBER APOSTOLAKIS: Okay. Okay.

MEMBER STETKAR: Sheet 50, like it says on the table. Sheet 50, .pdf file, page 579.

MEMBER APOSTOLAKIS: Fine. I have some other things, but they can wait.

MR. WACHOWIAK: It's always difficult to try to follow through the fault trees on the paper copy.

MEMBER STETKAR: The good thing is .pdf you can search.

MR. WACHOWIAK: Search into those, yes, but it's a pain in the neck to try to follow up.

MEMBER STETKAR: Do you want to take a break now?

CHAIRMAN CORRADINI: No. You're doing so well. Keep on going.

MEMBER STETKAR: I heard somebody say, "Break."

DR. KRESS: We took a break.

MEMBER STETKAR: Rick, I don't know. I know there were some communications in the last week back and forth regarding these sequences. And I see what you brought. And I thought -- and that's good.

I mean, that's fine, but I'm not sure that we're actually going to discuss that.

MR. WACHOWIAK: Okay.

MEMBER STETKAR: One of the questions that we had in particular was -- and I was using it as context -- is this sequence FDW-0033, which the feedback, at least as it was finally filtered to us, was, gee, you know, there are no cut sets for that sequence. So it's not worthwhile discussing it.

Well, I hope we communicated back that we wanted to understand why there are no cut sets for that sequence because that's more important to me than the sequence. The sequence is an interesting sequence, but I want to understand why there are no cut sets for that particular sequence.

MR. WACHOWIAK: And the communication I guess the way it got back around to you wasn't exactly that way. The sequences were presented. And I think what we said back was, were they aware that there were no cut sets for these sequences --

MEMBER STETKAR: We were not.

MR. WACHOWIAK: -- and do you want to dust them or propose different ones?

MEMBER STETKAR: And the answer to that

was no.

MR. WACHOWIAK: Well, no. The answer was go ahead and propose the other ones, but they still want to know why there are no cut sets.

MEMBER STETKAR: Okay. Yes.

MR. WACHOWIAK: So we have an explanation of why they --

MEMBER STETKAR: Why are there no cut sets for that sequence?

MR. HOWE: There's a short kind of description right here. What it really comes down to --

MEMBER BLEY: Can you tell me where you are in the report?

MR. HOWE: No. This is just a stand-alone page.

MR. WACHOWIAK: This is just an answer to the question. In response to the e-mail --

MEMBER STETKAR: We don't have this, right?

MR. WACHOWIAK: No. Because we were coming here.

(Laughter.)

MR. HOWE: What it boils down to is

really the common cause modeling that's used combined with the success criteria of both that the VIGDCS top and the VE top there. So you have the --

MEMBER STETKAR: Let me ask you first.

CHAIRMAN CORRADINI: Wait a minute. I've got to stop you. Maybe he understood what you just said. I have no clue.

(Laughter.)

MR. WACHOWIAK: Okay. Take a step back.

MR. HOWE: This sequence that we're talking about -- and there are a few of them in the model like this -- is examples T feedwater, 033, where we have successful early injection of GDCS, and then failure of what we call the long-term GDCS, which could either be achieved with two of the three pools or one pool, one equalizing line. And so you have failure of that second function.

And then that goes to core damage. And then the question is, how come those sequences have zero cut sets in the quantified model results? And the answer is theoretically you can get cut sets in those sequences. It's just that you would have to have an extremely low truncation value. I will kind of explain why that is.

The common cause modeling that we use really models combinations of like any two of the eight valves, any three, and beyond that, it just says, "common cause of all valves failed to open."

Based on the generic multi Greek letter factors that we have -- and that's for the common cause modeling -- the EPRI utilities requirement document also says, really, to use multi Greek letter factors of 1.0 after you've gotten to four valves anyway or four components.

MEMBER APOSTOLAKIS: Now you have a big problem with the actual numbers you use. You have some guideline delta that are much, much lower than what you just said.

But also let me come back to this discussion. So you are saying that in a system where there is a common cause failure, there are no cut sets?

MR. HOWE: No. See, what happens is the primary failure mode for both early GDCS --

MEMBER APOSTOLAKIS: Right.

MR. HOWE: -- and late GDCS, --

MEMBER APOSTOLAKIS: Right.

MR. HOWE: -- those failure modes, the

dominant ones are all the same.

MEMBER BLEY: The common cause failure.

MR. HOWE: Right. The common cause failure because early GDCS, to fail that, you have to fail seven of eight valves. And the later GDCS requires either that you fail six or that you fail four and that you fail all of the equalizing lines. So still the dominant failure mode there is CCF of all injection valves.

CHAIRMAN CORRADINI: So let me translate.

MR. HOWE: Sure.

CHAIRMAN CORRADINI: So you are saying that you didn't do it because it is included in stuff that was more important than it?

MEMBER APOSTOLAKIS: What does it do? I mean, that's where I'm lost.

MR. WACHOWIAK: No, no.

CHAIRMAN CORRADINI: The cut sets don't appear. I mean, I'm just trying to get back to your original answer. I'm sorry that I can't explain it properly. But the cut sets don't appear because they are essentially subsumed into something that was more probable.

MR. WACHOWIAK: No.

MR. HOWE: Well, no. It's just saying that the dominant failures are the same for both early and late. So if you're going to fail either one, you're just going to fail early. You'll never see those cut sets that had success early, failed late.

MEMBER APOSTOLAKIS: That makes sense.

CHAIRMAN CORRADINI: Just to finish, because they are so low-probability they got screened away?

MR. HOWE: Right.

MR. WACHOWIAK: Let me try one more way. There would be several cut sets in early and the late. Okay? One is a common cause failure of all valves. That's common to both of those. And then you have failure of one valve, common cause failure of seven. I don't have the numbers quite right but failure of two individual valves, common cause failure of six.

Okay. You could get some combination of those things that might show up, but they're all below the 10^{-15} truncation level because the ones that we do have that would show up in the model are included in both the success path and the failure path.

So the common cause failure of all is already handled by the success of the early. So all we're left with are the individual valve failures. And since so many valves have to fail, you end up with cut sets that are below our 10^{-15} truncation level.

MEMBER STETKAR: I think the answer to the question is the fact that your truncation level is set at 10^{-15} and the cut sets that -- there are valid logical cut sets that contribute. Just none of them are greater than 10^{-15}.

Okay. That's important because my original understanding was that this sequence was logically -- it was a logical null set. It can't happen because of the way common cause is modeled.

And that's not true. It is not a logical null set. There are logical contributors to this sequence. So I kind of got that. I sort of figured that out Sunday.

So I would like to look at some of the logical contributors. And if I look at --

MEMBER BLEY: John?

MEMBER STETKAR: Yes?

MEMBER BLEY: Can I interrupt? Would it be helpful for the rest of the Subcommittee --

MEMBER STETKAR: Yes,it would. What do you suggest?

MEMBER BLEY: -- if you took us along the event tree and then told us where you are going to focus os they can understand what you're talking about?

MEMBER STETKAR: Yes. Okay. The particular place that I'm focusing on for the rest of the Committee --

CHAIRMAN CORRADINI: For those that would like to stay with you.

MEMBER STETKAR: I didn't ask about BiMAC crap this morning.

(Laughter.)

CHAIRMAN CORRADINI: Yes, you did.

MEMBER STETKAR: If I look at the loss of feedwater --

MEMBER APOSTOLAKIS: What are you looking at?

MEMBER STETKAR: I'm looking at the second event tree, second event tree, 22.319, loss of feedwater event tree. And if you can read that, the two top events that I am particularly focusing on right at the moment are called VI and VE.

MEMBER APOSTOLAKIS: Oh. I see the VE. Yes.

MEMBER STETKAR: And, in particular, if you -- okay. Directly under NEDO and directly under 33.201 appear VI and VE. The particular condition that I'm interested in because I kind of want to follow dependencies and how the models are put together is a sequence that if you trace through the tree, you come in from the left.

You go up at the first branch, which is a reactor scram. You go down and just keep following the up branches. You are sort of in the middle of the piece of paper right now. You see up branch on VI.

CHAIRMAN CORRADINI: So you are VI-TOPINJ.

MEMBER STETKAR: Right. And go up on that branch, which means I have successful early injection, means the GDCS pools enough of them injected.

CHAIRMAN CORRADINI: Two out of eight lines, one out of --

MEMBER STETKAR: Whatever. Enough went in. And then I'm headed down. So I'm up on VI. And you come to now a question on VE. And I am going down on that branch. And to get eventually to FDW-0033, the sequence that I'm using as the context for this, you then need -- so I'm down on VE, top EQU. Then you have to go down on UD-TOPINJ. Then you have to go down on VL-TOPINJ and you have to go down on VM-TOPINJ. And you eventually pop out on FDW-0033.

MEMBER BLEY: Which is the first one of that group that is not a success.

MEMBER STETKAR: Which is the first one of that group that is not a success. And it's one that goes to CDI, which is a low-pressure late melt with no water in the bottom, the lower part of the drywell. So it is sort of interesting for a level 1 and level 2 also.

Right at the moment I am interested in the interactions between VI-TOPINJ up and VE-TOPEQU down, which is sort of what we are talking about, which is why I was trying to find out when you said there were no cut sets whether it was a logical null because of the way common cause is modeled or whether it is just numerically so small because of all of the combinations.

And your answer is that it is numerically too small to exist. So there are logically valid --

MR. WACHOWIAK: It's both, though, too, because we don't have all of the different common cause splits. We only have one, two, three, all. So because we have all is the only way to get the common ones, then the only cut sets that would be left would be the individual valves.

MEMBER STETKAR: I understand.

MEMBER BLEY: Can I?

MEMBER STETKAR: Sure.

MEMBER BLEY: And if you'd had all of them fail, you would have gone down at the first branch there, VI.

MEMBER STETKAR: That's right.

MEMBER BLEY: And you wouldn't be up from the stop area.

MEMBER STETKAR: Right. So know that if I look at now the fault tree for TOP event VE-TOPEQU -- you will have to excuse me because I have to pull it back up here because I got -- I guess you can tell me what page we're on. This has to search for a while. Yes. You might want to for everybody else. We can look at it on here.

The fault tree for top event VE-TOP --

MEMBER BLEY: Look at the fault tree you were looking at, John.

MEMBER STETKAR: That is not the same picture of a fault tree that I was looking at. I believe it is probably logically equivalent, but it's not clear to me that it's logically equivalent.

MR. LI: This is Jonathan Li.

I think I want to make a clarification. This is revision 3, which is --

MEMBER STETKAR: Yes. And I was looking at it. I've indeed printed out revision 3 and all of the revision 3 documents that we had. And this is different from the revision 3 --

MR. HOWE: Right.

MEMBER STETKAR: I printed this out. I printed this out. It's in section 4, and it was not changed in section 22.

MR. WACHOWIAK: It wasn't changed in 22.

MEMBER STETKAR: That's indeed correct. I made sure that that was absolutely true.

MR. LI: This is 22.3, actually. No.

This is actually we discovered change in 22.4 something with systems, but we didn't show every --

MEMBER STETKAR: Oh, you didn't show? So you said something in words, but you didn't show me how you actually changed the model?

MR. LI: No. We evaluate every single change to why it's --

MEMBER STETKAR: No, no, no. You said you made a change in words, but you didn't show me the actual logic change. How can I then review the PRA?

MR. LI: That is why I am --

MEMBER APOSTOLAKIS: Let me understand that. There is a --

MEMBER STETKAR: They just have to give you the results.

MEMBER APOSTOLAKIS: And then there is a --

MEMBER STETKAR: There was a rule that they set up. They kept chapter 4 the same from rev. 2 to rev. 3 because the vast majority of things --

MEMBER APOSTOLAKIS: Yes, were the same.

MEMBER STETKAR: -- were the same. And then they created this chapter 22 that documents all changes from rev. 2 to rev. 3, all changes. So that if any change was made from rev. 2 to rev. 3, it actually is supposed to be in chapter 22.

So now I seem to see a change that was made to a fault tree that in chapter 4 is identical to the way it was in rev. 2, as it should be. And in chapter 22, I don't see a new picture of the new fault tree, which starts to bother me a lot.

MR. WACHOWIAK: I know we didn't include all of the pictures of all of the fault trees because chapter 4 is --

MEMBER STETKAR: But if I am the staff and I am supposed to be reviewing rev. 3 of the PRA and you have made a change to a fault tree in the real PRA in the real computer and not shown me that changed fault tree, how can I review the rev. 3 PRA?

MEMBER BLEY: To test your conclusion.

MEMBER STETKAR: To test your conclusion. I don't have the computer model in front of me. I can't look at the real computer model. The only pictures of the fault trees, which I have, are now not consistent with what is really in the computer. So I can't. How can I do my review?

MR. CARUSO: This is Mark Caruso of the

staff. I guess you're asking that question of me.

MEMBER STETKAR: No. They didn't give it to you to review. You can't review something that you have not seen. And if they made any logical change to any event tree or any fault tree between rev. 2 and rev. 3 and did not document that in chapter 22, show me the picture of the fault tree. Then it cannot be reviewed. I cannot look at the picture and say, "Yes. You said in words that you made this change."

In fact, this comes back to in words in chapter 22, you said, "Oh, yes. We made a change to the GDCS models," for example, that correlated failures of the injection lines with the GDCS pools because we need to do that. It's a small change. It doesn't make any difference to the results.

When I was reviewing rev. 2, I identified that as a fundamental logic problem in the GDCS fault tree. So I read those words. And I said, "Well, gee. I wonder how they did that. I wonder how they actually correlated those failures."

I must have a fault tree, then, that shows me how they did that. It's not here. I can't see how you did that, whether you did it correctly, incorrectly, in an ad hoc manner. It's just not here. It's not documented. I can't review whether or not that's done properly.

In particular -- I mean, I as going to bring that up in about ten minutes, but we fell into it. In particular, the thing I was going to bring up, which apparently has disappeared in VE-TOPEQU, is that that model, at least everything that I have seen of it for the last year, had a nebulous single basic event hanging out there that said common cause failure of all injection valves.

It was only a single basic event. It wasn't linked to the front model. And it had a number assigned to it. That number was 1.5 times 10^{-5}, which is indeed a factor of 10 lower than common cause failure of all injection valves in the real injection model.

So there is a disconnect there. There is indeed a cut set that pops up that has common cause failure of all of the equalizing valves with this single basis event hanging out there by itself, which indeed is logically correct. But numerically it is inconsistent.

And now it seems to have just completely disappeared form the model. So I'm not sure if the current model actually accounts for all of the failures because the old model used to but incorrectly. The new model seems to just have removed them, but I can't see the new model.

So I am not kind of troubled about what other changes.

MR. WACHOWIAK: I understand your point that --

MEMBER STETKAR: I mean, now I can't have a problem that I used to have because what I used to have a problem with is no longer in the model, but I can't tell whether the new model has problems or not because I can't see the new model.

CHAIRMAN CORRADINI: So is this an isolated incident?

MR. WACHOWIAK: Probably not because -- well, and the reason is that the vast majority of the pages of the PRA are these fault tree pictures. And if we had gone through and printed out all of the pages again, it's just as difficult as going back through and revising the model to look at all of the pages again.

So we tried to end up with the right

balance of what we should describe in words. And there are other places where we have small sections of logic to explain the change.

One thing that I think we haven't stressed yet on this is that just submitting rev. 3 was not the total of the agreement that we had on how we were going to perform this review of the changes that happened to the plant, which are now reflected in the PRA over the process of doing the DCD.

After the staff had a chance to look at rev. 3 and we had a chance to clean up our documentation -- by "clean up," I mean taking everything that is in 22 and actually putting it into the sections 1 through 21 -- they have an audit schedule to come out and take a look at that.

CHAIRMAN CORRADINI: "They," the staff?

MR. WACHOWIAK: The staff, come out to GEH and spend whatever time they need looking at those things to, in fact, ensure that what we said in 22 was implemented properly.

So that hasn't happened yet. I understand that you don't have access to that information and how you're going to deal with something like that. I understand where you are.

MEMBER STETKAR: Okay. I've got that.

MR. WACHOWIAK: Okay.

MEMBER STETKAR: I mean, I understand. You know, that's annoying, but you get annoyed.

Let me back up to -- and I hate to do this, but let me back up to rev. 2 if I can. And I hate to do this to you guys, but I need to understand. Two things I'm trying to get at, as I mentioned earlier, are, does the current PRA accurately model the current design as we understand the design? So is it a reasonable representation of the risk from the current version of the design, recognizing that both the PRA and the design have been evolving over time?

The second part is indeed to have some confidence that the staff's review of the PRA, recognizing that it's been evolving, has indeed been reasonably thorough, that indeed the review process has worked because that ultimately I think is one of the functions that we provide here. It's not the ACRS's job to review the ESBWR PRA. I hope not.

So if I back up to rev. 2, if I can do that, in the rev. 2 fault tree for top event EQU, if I solve the combined fault trees, if I did this right in my head, if I solve the combined fault trees for success of INJ and failure of EQU, I have essentially a cut set that has one contributor as common cause failure of all four equalizing valves. That's a basic event, you know.

And I have this other basic event that is called E50, SQV-CF4 open. And I think that that -- and it is a single basic event. It's nothing more than that. And I think that that basic event was supposed to be some sort of surrogate for common cause failures of all the injection valves. Is that true?

MR. HOWE: That one was actually a vestige from the rev. 1 model that we -- that was one of the things that we picked up in rev. 3. And we removed that.

MEMBER STETKAR: Why did you? Okay.

MR. HOWE: I'm just saying we have the common cause modeling that we do now. This was just a leftover from rev. 1.

MR. WACHOWIAK: We used a different common cause method.

MR. HOWE: Correct.

MEMBER STETKAR: Okay.

CHAIRMAN CORRADINI: Was it duplicative? Is that what you're saying?

MEMBER STETKAR: It came in rev. 1. It stayed in rev. 2.

MEMBER BLEY: It got put back.

MEMBER STETKAR: It's not right in rev. 2.

MEMBER BLEY: It's not right in rev. 2.

MEMBER STETKAR: It's not right in rev. 2. And it got pulled out in rev. 3, which is something I just learned today because up until ten minutes ago, I was convinced it was still in rev. 3 because it was the only thing I could see in rev. 3.

The staff, however, didn't seem to identify this as a problem in the common cause modeling across those two functions because I couldn't understand what the basic event was.

I thought it was for common cause failures of the injection valves, but if it was, recognizing that it's -- then its numerical value was a factor ten times lower than the real common cause failures of the injection valves, which based on George's concerns might be too low anyway.

But there was that numerical disconnect.

And I'm trying to understand. I understand that you have taken it out. I don't know whether the current solution picks up all of the -- it probably does, the current solution.

CHAIRMAN CORRADINI: So can I take it one level up before we do one more specific thing? You said there's an audit. When is the audit?

MR. WACHOWIAK: It hasn't been scheduled yet. We sent a note or it was packaged in with a bunch of other things, other NEDO commitments, that said, "We will be ready after." We gave a date, and staff hasn't responded back for which date they want to come after that.

CHAIRMAN CORRADINI: So I guess I have a question for the staff about this. I am sorry you --

MEMBER STETKAR: No, no.

CHAIRMAN CORRADINI: I need to talk like this so at least my brain starts reengaging.

So I guess I hear when an audit happens like this, can you explain? Is it primarily level 1 analysis of the sequences or is it all forms of documentation and one of the parts of the team looks at the PRA when you come on site?

The reason I'm asking, that leads me to

another question. I just want to understand. Is it just the PRA that they are going to be coming in to look at?

MR. CARUSO: Well, this is Mark Caruso again.

I have to admit I haven't had a conversation with Hossein about what he had in mind. We have done staff audits of PRA or parts of PRAs for operating plant issues, where we have an audit procedure, we go out and we look at the files, we do spot-checks, and then there is an audit report. That would be probably a model that would be used if that is the intent. I can't tell you what the intent is because this wasn't discussed with me.

So I am presuming if we are going to do an audit, that's what we would do. We went and visited once before, which is more of a -- we discussed a lot of things. We did look at the quality assurance procedures. We did look at a number of other things. But it was a visit. It was not an audit.

CHAIRMAN CORRADINI: Okay. But this would be -- the reason I'm asking the question is -- and so here is where I am going -- hearing all of this, I am getting hesitant to write a letter in October until the audit occurs so I can turn back to the staff and say, "Okay. You have had a visit. You had an X day meeting with GEH."

And now you guys are on the same page. You understand what was put in, what was taken out. What were the details that were there, all the stuff that we were talking about?

So I want to make sure that that's a sanity check for me. So is that the sort of thing that needs to get done before we hear from the staff that they are satisfied with the PRA rev. 3 results?

MR. CARUSO: Yes. This is something we are going to do before we sign off on our final SER. Right? We're at the point now where --

CHAIRMAN CORRADINI: I understand that part, but I'm taking a step further back. I'm saying, is this something you're going to do before we hear from you in October that everything is hunky-dory to a certain point with open items or is this something that is going to be out there much longer in time?

I'm asking this in front of the members so I get a feeling for what the expectation is in

October.

MR. OESTERLE: Mike, I'm not aware of any audits scheduled between now and October.

CHAIRMAN CORRADINI: Okay.

MR. CARUSO: But perhaps I might suggest that you might want to consider asking -- we're still considering this and working out the details with GEH -- asking the staff what their plans are for performing this audit of the PRA as part of your interim letter.

CHAIRMAN CORRADINI: Thank you.

MR. WACHOWIAK: And so to get back onto this, the date that we have given so far is about Thanksgiving is what we expect to have this done because one --

CHAIRMAN CORRADINI: Are you going to serve turkey? Sorry.

MR. WACHOWIAK: -- because one of the things that we have to do is we have to do is we have to put the document through our change process. So to your point, when they would go and look at section 4 as updated, what they would have is 22 from before, which has in text what the changes are. And then the document itself will be marked with rev bars.

And since they're coming for the audit, they'll probably have the redlined, strikeout version of the file itself and will be able to say, "Okay. You said you were going to make this change. Yes, this change is in here. I can see how this change has been made into the document."

So that works great with the things that are generated in Word. CAFTA doesn't have that kind of revision control on it. So we're going to have to figure out how to --

MEMBER STETKAR: That's what bothers me because in many cases, when I checked in chapter 22, there are indeed pictures of logic that have been changed. I'd flagged the words about -- in fact, I want to ask a second question before we -- what time are we supposed to take a break, 3:00?

CHAIRMAN CORRADINI: Very soon.

MEMBER STETKAR: Okay. Well, after we come back from the break, then. But I flagged a couple of words. I just printed out the pages and highlighted. And I said, "Gee, that sounds like they might have changed the fault tree logic here, but I don't see any changes. And I don't see any revised picture in chapter 22."

So when you go through this document reconciliation process or whatever you call it between 22 and 4, certainly wherever the pictures are changed is a flag to make sure that the appropriate new pictures get added or revised in chapter 4.

But how does that process where only, you know, maybe one sentence gets picked up that somebody realizes that pages 47 and 56 of a 4,400-page document need to be changed unless you reproduce every single sheet from the CAFTA output from the new --

MR. WACHOWIAK: That's the difficulty that we have with the CAFTA thing because --

MEMBER STETKAR: Don't blame the software. This is not a software problem.

MR. WACHOWIAK: No, no. What I'm saying is we know how to do this with Word when we change the document. It keeps those revision controls, and it will show us where on the page we change it.

One of our things that we have to do with this is we have to do that piece manually and --

MEMBER STETKAR: Well, it's basically your analysts should be making sure that the -- the documentation is updated.

MR. WACHOWIAK: And that's part of our design process that we use for the PRA -- when the model is changed, someone had to change the model. It doesn't change itself, much as we would like it to.

MEMBER STETKAR: Sure. That's right. Yes.

MR. WACHOWIAK: Someone changed the model. And then an independent person goes back through and verifies that that change was indeed done correctly. And then that's all signed off in our QA record. We have that piece.

And so I have the fault tree picture, the old one. We have that. The new one, I have that. But if it's one page that's changed in the middle, right now we have to back and manually say it's page 45 of --

MEMBER STETKAR: That's right except that what we were led to believe -- and we were corrected -- several times in the last meeting that chapter 22 had all of the changes that were made, that that was the documentation so that the process is look at 22. If it's not changed in 22, then 4 is 4 in the rev. 3 PRA report, the operative 4, 8, or whatever other things that show logic models is indeed still valid. And that doesn't seem to be entirely consistent. I am not quite sure how any staff audit would indeed discover that either.

MR. LI: Rick, should I say something on it?

MR. WACHOWIAK: Sure. Go ahead.

MR. LI: This is Jonathan Li from GEH.

When the staff comes in, we have more prosperity. We have all the activity to show what you can get. You know, you want printed .pdf version and to tell them what has changed. That's almost inhumane to the reviewer because you cannot show readily what's changed because the first you print out will change dramatically, you know. The pages will be different. The descriptions will be different.

But when you come in, we can show them the real fault tree changes between the old one and new one and show them one by one, "This is where we changed." And if they are really interested in changes one by one, make sure --

MEMBER STETKAR: That's the key. If they are really interested and they know what to ask about and are applied that they should go ask about it, that's fine.

MEMBER APOSTOLAKIS: This is a record here. You can't just say, you know, "We have good stuff because we explained it to the staff auditor." Isn't there a record that has to stay somewhere for future reference?

MR. LI: The 22 sections are intended to describe our changes.

MEMBER APOSTOLAKIS: Yes. But you are saying that when they come in, it is easy to explain, but when you go to 22, it is hard.

CHAIRMAN CORRADINI: Can I just repeat what Rick said? Because he said it precisely. Twenty-two marked this change in words but did not reflect it by repeating the modified fault tree.

MEMBER STETKAR: Twenty-two actually did not say anything about the one that I just -- it did not say, "I didn't find a word." I mean, it might be in there, but I am not sure that I read every word of chapter 22.

But because I was using GDCS as one of my spot-check systems, I pretty well thought that I read everything in 22 about like GDCS. And I don't recall reading that, "Oh, by the way, in top event EQU, we removed this basic event." I don't think I found that. I was kind of surprised.

I found some other words in there that we'll talk about after the break that I want to check on that may affect top event INJ also. But I don't know whether or how.

So it's not at all clear that -- I certainly didn't know about that change, even any words.

CHAIRMAN CORRADINI: Okay. Let's have a break, 3:20.

(Whereupon, the foregoing matter went off the record at 3:00 p.m. and went back on the record at 3:20 p.m.)

CONTINUED PRESENTATION/DISCUSSION

CHAIRMAN CORRADINI: Mr. Stetkar, did you want to bring something up?

MEMBER STETKAR: I would like to, yes.

CHAIRMAN CORRADINI: Okay. Good.

MEMBER STETKAR: I'm probably going to regret this, but could you show me the top logic for top event VI-TOPINJ, the current? That's what it is today?

MR. LI: Yes.

MEMBER STETKAR: No. That's fine. I know this picture. That's the good news.

How easy is it for you to chain down? Easy?

MR. LI: Yes.

MEMBER STETKAR: Okay. Go down the 3 of 3 pool tail branch. Okay. Good. Now go back up and go down. Move it over and just go down one of the like line A injection failure. Okay. That's how you did the pool empty, the positive. There you go. Stop. Thank you. The first, don't do anything there, please.

Those two at the top where it says, "Mechanical Failures on Line A, Pool A" and "Pool A Empty Due to Other Causes," are new in rev. 3. Is that correct?

MR. LI: This is the one you have for this system.

MEMBER STETKAR: Okay.

MR. LI: That probably is true because what we did is we investigate how to gauge costs, tried to add a basis, which could be new.

MR. WACHOWIAK: I'll find it. I've got a

rev. 2 model.

MEMBER STETKAR: No. I've got the rev. 2 model right here. It was kind of a rhetorical question. I was hoping that you were actually the systems analyst.

Indeed, those are new. I am hoping that they are logically correct. This indeed is the thing that I stumbled over in chapter 22, where there is a sentence that says, "In rev. 3, we have correlated failures of the injection with failures of the pools," which we didn't do before.

I couldn't see this fault tree anywhere because this fault tree is not documented in the rev. 3 PRA report anywhere. So I couldn't go check to see how you have really done that because I was really concerned about that because my first comment on the first page of the first GDCS fault tree that I looked at back in rev. 2 was that that fault tree did not logically account for all of the combinations of failures that indeed would disable GDCS. Logically it was not complete.

MEMBER APOSTOLAKIS: This fault tree you have not seen before?

MEMBER STETKAR: That statement is

correct. I have never seen the fault tree that is up on the board.

MEMBER APOSTOLAKIS: So where did you get it from?

MEMBER STETKAR: He may have gotten it from the computer.

MEMBER APOSTOLAKIS: I mean, is there --

CHAIRMAN CORRADINI: Where is it documented?

MEMBER STETKAR: It's not.

MEMBER APOSTOLAKIS: Are we keeping separate documents or what?

MR. LI: No. Let me explain the process here. So I think Rick earlier talked to the staff. What we decided is we will update our model. So the system model for rev. 3 was updated.

MEMBER STETKAR: This change was made?

MR. LI: These changes were made. Instead of showing every single change to the thousands of fault trees, we don't think it's feasible for the NRC to do the DCD revision 5 review.

So what we did, we do extra. So if you read all 22.4 something, we describe the change in detail. And we develop every single change, say, "Is that change notable?"

CHAIRMAN CORRADINI: Is that change what?

MR. LI: Notable. So after we completed that process, we did have another round of quantification. So the quantification is documented in 22.7 and also 22.8 for level 2. So, again, we check any notable changes. If it's notable, we would describe it. If it's not notable --

MEMBER APOSTOLAKIS: "Would describe it" means you will also show the tree?

MEMBER BLEY: No, not always.

MEMBER STETKAR: Let me ask you something about notable. Notable, the difficult thing about performing a review is not to look at the things that are important, notable. It's to look at the things that are not important, not notable, and understand why they are not notable.

So to do a review, most of the review process is not to look at the things that are there. It's to look at the things that are not there.

So, for example, when I picked up the first page of the GDCS fault tree back in rev. 2, the top event INJ, I looked at that. And I said, gee, this as a fault tree logic does not account for all of the failures that contribute to the system, to the system failure.

I can't find that by looking at only the failures that I can see in cut sets. I can't find that by looking at the dominant contributors to core damage. I can't find that by looking at anything that I can look at. I can only look at the fault tree logic and the system and say the fault tree is not a correct logical representation of the system. It is something that is wrong. It is logically not complete.

So I made that comment. I said, "Gee, the fault tree is not a logically correct representation of the system. We need to find out why that is. How did that happen?"

You have now made a change to that fault tree, which I can't see because you have determined that the change is not important. Well, you determined that the original error was not important. If it had been important, if it had been the dominant contributor to core damage, you would have fixed it.

It was not the dominant contributor to core damage because the fault tree was logically wrong because it did not include things. You could not look at the results. You could not look at the notable contributors and find this because it wasn't there at all. Its contribution was precisely zero.

Now you're telling me that you fixed the fault tree, you fixed that error, you found the error. That's really good. You found it internally. You have requantified the model, and the change is not important.

Okay. That might be correct or it might not be correct because there might still be an error. But I can't see the error. I have to take your word for the fact that numerically this change didn't make any difference because it was not a notable difference to the overall result. And that leaves me a bit uneasy because you have fixed an omission by putting in something that I cannot review because I can't see it.

CHAIRMAN CORRADINI: I think they get it.

MEMBER STETKAR: Okay.

MEMBER BLEY: Can I add just one short thing?

CHAIRMAN CORRADINI: You get it, right?

MR. WACHOWIAK: I get it.

MEMBER ABDEL-KHALIK: I mean, you got it, but how is it going to be fixed?

MEMBER BLEY: Well, that's what I wanted to talk to, Said. Let me say something.

MEMBER STETKAR: Go ahead.

MEMBER BLEY: It's short because I have been struggling with this since I reviewed the stuff you guys wrote. And I can't speak for staff, but it hit me through the discussion today that if you had, in fact, updated rev. 3 completely and included chapter 22, then it would be very possible to say, "Gee, I see something here. Let me go back and look and see how it worked out."

I'd sure like that better on the receiving end, but it's up to you guys what to send.

MEMBER APOSTOLAKIS: So what is the resolution for this?

MR. WACHOWIAK: I don't know that there is a resolution. Let me try to put this into an analogy for other things that we are doing with the certification. In the accident analysis, we submit the limiting accidents. We don't submit the non-limiting accidents, non-limiting. And the choice of the limiting accidents are the ones that we chose that we examined as limiting.

So it's a very similar case. There could be an error in our model that we're not showing an accident as limiting because there is an error in our model and the reviewers don't get to see it.

So I am not sure how. You know, that's a similar situation, and it's the way that we have been organized for passing this information on. We do the analysis. We determine what are the significant things. And we show the staff the significant things that contribute to our conclusions.

So the review that you are looking for -- and maybe this gets back to that whole thing about the peer review concept and what they're doing is not equivalent to a peer review because the things that you're looking for specifically are some of the specific things that are not sent in for review.

MEMBER STETKAR: But this is a little bit different, I think, Rick, because this is the PRA of the design as it exists today. So it's not the PRA of the particular pieces of equipment that you thought would probably be important that go through the particular systems that you thought were probably important that would go through the particular event trees that you thought were probably important, the analogy to your transient analysis stuff.

This is the PRA of the plant design as we understand the design as it exists today. So, therefore, if a piece of equipment is in the plant design, as we understand it, it should be in the PRA model. And the PRA model logic should have the appropriate and and/or branching logic to combine that piece of equipment with other pieces of equipment in the plant. I mean, that's, after all, the whole reason that we do the PRA, to look for these combinations of failures and how relatively important they are to overall risk.

So I think this is a little bit different because the PRA and the PRA logic models, in particular, are not filtered or I would hope that they're not filtered by your value judgments about what is important that reviewers -- what is so important that reviewers should see it? And what is insignificant that reviewers don't need to look at it? Because in many cases, the review process looks for things like completeness, looks for logical consistency and and/or type logic.

So I'm not quite sure that that --

CHAIRMAN CORRADINI: I am listening to you guys discuss this. And I am not a practitioner of this. I am trying to understand a path forward that gets you over the concern that Dennis and John have raised.

MEMBER BLEY: To me it's not the same. What if they said they used a new heat flux correlation and it's all okay but they didn't show you the new correlation? Where's that correlation? I want to see it. Where did it come from?

Well, if we got a new fault tree model, you say, "Yes. They fixed something. I saw it. It needed to be fixed." But how did they fix it? What is the basis of it? What does it look like?

To me a simple solution would be the next time around give them the whole thing and tell them what changed.

MEMBER SHACK: I think Dennis' idea, you submit the complete PRA and chapter 22 and you can find --

MEMBER BLEY: You can see what happened. This one you couldn't go see. You haven't gone through it yet to see if you liked what was done.

MEMBER SHACK: You know, it would take a

while. The problem is I don't know whether we want to --

MEMBER APOSTOLAKIS: So what you're saying is --

MEMBER SHACK: -- go through this in real time --

MEMBER BLEY: With everybody here, yes.

MEMBER APOSTOLAKIS: Rev. 3 should have the updated fault trees and still a chapter to tell you how it differs from rev. 2.

MEMBER STETKAR: Yes. Well, my --

MEMBER APOSTOLAKIS: Right now they show you rev. 2.

MEMBER SHACK: It's not that much more work for them. They've got rev. 3 on their computer. It's a .pdf file.

MEMBER APOSTOLAKIS: Yes.

MR. WACHOWIAK: It would have been more work. Number one, there is a lot of overhead in producing the whole document in our processes, the things that have to be done to make that happen. It's an 8,000-page document. So it's not insignificant to produce the whole thing with the change. So there's that piece.

The other piece that we described in 22 is that the level 1 and level 2 models' internal events were completely updated. But the other models, the fire and external events and things like that, were evaluated to see if any of these changes that we did to the fault tree models or the event tree models or the data, any of those things, would have impact on those models. And those had not been updated at the point where we submitted this, but a evaluation was performed on whether there were going to be any changes to those.

So one of the reasons that we went this way was so that when DCD rev. 5 went in, that the PRA that reflects, to the best of our ability at that time, reflects DCD rev. 5 could get to the staff at the same time without having to wait six months after the DCD goes in for the PRA and all of the niceties of fixing the document up get reflected because our best estimate, our best of our ability right now is probably about six months from when the DCD gets changed to when the full PRA can be updated.

So this was a mechanism to get those changes in front of the staff and start reviewing them immediately upon getting the difference in rev.

5 because if we didn't do that, then they would be there with DCD rev. 5 looking at a design that they don't even have a road map of how it should be changed in the PRA because there is nothing there in front of them.

So this was our best option from getting that part of the --

MEMBER STETKAR: It's okay for the design changes, but it still doesn't address changes like this.

CHAIRMAN CORRADINI: Can I just intervene? I want to make sure I get this right. So, if I understood what you just said, the fact that you issued rev. 5, DCD rev. 5, and the version 3 of the PRA almost simultaneously was facilitated because you didn't choose to, need to, want to enumerate all the details that have been changed and document them. Did I get that right?

MR. WACHOWIAK: Not exactly. We didn't need to and we didn't necessarily want to change all of the sections in the document to do that.

CHAIRMAN CORRADINI: That I get. So let me just --

MR. WACHOWIAK: So we were able to

address all of the changes that happened to the plant between the plant design, which was like rev. 3 and a half of the DCD, which is where rev. 2 PRA was. And we were able to address all of those changes because the time difference in doing it this way, we were able to catch and address things that changed up to approximately a month before when they were submitted.

CHAIRMAN CORRADINI: Again, from my standpoint, it's a matter of just so that I understand how they fit together. The converse is if you were to have produced a chapter 22 which had essentially what was revision 2 -- I'm sorry -- what were the changes to revision 2, almost like a compare document, that would have been much more onerous and it would have created a time delay, even though the design that you were looking at and the analysis that you would have done, were back with DCD rev. 5? That's what I hear you telling me.

MR. WACHOWIAK: Most of the analysis was done.

CHAIRMAN CORRADINI: Okay.

MR. WACHOWIAK: The level 1, all of the systems models were done. Level 2 internal events were done. The fire and flood models were not done. What we did was we looked at what the changes were to the results in the level 1 and compared those to the same event tree logic that we had in the external events to see if there were any changes that we made in the level 1 that would have affected those and described what we thought that the differences would be for those models.

MEMBER APOSTOLAKIS: But there is --

CHAIRMAN CORRADINI: I'm sorry. Can I just end up? So let me turn to the staff and ask. So the approach that GEH has taken, has that facilitated your review such that you are happy with this? What is the staff's view on this?

MR. CARUSO: This is Mark Caruso.

CHAIRMAN CORRADINI: Some of the members are a bit confused.

MR. CARUSO: This is Mark Caruso.

I think from our perspective, it was "Okay. Thank you. We agree that this could be very much for convenience. I think in the sense where there wasn't a lot of stuff being changed, you know, a lot of significant stuff or stuff being changed, that this was probably an acceptable way to go.

I guess the other thing I want to say is our sort of criteria or our objectives in looking at this were to see whether or not we thought these changes would change our conclusions. I mean, we are pretty far along.

And when they presented it to us, it was "We haven't really changed much of significance. You know, there are no big design changes. There are no big modeling changes. There are some modeling changes, small modeling changes. This has been incorporated. We'll describe those to you."

And we said, "Fine." And we looked at that as an opportunity to look at what they said and see if we agreed. If we agreed, if we felt there wasn't enough information to agree or we felt like "Wait a minute. This could be significant, and they haven't told us enough," we had the opportunity to go back and issue RAIs to get more information.

But I think, for example, if this had been the difference between rev. 1 and rev. 2, this would have never flown. That would have been this process would not have worked. I mean, we were talking about changing from beta models to multiple Greek letter models, from I "don't have this part of the system in there anymore. I took this out. I took that out." That would not have worked.

But in this case, I think the changes were such that they were not that significant in terms of affecting the overall results and conclusions.

MEMBER APOSTOLAKIS: But there is a question here. The issue which it appears we will be discussing -- and I don't think it is the right issue -- is whether to replace rev. 2 by rev. 3 or actually have rev. 3 be the complete new PRA and report that. And that would be a lot of work and overhead and all that.

But could at least chapter 22 be complete? It appears that even 22 is not complete in the sense that it doesn't have some diagrams, some key fault trees, and so on. And that I don't understand why it can't be.

I mean, why do you have this fault tree on your computer and you can't add it to chapter 22 so somebody like Mr. Stetkar can look at it and draw some conclusions?

And the next point is that, having not done that, what if we need to go back to the PRA, say, three years down the line for some issue?

MR. CARUSO: No. I think --

MEMBER APOSTOLAKIS: Then what do we do? We say, "Well, gee. We have to go back and find Mr. Caruso and Mr. Li and look at that. And they will tell us what is supposed to be there." That's not the way we do business.

And you said, I think, that the changes were not of great magnitude. So that would mean that chapter 22, you know, making it complete is not such a big deal, especially since you seem to have all that information. It's not that you're going to start drawing trees again.

CHAIRMAN CORRADINI: So, just to add to that, I guess my question is, another way of asking this is the fact that -- well, first of all, did you guys realize that 22 was not complete?

MR. CARUSO: Yes

CHAIRMAN CORRADINI: Okay. That doesn't give you pause?

MR. CARUSO: Well --

MEMBER APOSTOLAKIS: It's the result.

MR. CARUSO: I think we went on knowing that. And I think in some cases, we had asked some additional questions.

CHAIRMAN CORRADINI: Okay. So additional questions had been asked for clarification.

MR. CARUSO: We knew it was going to be mostly descriptions of changes and arguments as to why they weren't important. And we agreed that we would -- you know, we would have preferred to have all the stuff so that we could look at the stuff, but I think we agreed to take a shot at looking at what they presented and seeing if we could make a judgment, a satisfactory judgment, that we could sleep over, that it was okay.

CHAIRMAN CORRADINI: From a QA standpoint, to get back to George's question, -- I kind of did a detour question -- from a QA standpoint, how does one reconstruct what was there, then, if it's not there later on?

MR. CARUSO: They are going to reconstruct. I mean, they eventually will have the complete rev. 3. And the record will be made complete.

CHAIRMAN CORRADINI: This is not the end.

MR. CARUSO: It's not the end.

MEMBER BLEY: It might be rev. 4 perhaps

but not rev. 3.

MEMBER APOSTOLAKIS: So there will be a rev. 4 with all these fault trees without a chapter 22?

MR. WACHOWIAK: Yes.

MEMBER APOSTOLAKIS: And it will be that PRA?

MR. WACHOWIAK: That's what we are working on right now. And we have let the staff know when we expect to complete that. And right now we are at a stage where the project managers are deciding when they are going to come down to GE and look at it.

MEMBER APOSTOLAKIS: I just don't see how this Committee can write a letter on the PRA without seeing this.

MEMBER STETKAR: You know, we were led to believe that the rev. 3 PRA was it and it was fully consistent with DCD, rev. 5 and that was this is it.

MEMBER APOSTOLAKIS: I don't think we can write a letter.

MEMBER STETKAR: In some sense, the rev. 3 PRA model that's in the computer probably does satisfy in CAFTA -- well, all right -- to a greater or lesser extent satisfies that. But the rev. 3 PRA report as it's currently --

MR. WACHOWIAK: And this is where I think there is a little bit of a disconnect on this in that the requirements for certification are a description of the PRA and a description of the results and insights, not the PRA.

MEMBER APOSTOLAKIS: This is asking us to write a letter.

MR. OESTERLE: This is Eric Oesterle from the staff.

Just to provide some historical context for all of this discussion --

MEMBER APOSTOLAKIS: I do think, though, that Rick has a point. It seems to me there are two different objectives here. Mr. Caruso mentioned two. You are looking at it from the perspective of certifying the design.

MR. WACHOWIAK: Right.

MEMBER APOSTOLAKIS: The staff is looking at it from that perspective when you said, "Are these changes going to change our main conclusions?" and you concluded probably not.

And in the discussion today, I think we

have been focusing more on, is this a good PRA, actually not a good PRA? Does it reflect the design that has been given to us? It is a very necessary step for a good --

MEMBER STETKAR: That is a necessary step.

MEMBER APOSTOLAKIS: A necessary step.

MEMBER BLEY: Even a category class 1 in the left-hand column.

MEMBER APOSTOLAKIS: Right, the category 1. Exactly. So I'm wondering now whether there is a disconnect there. I mean, are we demanding more in your opinion than is necessary for certifying the design? And that question is to the staff.

MR. OESTERLE: This is Eric Oesterle from the staff.

Rick is exactly correct. The regulations in Part 52, Subpart B for design certifications -- it's 52.47 and a bunch of numbers, and it talks about a description of the design-specific PRA and its results.

MEMBER APOSTOLAKIS: Yes. But once you start questioning the results, presumably they will give you the reasons why the results came out the way they did.

MR. OESTERLE: I understand. And what I am sensing is some frustration on the part of the Subcommittee members in that you don't have the same tools available to you to review this information as the staff does.

I mean, we can go down to the GEH facilities and audit the PRA and all of the supporting documentation behind it and everything like that. And perhaps you don't. I'm not sure. I don't know if there is anything preventing you guys from going down there.

MEMBER APOSTOLAKIS: It will be worse in the future.

CHAIRMAN CORRADINI: Let me just ask you, Eric. I think I understand Rick's point and the staff's in agreement with it relative to the level. So without an audit, without a rev. 4, does the PRA satisfy the DCD at this point? As a progress report sort of view, does it or doesn't it?

I guess my feeling is given what the RAIs have been -- there's no other full RAIs, then I get the impression that this is the level of detail that is good enough.

MEMBER APOSTOLAKIS: We don't know. At least I don't know what it means to use a PRA in the design certification process. What on Earth does it mean?

CHAIRMAN CORRADINI: Well, a couple --

MEMBER APOSTOLAKIS: Wait. And I look at it, and I say, "Okay. There is a PRA. What does it mean?" We don't know, I don't think.

MEMBER STETKAR: We've heard some of that. We've heard that the PRA has been used in some fashion to identify a lot of RTNSS systems.

MEMBER BLEY: This morning we heard that significant sequences all had melt greater than six hours, which led to the criteria for running the experiments. Once things like that are hooked to the PRA, it seems to me you've got to go a level deeper than just saying there is one and that the results don't --

MEMBER APOSTOLAKIS: Yes, I agree with that, but I don't think there is a list of requirements that says requirement number 4 says that you should use your PRA to prove this or to do that.

MEMBER BLEY: No. Stop. Stop. There isn't.

MEMBER APOSTOLAKIS: So it's kind of fuzzy.

MEMBER ABDEL-KHALIK: But how can you review something if you don't have a complete set of documents?

MEMBER APOSTOLAKIS: I agree with that. All I'm saying is maybe the root cause of the problem is that there isn't a clear role of the PRA in the design certification process.

MEMBER SHACK: Well, if I could just back up --

MEMBER APOSTOLAKIS: Just put PRA, they say.

MEMBER SHACK: If you are even going to get a summary of the results, George, you would like to have confidence that it is a summary of --

MEMBER APOSTOLAKIS: Somehow you got the impression that I am against that. I am not saying --

MEMBER SHACK: You are saying you only have to submit the summary of the results.

MEMBER APOSTOLAKIS: What I am saying is Rick says for our purposes. And I'm asking, what are the purposes?

MEMBER SHACK: As I understood --

MEMBER APOSTOLAKIS: Certify the design. Well, yes. But, I mean, what does that mean? Part 52 says --

MEMBER SHACK: Do a PRA.

MEMBER APOSTOLAKIS: -- do a PRA. Yes. Now what?

MR. CARUSO: This is Mark Caruso with the staff.

We discussed this. There are a number of objectives the Commission has let out in policy papers about what you should use the PRA for. I mean, there are not regulations, but the requirement is have a PRA and do it.

Well, I agree with you. It talks about how they should use it. Look for reliability. You know, make sure there is a balance between prevention and mitigation. And I think from my perspective, when you look at those objectives and you say to yourself, "Well, you know, I've got to have a PRA of pretty good level to do this stuff. And it's got to be able to give me answers," I think we struggle a lot with what level of quality do you need for this. We don't have a guide for that or a standard.

MEMBER APOSTOLAKIS: Draw the contrast. There is a contrast between, say, risk-informed ISI and what we are doing here.

MR. CARUSO: Right.

MEMBER APOSTOLAKIS: I know what I should be doing for risk-informed ISI. EPRI has guidance. Westinghouse has guidance. The staff has reviewed them. So it says you go and look at the potential mechanisms. So you develop a matrix, and you say there are consequences. I have guidance. I know how to use the PRA. I know what the requirements are.

Here it says do a PRA. Submit the results.

MEMBER SHACK: There seems to be agreement we want a category 1 PRA.

MR. CARUSO: Well, maybe you don't have agreement on category 2.

MEMBER SHACK: You still have to reflect the plant, no matter what.

MEMBER APOSTOLAKIS: No matter what.

MEMBER APOSTOLAKIS: So it's clear to you, the, what the role is of PRAs in certification? I mean, let me ask the question because maybe I am missing the point. It is not clear to me at all.

And Part 52 is very vague. Do it.

MR. OESTERLE: I believe it's been left vague intentionally so.

MEMBER APOSTOLAKIS: I know.

MR. OESTERLE: Eric Oesterle from the staff again.

Because, again, the design is to be informed by the PRA. And that is part of the risk-informed nature of this process. Also, what we understand is that the PRA is commensurate with the level of design completion of the certification.

I mean, you were comparing these risk-informed ISIs with completed plants already. And design certifications still have some detailed engineering to be completed before we can get to the level that you're talking about using these risk-informed --

MEMBER APOSTOLAKIS: I guess I can't express myself clearly today.

CHAIRMAN CORRADINI: George, can I try an analogy on the level 2, which is what I was looking for this morning?

MEMBER APOSTOLAKIS: Yes.

CHAIRMAN CORRADINI: I was listening to

the discussion. And there are only two things that I was watching for. I wanted to understand, if certain features didn't work, could I still feel comfortable that nothing happens within 24 hours? And given the features, what is the chance that it would work one out of ten times?

MEMBER APOSTOLAKIS: I heard --

CHAIRMAN CORRADINI: That is the only two things that I was looking for for the level 2.

MEMBER APOSTOLAKIS: I heard both from Mr. Wachowiak and Mr. Caruso for the purposes of the certification, it was good. And I don't understand that. I don't know what the hell that means. For the purposes of certification, but for the purposes of Stetkar, it is not good. They are different.

MEMBER STETKAR: Let me bring up something specific here.

MEMBER APOSTOLAKIS: What is the difference?

MEMBER STETKAR: I am a specific detail-focused guy. And since we have got this part of the fault tree up here, it is relevant to give you a little bit of my concern. It gets back to a drawing that you brought up, Mike.

At the outlet of each GDCS pool, there is a manual isolation valve that is normally open. It's characterized as a maintenance isolation valve or whatever. It is a manual isolation valve. It is normally open.

Why are those valves not in the PRA model? That's a question.

MR. WACHOWIAK: Right. Okay.

MEMBER STETKAR: Why are those? I brought it up earlier in June, but we said we would get to it.

CHAIRMAN CORRADINI: Rick acknowledged it and said he is going to have to get back.

MR. WACHOWIAK: Yes. And we looked at this. There are a couple of things. First, if we remember back to this morning, we said we originally didn't have back in rev. 0 and rev. 1 of the PRA a BiMAC model. We said it had to have a reliability that gave us a 10^{-3} failure rate or better back then. It was a single point thing. And so there was no BiMAC model.

Then when we were looking or we were modeling GDCS, we hadn't decided yet how the deluge lines were going to work and those sorts of things.

There were some concepts for it, but it wasn't fully formed yet.

One of our screening rules for these manual valves was, does it affect any other system? And at the time it didn't. Okay? Also, we weren't sure where in the line the -- well, I said that -- where in the line the BiMAC pipe was going to take off.

Was it before that manual valve or after the manual valve? I think on some of the cartoon P&IDs that we've had later, they started to show up after the maintenance valve.

This is one of those areas where as that detail was being filled in, we hadn't caught yet the fact that our initial screening process, that this locked open manual valve that was going to be indicated and alarmed in the control room that didn't affect any other systems now affects other systems.

So we lost one of our legs of our stool. That's a four-legged stool, I guess, there. We lost one. And we needed to go back and look at that and see what to do about it.

So you're right. A design detail got filled in that we didn't catch in the modeling of the

PRA. So after that came up, a couple of things that we have done. We have done a sensitivity now at looking at whether or not adding that part to the model is going to make any difference. Okay?

And I think we have got the results here somewhere in one of our files. In essence, you would have to have the valve, all four of the valves, be in the closed position with the indication showing that they were open and a separated stem and disk sort of thing.

So in the end, it turns out that yes, we missed that. It doesn't affect the model. It goes in the PRA maintenance process, as described in the ASME standard, as something you fix the next time you update the PRA.

The other thing that we look at with that is we are supposed to have two independent systems here: mitigation and prevention. I don't like that BiMAC line taking off after the maintenance valve. I would rather have it take off before the maintenance valve.

So the second piece of this is just not probablistically but deterministically, I can use my influence on the design, whenever that might be, to try to get those guys when they fill in the design to put that line before the maintenance valve because the BiMAC is supposed to have its own maintenance valves anyway.

MEMBER STETKAR: You know, Rick, I hear you say all of this. And you have spent ten minutes justifying in an ad hoc basis why the PRA did not include those valves when it would have taken an analyst all of a minute to put the valve in the PRA model initially and we wouldn't have this discussion.

And the valve has been in the design. It's always been there. Every picture that I have seen has had these valves in there. It is not labor-intensive to put those valves in the PRA model. If they were in there, their importance indeed would be explicitly quantified. Their effect on injection and deluge would, in fact, be explicitly modeled.

The fact that one valve, in fact, affects four injection valve lines, which you have not mentioned but one valve being closed affects, well, four injection valves, if that valve is closed, your m out of n injection valve opening criteria changed dramatically, injection valves.

MR. WACHOWIAK: If two --

MEMBER STETKAR: If the sample is four injection valves.

MR. WACHOWIAK: Two injection valves. There are four maintenance valves. Each one has two --

MEMBER STETKAR: There are three back at the -- are we talking about the same valves?

MR. WACHOWIAK: About the GDCS line injection.

MEMBER STETKAR: Not the GDCS line injection. The GDCS pool isolation valves.

MR. WACHOWIAK: Okay.

MEMBER STETKAR: Pull up a drawing. I'm talking about valve F004A, for example.

MR. WACHOWIAK: Yes. So open up in chapter 4 the --

MEMBER STETKAR: If you have a simplified diagram of GDCS. And there are only three of those because there are only three pools.

MR. WACHOWIAK: But there are four lines.

MEMBER STETKAR: One of them, I believe --

MR. WACHOWIAK: The larger pool has two injection lines.

MEMBER STETKAR: But I thought there was only a single valve.

MR. HOWE: Each maintenance valve is on a line that then branches into two injection lines. So one valve takes up two. I don't have the drawing in front of me.

MR. WACHOWIAK: When we build a PRA, we set up some initial ground rules for what things get put in and what things don't get put in.

MEMBER STETKAR: I guess that's what I'm asking.

MR. WACHOWIAK: Manual valves that have indication in the control room. Unless they affect more than one system, they're not modeled.

MEMBER STETKAR: And that's --

MR. WACHOWIAK: That's one of our basic assumptions.

MEMBER STETKAR: I really question that assumption because: a) people who have ever operated a nuclear plant know or any kind of facility know that those valves do indeed fall apart, that the indication control room tells you nobody randomly walked around and closed it, but they do fall apart.

And if there's a very long exposure

period to that failure, like, for example, you don't put flow through that line for, oh, several years, the likelihood that that thing is closed when you need it can get rather large.

So leaving it out of the PRA regardless -- the whole point is that we're having a discussion about why you did not put something in the PRA that would have taken an analyst one minute to put in the PRA.

This is not a huge philosophical issue. It's not a labor-intensive issue. It is not anything. It is putting a basic event in there that says, "Valve closes spuriously." That's all it takes. An analyst knows how to do that that quickly.

In fact, you have the data for it already in the PRA model. So you don't need extra data. It's that level of effort that we're talking about, and it is part of the design. That valve is in the design.

Now, where is the pool BC valve? That's the A. That's the valve that I was talking about. And that indeed only affects one injection. It affects the A and whatever it is, the A and E.

What about the pool B/C valve, though?

Isn't there just a single valve from the discharge of pool B/C and then the discharge breaks?

MR. HOWE: Pool B/C just has two equivalents of this coming out of the pool. It doesn't just have one, as we said before.

CHAIRMAN CORRADINI: Because it's a bigger pool?

MR. WACHOWIAK: My understanding is that there are a total of four injection lines --

MR. HOWE: Right.

MR. WACHOWIAK: -- that do this. And one pool just has two of those injection lines coming out the bottom.

MEMBER STETKAR: You know, I thought that the drawing that I saw that had all the pools on it -- does your drawing show all the pools?

MR. WACHOWIAK: I don't remember any --

MEMBER STETKAR: Because, you know, I was concerned about it in a bigger picture sense, not the details of level of effort and screening criteria. I was concerned about it in a bigger picture sense that here is a single failure that affects two functions, both deluge and injection.

And also I was concerned that on the B/C line, if there is a single isolation valve there, it affects four injection valves and six deluge valves, which is a big deal if that one is --

MR. WACHOWIAK: Much bigger deal, and it would be a much bigger deal.

MEMBER STETKAR: And it would be. It's still a single failure that affects one train of injection and one train of GDCS deluge.

MR. WACHOWIAK: Right.

MEMBER STETKAR: You know, I don't want to make value judgment. The reason I do a PRA is not to make pre-decisional value judgments about what is going to be important and what is not going to be important.

The reason I do a PRA is to model the plant and the plant design and let the PRA tell me what is going to be important, what is not going to be important.

So if spurious closure of that valve, if it's in the PRA, if it's in the PRA and it's not important in the PRA results, fine. I've solved the problem. I've indeed modeled the plant and determined that that is not a big deal.

If it's not in the PRA model at all, I

just don't know. I have no idea how important that might be.

CHAIRMAN CORRADINI: George?

MEMBER APOSTOLAKIS: I am wondering now where we're going with this discussion. Are we going to make a recommendation of some sort? This is a very unusual Subcommittee meeting. We are doing the review in real time.

CHAIRMAN CORRADINI: The purpose of the Subcommittee meeting was to give ample time to ask questions about level 1.

MEMBER APOSTOLAKIS: Yes. We have been talking now for about 50 minutes about what is in chapter 22. Where are we going with this? I mean, John probably has no examples of what he just gave us. So where is this going? Is it going to be a recommendation regarding what should be in the PRA or are we going to write a letter in March, when we see it?

I'm trying to figure out where we are going with all of this. And I still have this question in my mind when the applicant and the staff say for our purposes this is good enough and we seem to disagree because I don't know what those purposes are.

MEMBER STETKAR: But part of your discussion was everybody agrees that it should satisfy, should be at least --

MEMBER APOSTOLAKIS: Category 1.

MEMBER STETKAR: -- at least category 1, --

MEMBER APOSTOLAKIS: Yes.

MEMBER STETKAR: -- which says that valve should be in there, shouldn't it? That's part of the plant design.

MEMBER APOSTOLAKIS: Well, should be a faithful model of the plant. There's no --

MR. WACHOWIAK: I think you've got an assumption that open manual valves that don't affect more than one system is typical --

MEMBER STETKAR: Bring up your -- it's typical and typically applied wrong, but it's typical. Bring up your fault tree, if you could, again, for top --

CHAIRMAN CORRADINI: Can we just get back to George's question? I guess when we left the June 3rd meeting, there was uncomfortableness from most of the Committee that was in the room when we had the

Subcommittee meeting.

MEMBER APOSTOLAKIS: Okay.

CHAIRMAN CORRADINI: But we wanted to understand some specific sequences and dig into details of the level 1.

MEMBER APOSTOLAKIS: Right.

CHAIRMAN CORRADINI: And we ran out of time for the level 2 severe accident management piece. So we wanted to have the Subcommittee meeting for two purposes. One was to go over the severe accident management.

And secondly is to dig deeper into the road three of the PRA to get a warm and fuzzy feeling that things were of a level of reliability and robustness that we should feel good with an interim letter that said they looked like they were on the right path, you know, keep going.

MEMBER APOSTOLAKIS: Yes. And what came up today is that documentation is not to the level where we can actually draw conclusions. I think that's what really is happening here.

CHAIRMAN CORRADINI: I guess I --

MEMBER APOSTOLAKIS: We are having some logic diagrams that John, for example, who obviously looked at it in detail, sees for the first time. Right?

MEMBER BLEY: Could I say something on that? This came up last time. And it began because John and I before we had that last meeting had decided to just look at little bit into the model. And each of us picked a little different part of the model.

And I went into the fault tree for the IC system and kind of found the same thing John did. I found four or five things that were just wrong with respect to the system description right there at the top, not spending hours and hours, just looking where you would, top event, the first couple of pages. And there they were. And I said, "Well, you know, maybe that's the only few there are."

But how could we get confidence that that's the only few there are? And the only way we could think of was what if we pick a sequence and just work all the way through, see the event, look at the data, look at the model, and see if this is an anomaly or if there is a lot of it.

Now, the things that I had found in the IC tree, it looks like most of them you guys identified and fixed. I am also a little uncomfortable that if we could look in 15 minutes and see things like that, that the staff hadn't flagged those, those kind of levels in the tree. And I think we were told at the last meeting, well, you know, the trees are too complicated for us to dig very hard into.

So we were left with this uncomfortable feeling. We talked as a group. And I'm just hit with -- you know, I'll stay with the correlation. If you found the correlations that were used were wrong, would you be comfortable? And we had this feeling.

So now I've got a lot more confidence in the review process that's going on at GEH, but we're still finding a few things that --

MEMBER APOSTOLAKIS: But the real issue that we have been discussing is this documentation because you say, "I've heard them, and now I feel better."

MEMBER BLEY: Well, some better.

MEMBER APOSTOLAKIS: Yes. But you couldn't find it in the written document.

MEMBER BLEY: And I couldn't see the trees to check and see how the model was really done.

It fits great now.

MEMBER APOSTOLAKIS: My question is, where are we going with this? We're going to recommend something? Because we can discuss this for two more hours.

MEMBER BLEY: Yes.

MEMBER APOSTOLAKIS: Is that where we're going? To try to formulate a recommendation?

CHAIRMAN CORRADINI: I guess I actually look to you guys to get what you might be suggesting. A recommendation might be that until there is an audit, a letter can't be, an interim letter can't be, issued because we have no way and unloose I misunderstand it, the staff has no way of verifying some of this stuff because they don't have it.

MEMBER APOSTOLAKIS: An audit or until we see four or five of the PRA, which would be it.

CHAIRMAN CORRADINI: Well, I don't view our job -- this is just for me because I'm not sure since you want to use the heat transfer. If you want to use these sorts of analogies -- and I'll go back to the level 2. Until I hear something about the transient response of the BiMAC, I am not going to buy off that the BiMAC is any better than just having the ABWR approach.

But I hear that they have done an analysis and are giving to the staff analysis as for, essentially, severe accident management as the ABWR approach will probably satisfy the design certification criteria for essentially severe accident management. So if I see that and I see some implications relative to the transient analysis for the BiMAC, that might be fine.

Similarly here, I am listening to you guys. And you are not feeling comfortable. But I don't think it's our job to feel comfortable. Our job is to feel comfortable with the staff's review, not with their level, rev. 3 PRA.

So if the staff has an audit, they look at things in detail, and they feel comfortable and they come back to us and say in October or whenever, that we went down and we visited, we checked, we did this sort of stuff, and now we feel comfortable that all of the things in the rev. 3 have satisfied us, that's what we --

MEMBER APOSTOLAKIS: Why, then, don't you say also that, instead of you wanting to see the transient analysis, if the staff comes back and tells you, "We looked at it. It's fine," then you accept it? Why do you want to look at the transient analysis?

CHAIRMAN CORRADINI: I want to talk to the staff when they look at it.

MEMBER APOSTOLAKIS: Then other people will talk to them when they come back and talk about --

CHAIRMAN CORRADINI: What I'm hearing from you guys, just so we're clear, what I'm hearing from you guys, at least that's the impression I get, is if this is -- I don't know what you say -- a category 1 PRA.

If you're not comfortable with this at the point that you have the ability to look at it, it doesn't exemplify the characteristics of a level 1 PRA. Then you don't seem comfortable going forward.

MEMBER APOSTOLAKIS: And in order to do that, we have to see.

MEMBER BLEY: So parallel to what you just said, I would like to see the staff come back, say they have looked through the details. I would also like to see the fault trees that go with the event trees that were provided --

CHAIRMAN CORRADINI: And be able to ask questions.

MEMBER BLEY: -- and be able to ask a few questions.

MEMBER APOSTOLAKIS: Exactly.

MEMBER BLEY: Very similar to what you are saying.

MEMBER APOSTOLAKIS: So we cannot really reach any conclusions until these things happen.

MR. WACHOWIAK: I think you'll find it very difficult, then, to get through the EPR review because they're not submitting any of this stuff.

MEMBER APOSTOLAKIS: I'm telling you the future is even bleaker.

MEMBER BLEY: I haven't seen theirs. So I don't know what they're using it for, but it strikes me. The rule says you need a PRA and doesn't say much more.

But when you start using the PRA to make decisions, I think that is great. I think that is important. I think we'll have safer plants because of that. That puts a little higher level need on being comfortable with what is in the PRA. It's a representation as a safety model.

MEMBER STETKAR: And because when you have a passive design that relies, in large part, on non-active equipment with multiple redundancies that result in extremely low numbers, results, the bar is then raised when you start talking about relative contributors. The bar is then raised in terms of completeness and consistency and things like that. You know, it would be great.

MEMBER BROWN: How do you test them?

MEMBER STETKAR: You don't test them. That's what we're doing now. This is it.

MEMBER BROWN: I know. That's why they look marvelous. You can't test them. How do you know they're going to operate? The nice thing about more active systems is you can test them. You see them do something.

MEMBER BLEY: The trouble is you've got to test them, you know, 10,000, 100,000 times to get the kind of confidence we need to --

CHAIRMAN CORRADINI: So have we satisfied George because I don't think we have yet? I want to make sure.

MEMBER APOSTOLAKIS: And my second conclusion is since we have reached this question today, do we need to be here tomorrow? I mean, that will be more of this.

CHAIRMAN CORRADINI: Well, let's not go to that question just yet.

MEMBER APOSTOLAKIS: It's a big question. I mean, yes. Okay. So Stetkar comes up with ten more examples, and we always get the same thing. No. We had the three that we didn't show you. Here it is, this and that.

MEMBER STETKAR: No, George, it's not all of that.

MEMBER APOSTOLAKIS: What is it?

MEMBER STETKAR: If you just let me get to a couple of more examples.

MEMBER APOSTOLAKIS: Okay.

MEMBER STETKAR: Because some of these things have come up. So far I have been surprised because they made changes to the models in areas that I had problems with, but I couldn't see the changes, which is the documentation, the thing you've got.

MEMBER APOSTOLAKIS: Right.

MEMBER STETKAR: There are still things that I would like to understand a little bit better. Okay?

MEMBER APOSTOLAKIS: That's fine. That's fine.

MEMBER STETKAR: And I hope that they're not just documentation-related. In particular, something that is perhaps documentation-related, if you drop -- do you see where your dotted black line is there?

Drop down to something that says, "GDCS injection line break." I don't recall. I don't ever recall. I just tried in real time to -- I don't ever recall seeing that before. Well, okay. So that wasn't in the rev. 2 model. So this is another change since between rev. 2 and rev. 3. At least I would like to know where it is because I --

CHAIRMAN CORRADINI: You guys are nodding funny. Is that true?

MEMBER APOSTOLAKIS: What is true, that it's not --

CHAIRMAN CORRADINI: That it's not in rev. 2.

MR. HOWE: Yes, that's true.

CHAIRMAN CORRADINI: That is true? Okay.

MEMBER STETKAR: Then if that's true, then if you could go back to that --

MR. HOWE: It is described right here in 22.

MEMBER STETKAR: Okay. But I didn't see the fault tree. That's documentation. But go back to it, please, because right here numerically sometime somebody made a value judgment that spurious closure of a normally open manual valve, everybody knows that that's not significant in terms of a contributor. Everybody knows that. And, yet, here I have added in an and gate a break of a pipe multiplied by some factor-apportioning things. I have explicitly modeled this thing.

MEMBER BLEY: A very unlikely event.

MEMBER STETKAR: I don't know what the numbers are, pretty --

MEMBER BLEY: 10^{-5}, 3 minus 5.

MEMBER STETKAR: Multiplied by something else.

MEMBER BLEY: Times .4, .4.

MEMBER STETKAR: So roughly a 1^{-5} contributor is what they have. But a pipe break. I have modeled a pipe break, but I haven't modeled -- and pipe breaks don't occur very frequently. I have seen valves fall apart.

They occurred countably more frequently than pipe breaks, but somebody made a value judgment not to put the valve in there. But they made a value judgment to put the pipe break in.

MR. WACHOWIAK: It is not a value judgment to put the pipe in. This is a modeling technique such that only initiating events that have medium liquid LOCA will get that injection line failure. So what that does is --

MEMBER STETKAR: This is just a switch for your --

MR. WACHOWIAK: A switch where our code calculates multiple initiators. So that's filter for that.

MEMBER STETKAR: This is just a filter for that initialing --

MEMBER BLEY: While you have it up there, though, I saw the same thing. And maybe I'm reading something wrong. I saw the same thing in the tree for the IC. And that is you have a pipe rupture there.

But when I go to the data point for the pipe rupture in the data tables, it is a different number, not a lot different but different, same thing here. This is a 3.22^{-5}. And when I run over to the data table, it says 7.5^{-5}.

Why isn't the data in the data table the same as the data in this tree?

MR. WACHOWIAK: Is that in section 2.22?

MEMBER BLEY: It tells us that it's different data?

MR. HOWE: Yes.

MEMBER BLEY: I missed that.

MR. HOWE: Initiating events changed a little bit.

MEMBER BLEY: I missed that. Okay. As long as you documented it. But I didn't see it as I --

MEMBER APOSTOLAKIS: I have found they are the same type, though, where the table has --

MEMBER BLEY: Yes, I found several of them, but I didn't notice that you told us you changed the data.

MEMBER APOSTOLAKIS: Right.

MEMBER BLEY: So I missed that. So it's that documentation thing that's pretty tough.

You are frowning.

MEMBER STETKAR: Yes. I am still -- the

valves bother me because the problem is that if it is value that is spurious with a pump, that is not a problem. There have been many and early PRAs done to identify the fact that spurious closures of manual valves whose status was not verified by actual flow tests can be visible contributors.

MEMBER BLEY: In fact, there's a data point, for example, in certain kind of PWR back 20 years ago after WASH-1400 was done 30 years ago that made them take the internals out of some valves like that, "they" being NRR, to make them a piece of pipe, instead of a valve, because they thought it was one valve that could take out a system, so same kind of thing.

MR. WACHOWIAK: It's not one valve that can take out a system here. It is one valve that can take out --

MEMBER BLEY: That's true, yes.

MR. WACHOWIAK: So one of four trains that are needed. So I understand that you don't like that blanket assumption and there are some reasons why that you don't think that that is appropriate.

A couple of things, though, with that. I mean, we have since you asked that question, since the time that you additionally asked that question, we did look at what would happen to the results if we did change this assumption and explicitly model that valve using the data that was suggested in June that we already had in the document to model that failed-to-remain-open of the manual valve. And, as we suspected, it didn't make much difference to the answer.

MEMBER STETKAR: Much difference.

MR. WACHOWIAK: What was the result?

MR. HOWE: The results I have here, actually, I have quantified with a large failure rate just so I could always back it down and to do it over.

But, even using a very high number, which per valve was like $5E^{-2}$, it still showed a reasonable impact. And I think if we used our data that's in there for spurious closure of a manual valve, each valve would be on the order of about E^{-6}. So we did take a look at that phenomena.

CHAIRMAN CORRADINI: Can I just make sure I understood what you just said because this is not my area again. So you're saying the deluge suggests something very low, but you upped the value up to

$5E^{-2}$. And at that point, it started being noticeable.

MR. HOWE: Right.

CHAIRMAN CORRADINI: Okay.

MEMBER APOSTOLAKIS: But not notable.

CHAIRMAN CORRADINI: Not notable?

MR. WACHOWIAK: In PRA, we continue to have to come up with new words for things because people keep codifying the words that we used in the past. We can't say "significant" anymore because the ASME standard ties significant to a specific number. So we can't say "significant" anymore. We've got to use something else.

We're going to use "notable" until somebody defines that.

(Laughter.)

MR. WACHOWIAK: You can't use the English language anymore.

CHAIRMAN CORRADINI: I guess, John, do you need more questions now or can we at least plot a path forward for tomorrow?

MEMBER STETKAR: I've got a couple of things.

CHAIRMAN CORRADINI: Because George has that second question that I refuse to answer, but I need to answer that to plan tomorrow.

MR. WACHOWIAK: Two other things that I want to bring up on this that should get up getting reflected into the rev. 4 description. Currently the plan for testing that check valve is to use flow through that pipe. So when they check the test valve, each outage, it is expected that we will get flow through that valve.

MEMBER STETKAR: That's really important because in the documentation we have --

MR. WACHOWIAK: It doesn't say that.

MEMBER STETKAR: -- the flow through that valve would be tested once every ten years.

MR. WACHOWIAK: That is correct. That is what it says there.

MEMBER STETKAR: That is a huge unavailability. It dominates that line, each line.

MR. WACHOWIAK: And now because of some other --

MEMBER STETKAR: Individually.

MR. WACHOWIAK: -- issues with how do we test the check valve, the process for testing the check valve is going to rely on flow through that valve.

MEMBER STETKAR: But the -- well, I've said enough. The only other thing that I want to bring up, then, before you get to the bigger-picture stuff is that the current models for GDCS and, in fact, I think most of the systems do not include any contributions from maintenance unavailability. Why is that? Especially because your tech specs allow you to have one complete safety division out of service indefinitely, there is no limit on me, Tom.

I can operate this plant with three divisions of safety operating, one inoperable continuously. The PRA model does not account at all for that possibility. Those four safety divisions are always 100 percent perfectly available to operate except for hardware failures.

MR. WACHOWIAK: And you are correct that that is the way it is modeled, that we don't have maintenance unavailability for many of the systems.

One of the things that you have to recognize for the passive systems, we don't wire it up the way that you were saying. There is a division 1 electrical system that controls division 1 valves. All four electrical divisions control all eight of the mechanical valves. So there really isn't a div.

valve.

So what we have looked at in our detailed I&C model is what happens if we assume one of the digital I&C trains, if you will, or divisions is out of service? Does that make any difference? And the answer is it doesn't make any difference because the common cause failure of software dominates the failure of the systems by, Tom, the digital I&C systems.

MEMBER STETKAR: Let me back off. In the tech specs, it allows me to have three or more GDCS injection lines.

MR. WACHOWIAK: Okay.

MEMBER STETKAR: This is not divisions.

MR. WACHOWIAK: Okay. I thought you were talking about --

MEMBER STETKAR: Well, I was trying to generalize it to the fact that no maintenance is modeled, but I will be specific. Three or more GDCS injection lines can be inoperable for 12 hours. Two can be inoperable for 14 days.

MR. WACHOWIAK: Right.

MEMBER STETKAR: And one can be inoperable indefinitely. Those are the way the tech specs are written. And those are GDCS injection lines. I don't care how many signals or things come into them.

MR. WACHOWIAK: I know what you are talking about.

MEMBER STETKAR: Well, I was talking in a broader context, but if we want to get specific, why are those allowed conditions not included in the PRA model?

MR. WACHOWIAK: Because we wouldn't be doing maintenance on GDCS valves. Even though the tech spec allows that, what are we going to do?

MEMBER STETKAR: Why is it in the tech spec?

MR. WACHOWIAK: I don't know.

MEMBER STETKAR: We aren't going to be doing maintenance on the valves because they are in the drywell, but I could certainly disable power to them if I am going to do stuff. I could disable signals to them. You know, I could do things in the plant.

MR. WACHOWIAK: You could do that, but, as I said, actually, we have four divisions of power going to every one of those valves. And you're only allowed to remove one of those divisions of power from anything in the plant anyway.

You can't get to a state in the I&C system that allows you to take four power sources away from that valve.

MEMBER STETKAR: You can have all of one division out. You can have all of one power division out.

MR. WACHOWIAK: Right. But the valve gets power from four different divisions.

MEMBER STETKAR: That's right, but the changes --

MR. WACHOWIAK: And we looked into that with taking one of the I&C systems out indefinitely and looking to see if it affected our model. And it turns out that it did not.

So the question would be, do you model it with them all in service or do you model them with it all out of service? In the end, the answer doesn't -- or is one of them always out of service? And the answer turned out to be that we didn't get any change from doing that.

So we looked into it. Should we have put all of those maintenance terms on there? That is a good question because typically in a PRA, you don't use the tech spec allowed outage time for your maintenance. You take actual maintenance records. And you look at how long something is out of service.

And when we looked at what kind of maintenance you would routinely do in the plant, not where you would have, you know, someone using an event but what kind of actual maintenance the plant would typically do, they don't see them doing anything with those valves, calculations.

MEMBER ABDEL-KHALIK: But if tech specs allow you to operate with one system out of service indefinitely, let's say, you know, you have some problem that results in a leakage from one of the tanks. Wouldn't a prudent operator sort of drain that tank until the next outage to find out what is going on and fix it?

MEMBER SHACK: I'd keep the water there. It depends on the point of prudence you're --

MR. WACHOWIAK: If there is a leak in one of the GDCS pools, that would be a GDCS pool unavailable. And they are probably only a 12-hour LCO on that. And it would show up as unidentified leakage anyway. And they would probably be shutting the plant down as a LOCA precursor.

What we are trying to do here -- and this is hard in the design PRA phase, when we don't actually have a lot of this stuff -- we are trying to extract from design documents what would go into a value in the PRA that is normally generated from historical data. And so we have to make the judgment on this.

Are we going to say that everything is going to be maintained, like it says in the tech specs, or are we going to look at each specific piece of equipment and say, "Okay. Do we expect any non-outage maintenance to go on with this valve?"

Now, it doesn't cover corrective maintenance. I agree that it doesn't cover corrective maintenance. But, once again, I don't think we're going to expect to see a huge fraction of corrective maintenance on these. And we do have the data for the valve failure itself that is somewhat based on the interval time where it could have failed since the last outage.

So I think we kind of sort of pick up the corrective maintenance piece in that because we have got it in the valve data. They are not going to close that maintenance valve because the maintenance valve is going to shut off the other GDCS injection line. Once they shut that, they're in the shorter LCO that is going to have to shut them down.

MEMBER STETKAR: It's a shorter LCO, but still it might be the most important contributor. If they only do it once every ten years and have it out for a couple of weeks, it might be the most.

See, the problem is I don't know how important it is. And I can't understand how important it might be because I don't have the volume control knob built into my sound system to even adjust it. It's just not in there.

You say that you have done some sensitivity studies and that it's not important, which you say for everything. And my problem is that in the 10^{-8} world, it is really easy to get factors of 2, 3, 5, or 6.

MR. WACHOWIAK: Yes.

MEMBER STETKAR: That's really easy. Now, is that important relative to a 10^{-4}? No, it's not. Understanding, however, the vulnerabilities of the plant and the risk assessment of the plant design and the way we expect it to operate and identifying those vulnerabilities is not an absolute. It's a relative thing.

In other words, if 90 percent of my risk comes from the fact that I allow a single division of safety-related power to be out of service indefinitely, I would like to know that. I would like to know that even if it was 90 percent of the 10^{-6} number. I still need all of my acceptance criteria. I still need all of that stuff. But that tells me something about the plant design and its interaction with the tech specs that I can't learn from this.

MR. WACHOWIAK: I fully understand what you are saying, but I think the main issue that I have is that you're looking at what the plant needs to do with its operational PRA and how they use the maintenance rule and how they do their performance monitoring.

They will need to know that when they do that. That's one of the reasons that Part 50 requires them to update the PRA and keep it for doing that sort of thing.

So if the question is, do we have 90 percent of CDF associated with this so 10^{-8} now becomes 2 times 10^{-8}, is that going to say that we shouldn't certify this plant? The answer to that is no. We should still certify the plant. And we should require the operators to model those things so that when they put their plant into a maintenance configuration that includes that, that they can detect those kinds of changes.

And so this is why it's really hard with this, because everybody is used to dealing with operating plant PRAs. And we're not trying to say, "Where is all the risk from this plant coming?" We're trying to say, "Is this plant safe enough to operate in the U.S. given the rest of the body of regulations that we have to follow?"

MEMBER STETKAR: Let me ask --

CHAIRMAN CORRADINI: I'm sorry. I need to go to George's question.

MEMBER APOSTOLAKIS: Go on.

CHAIRMAN CORRADINI: Are you happy for the moment? Okay.

MEMBER STETKAR: Sure.

CHAIRMAN CORRADINI: Okay. So I guess, with that, I want to get back to your question. So what are we looking for tomorrow from these gentlemen and staff to discuss?

And I guess I would like to turn first to Dennis and see what you are looking to ask them or wanting to -- because this is an open discussion tomorrow. They have nothing prepared. They're looking to us.

MEMBER BLEY: Let me tell you why I wanted the open discussion. I guess I am at the point right now. I know there were a lot of errors in the rev. 2 fault trees everywhere we have looked. I wanted to go through and track and see the data and see the fault trees and see how they worked. But we don't have them in front of us. It's going to be real hard up here.

I think a process that waits for the audit and allows us to see the fault trees and look for the new ones and see if we find problems like we did in the others would be more effective than rummaging through that tomorrow.

I had one last comment I had wanted to make. And that is when I read through chapter 22, I see an awful lot of "This is conservative," "That is conservatively assumed," "This is conservatively assumed."

And I remember coming here and talking when Hal Lewis was here, who would just, you know, "Why is it conservative? Is it conservative always?" There is no discussion of why it is conservative. And is it conservative under all conditions.

That leaves me a little empty as well. So I think that goes in with the other kinds of things. There is not enough information to know if this is really conservative, if there are some branches in the event trees for which this assumption of conservatism is backwards, you know.

And I think you need some statements of that sort. And I hope after the audit, staff can probably tell us if these are really conservative.

CHAIRMAN CORRADINI: So let me sharpen what you said so I get it right.

MEMBER BLEY: Yes.

CHAIRMAN CORRADINI: Are you saying that -- you said "audit," but I am going to change the word just so I get it. Are you saying that you have no need necessarily to talk more in detail about specific sequences tomorrow and to ask more specific questions?

Rather, you would want to wait until

staff has looked at rev. 3, either by traveling down there or by getting more information on a chapter 22 revision or by some mechanism and have them come to us so we can ask penetrating questions of staff now or them, GEH, rather than stay tomorrow and do more of this.

MEMBER BLEY: With one more addition, that we also get the new fault trees so we can look at them.

CHAIRMAN CORRADINI: Okay.

MEMBER BLEY: I think if we go through it tomorrow, it will be really hard to do it up on the board.

MEMBER APOSTOLAKIS: It will be the same as now.

CHAIRMAN CORRADINI: Tom?

DR. KRESS: My area was the severe accidents, rather than PRA.

CHAIRMAN CORRADINI: I know that.

DR. KRESS: And I basically asked all the questions I'm going to ask on this for the time being.

CHAIRMAN CORRADINI: Okay. Bill?

MEMBER SHACK: Well, I am here to learn

and listen about the level 1 PRA. So, you know, if John still has questions, you know, I think it might be worthwhile staying around. I think I learned a lot today. I'm not sure I've changed any of my conclusions, but I learned a lot.

CHAIRMAN CORRADINI: Said?

MEMBER ABDEL-KHALIK: I agree with what Dennis said. This is not really very productive.

CHAIRMAN CORRADINI: I am skipping you. Charlie?

MEMBER BROWN: I only had one observation out of this. They made statements about where they got their failure and other results data. It was in your June status meeting for both component failures and human probability stuff. And since I wasn't here, I haven't opened my mouth.

They didn't say why that data was valid for unique components that are in this plant that may not be in others. I guess we've got explosive valves or something like that in this plant that we -- do we have those in others? I don't know.

MEMBER BLEY: Yes.

MEMBER BROWN: So I had some -- I'm always suspicious of component failure data because my experience is you can report it and it's not very accurate. I did it for 22 years in the nuclear program and found that about a fourth to less than a fourth of the data was valid. And you got so many spurious reporting.

I mean, you take five things. It turned out it was the fifth one. Well, but you never go back and put those original of the first four in to see if it still works. But we had to report it all. They got all five failure reports. And it just skewed the data.

However, after 10 or 15 years, the skew is pretty consistent. So you could kind of evaluate a float as to where it is kind of okay.

My four-star admiral didn't really like that explanation too much but managed to sell him all three of them on it over that period. That was my only point.

MR. WACHOWIAK: And I think we agree with what you are saying, that the data is what it is. We were using the data that was provided by the utility requirements document.

MEMBER BROWN: That's fine.

MR. WACHOWIAK: And it compares across

the different plants. However, one of the ways that we use our PRA in the design is that we're trying to make it so that any individual component failure rate isn't the key to why the core damage frequency is the way it is. We want it to be less sensitive than existing plants. And in many cases, we have accomplished that, not in all cases.

There are still some components where there are a few things that lead you -- luckily, they're -- not luckily. By design, they're things that tend to be needed late after 24 hours.

MEMBER BROWN: I've gotten something out of this, but I agree with Said and Dennis. I just don't think grinding through these right now is overwhelmingly productive. That's my personal opinion.

CHAIRMAN CORRADINI: So I am going to look to John and George to end this off because I have some concluding things I want to get clear from the staff. George and John?

MEMBER APOSTOLAKIS: Well, first of all, I have a comment on common cause failure model, which is not a matter of documentation. Okay? So I can ask it. In ten minutes, we will have it resolved.

The way I see tomorrow is the following. If John says that he has other issues that will not lead us again to a question of documentation, then I see us coming in the morning and adjourning at noon.

If, on the other hand, John says, "Well, you know, more or less most of them will end up like this," GEH will say, "We have this new figure. He hasn't seen it" and all of that, then I don't think we should come at all.

And we should wait, as Dennis said, for the audit and the new documentation to be given to us. So it's up to you.

MEMBER STETKAR: Well, I think, George, that, unfortunately, the way we started -- and I'm open. You know, the way we started this afternoon and as we got into some of the detail that's making your eyes glaze over, unfortunately, some of that is indeed related to documentation. And, you know, we have said enough about that.

The thing that I just mentioned regarding the non-modeling of any maintenance contribution is not related to documentation. That's simply not in there. It's an active decision.

There are other parts of the model

dealing with physical and functional dependencies that I have a lot of detailed comments on that, as best as I can tell, are also not related to documentation. They are relatively detailed. They are relatively subtle. Is it worth spending people's time? I think that's the judgment of the Committee.

Part of my concern, quite honestly, is that we have been talking about now relying on the staff's audit of the rev. 3 PRA, whatever that audit means, as a way of resolving all of these concerns if they're going to do an audit and the result of that audit will be a determination that, indeed, the PRA is either acceptable or it needs yet more changes.

MEMBER APOSTOLAKIS: We will see also.

MEMBER STETKAR: I know, but the question is, are we only postponing the same discussion? Because part of my agenda for this discussion is to try to make the accumulated wisdom here sensitive to some of these issues.

Now, if the staff determines that, indeed, it is okay that maintenance is not modeled in the PRA at this stage, that should be an active determination. There should be something saying, "We recognize that maintenance is not modeled. And that's okay."

To this point, there has been no statement of anything regarding that. It's okay that these kind of dependencies are not modeled. We are aware of it, and it is okay that they are not modeled at this stage.

MEMBER BLEY: Would they not be -- it's kind of a question.

MEMBER STETKAR: To whom?

MEMBER BLEY: It is going through John, but it's really aimed at the staff.

Would those not be things -- I'll say it the other way. I would expect those things if, in fact, they are okay to be things that have DAC items associated with them. And I think it is important to get the issues on the table.

MEMBER STETKAR: But there aren't DACs and ITAACs on the PRA.

MEMBER BLEY: Is that true? There won't be?

MR. OESTERLE: True.

MEMBER STETKAR: It's true. The PRA is done.

MR. OESTERLE: There are DAC items

associated with certain elements I think that Rick talked about that factor into the PRA but associated with the actual physical design.

MEMBER STETKAR: But there will be no DAC items saying when the COL comes forward --

CHAIRMAN CORRADINI: Before we spin out of control, so your summary is? I'm going to now hold a tight leash. Your summary is that you do have some things that are probably not documentation but are specific that you would like to go over tomorrow to sensitize the rest of the -- at least I'll call myself an educated member into the joys of all of this.

I think you've convinced me I'm never going to be a level 1 analyst, never in my life.

MEMBER STETKAR: That's not a bad thing, by the way.

CHAIRMAN CORRADINI: To the subtleties of all of this, right, that aren't necessarily documentation? That's point one. Point two is -- and this one I guess I would like to ask the staff to think about to have an answer tomorrow because your silence leads me to believe that you were in agreement with what Rick has said, which is it's kind of good enough. That is, you're not dealing with maintenance. That's okay. There may be some small mistakes. That's okay. They are one level of no significance, whatever the right word is. It's not notable. Thank you. Thank you. Thank you.

I guess what I'm asking is if we do these detailed things, I guess I am going to turn to the staff sometime tomorrow morning and ask. I would like some sort of discussion as to since in 19.1.1 and 19.1.2 of the DCD, it gives the laundry list of things the PRA is to be used for to trundle down that list and say, at this point in kind of a progress status, are you happy with all these things?

Does the PRA as you see it at this moment satisfy these things? And if it does extemporaneously or if it doesn't, what sorts of things do you need to feel good about so that we know where you are going to be?

Because when you said "audit" and you said, "audit," I think the generalized review, it could be a review that they're going to come in. It could be a visit. It could be they just ask more questions and get answers.

I would like to ask the staff to be ready tomorrow for that so that we can get a feeling of what is good enough, which goes back to George's first question.

MEMBER APOSTOLAKIS: Okay. So now the last question to John, how much time do you need?

MEMBER STETKAR: We can cut that off whenever we want to. If you want to finish by noon, we can finish by noon.

CHAIRMAN CORRADINI: We will be finished by noon.

MEMBER STETKAR: Finished by noon.

MEMBER APOSTOLAKIS: That is good enough.

MR. WACHOWIAK: I would like to jump in on this as well. I think that -- I haven't discussed this with my staff yet, but I think it would be a good idea to go through those details tomorrow because what I don't want to have happen is in December somebody decide that we need to do a rev. 5 of the PRA.

MEMBER APOSTOLAKIS: That's a good point.

MR. WACHOWIAK: I would like to make sure that if there's anything that needs to be addressed, that we get it --

CHAIRMAN CORRADINI: That's fine. So

let's just push that point to make sure I -- so Dennis had a certain way of doing it, and John has. But they have additional specific questions.

The only thing that I have as an uneducated listener here, we did have in front of us -- now I have lost it -- four sequences from you and from Dennis and from John and George. Would it benefit us any more by taking one of these and walking through it in a forward fashion tomorrow and draw out further questions and details? For example, the feedwater, the FDW-0050 or --

MEMBER APOSTOLAKIS: I think you're getting into too much detail.

CHAIRMAN CORRADINI: I know, but --

MEMBER APOSTOLAKIS: The important thing in my mind is for the applicant and the staff to know by the end of the meeting what the concerns of the members are. Now, whether John wants to go through a sequence or to start saying, like he did today --

CHAIRMAN CORRADINI: What about this? What about that?

MEMBER APOSTOLAKIS: -- and this and that, leave it up to him. But that is the most important thing because I agree with Rick. We have to start reaching closure. So he has to know, he and his team have to know, what issues the members raise. So next time they come back, they will have answers. They will have done something. Right?

And I think the staff is in the same position. We cannot finish this meeting and have some members have some issues in their minds that were not aired. That should be the goal.

So it seems we all agree we need the morning. Okay. Let's come in the morning.

MR. WACHOWIAK: Give us everything you've got.

MEMBER APOSTOLAKIS: No, no, no. We never give you everything we've got.

MR. WACHOWIAK: I know. Then we can never answer everything.

CHAIRMAN CORRADINI: I'm going to put you guys a bit on the spot tomorrow, but I guess if you could give that some thought because I guess we need to get feedback from you as to how you see the wrap-up relative to chapters 19 and 21 so we know is an interim letter in October reasonable given what you're planning to do, is it unreasonable? And if not, what needs to be done to get it wrapped up because I know I agreed with Amy ahead of time that we would talk about this and plan it.

MEMBER APOSTOLAKIS: GEH has also responded to an RAI regarding passive systems in a certain way. We haven't discussed it at all.

CHAIRMAN CORRADINI: We haven't seen it.

MEMBER STETKAR: Have we got it?

CHAIRMAN CORRADINI: We got it.

MEMBER APOSTOLAKIS: A 207 response. And Harold said it was ten days ago. And I assume that means this is the current position.

MEMBER BLEY: That's why I was --

MEMBER SHACK: We had that basically at the end of the last meeting it was around.

MEMBER APOSTOLAKIS: We have had it for more than a year. And then Harold sent it again. This is the current position. Correct, Harold?

MR. VANDER MOLLEN: Yes.

MEMBER APOSTOLAKIS: Okay. So can we spend half an hour tomorrow on this?

MEMBER ABDEL-KHALIK: Good idea. Yes. We should, yes.

CHAIRMAN CORRADINI: You guys are all right for tomorrow?

MR. CARUSO: We'll address it tomorrow.

CHAIRMAN CORRADINI: Okay. Good.

MR. WACHOWIAK: We tried to figure out how we were going to fit it into one of your sequences, but we are prepared to talk about the TRACG runs and things.

MEMBER STETKAR: Part of the reason for identifying the sequences was actually a context. I thought that there were some very specific --

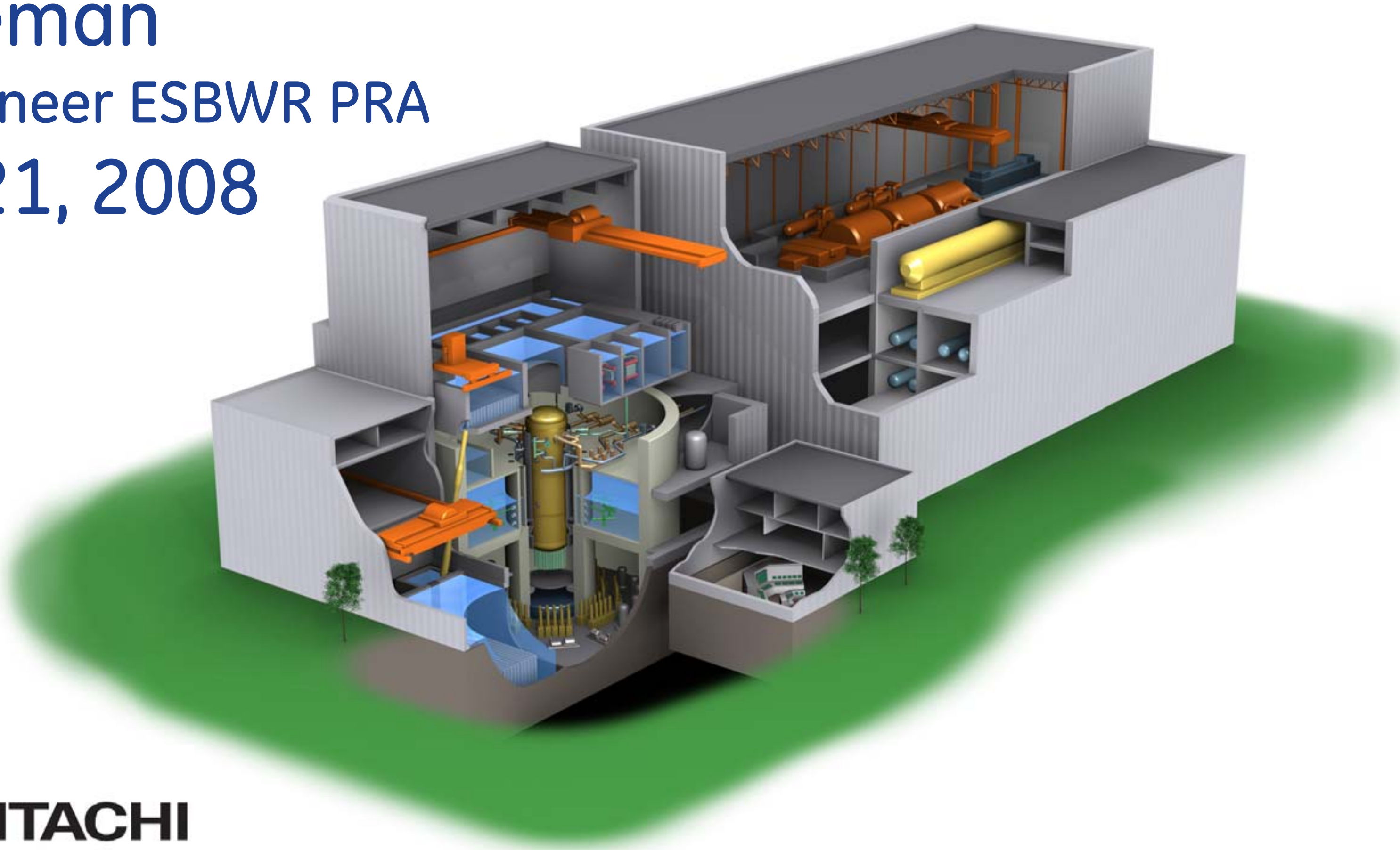
CHAIRMAN CORRADINI: So are we all set? All right. So we're adjourned. We're back tomorrow.

(Whereupon, the foregoing matter was recessed at 4:53 p.m., to be reconvened on Friday, August 22, 2008, at 8:30 a.m.)

ESBWR Severe Accident Management

Rick Wachowiak
Technical Lead ESBWR PRA
Glen Seeman
Senior Engineer ESBWR PRA

August 21, 2008



HITACHI

Scope of Severe Accident Analyses

Discussion of severe accident prevention

- Examples: ATWS, SBO, Fire Protection & ISLOCA
- Covered in previous meetings

Discussion of severe accident mitigation

- Examples: Hydrogen control, debris coolability, high-pressure melt eject, containment performance, containment vent, equipment survivability

Severe accident mitigation design alternatives

Contained in DCD Ch 19, NEDO-33201 Ch 21, and NEDO-33306

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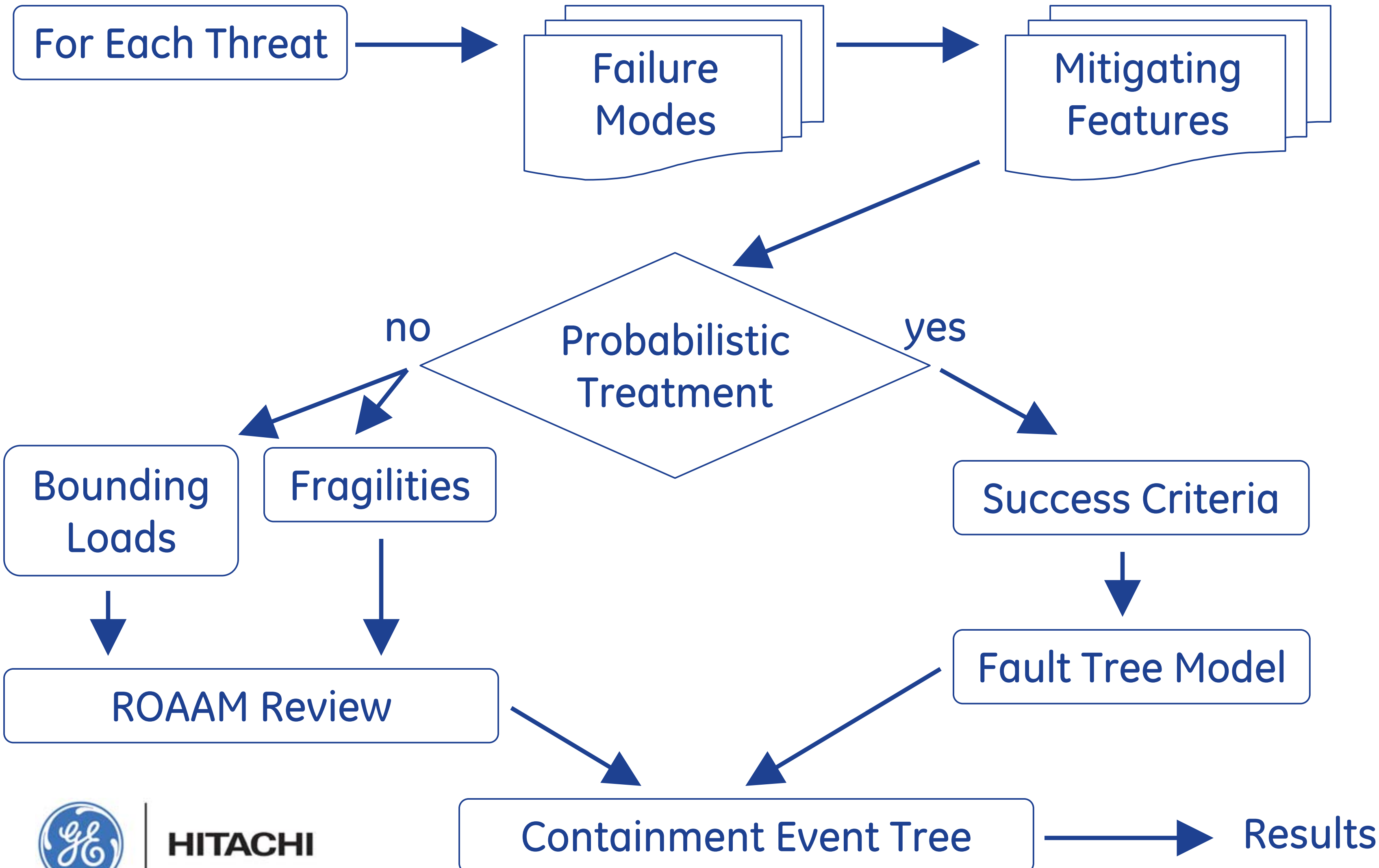
Severe Accident Evaluation Process Overview



Hydrogen Generation and Control

Detonation

- Inert containment atmosphere precludes H2 burn
- No credit for containment while deinerted

Overpressure

- Containment ultimate strength fragility
- Reacting all Zr surrounding fuel does not fail containment

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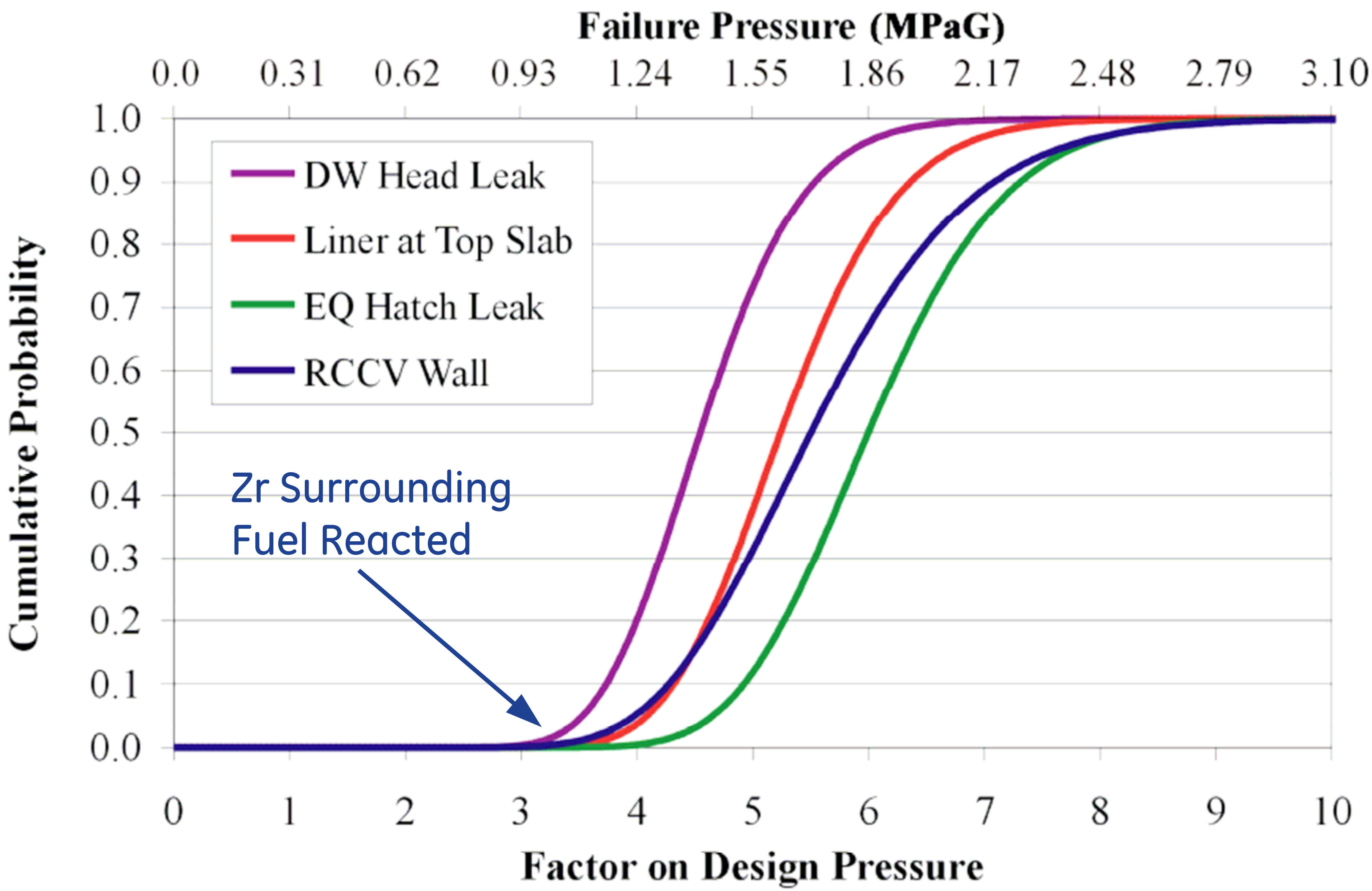

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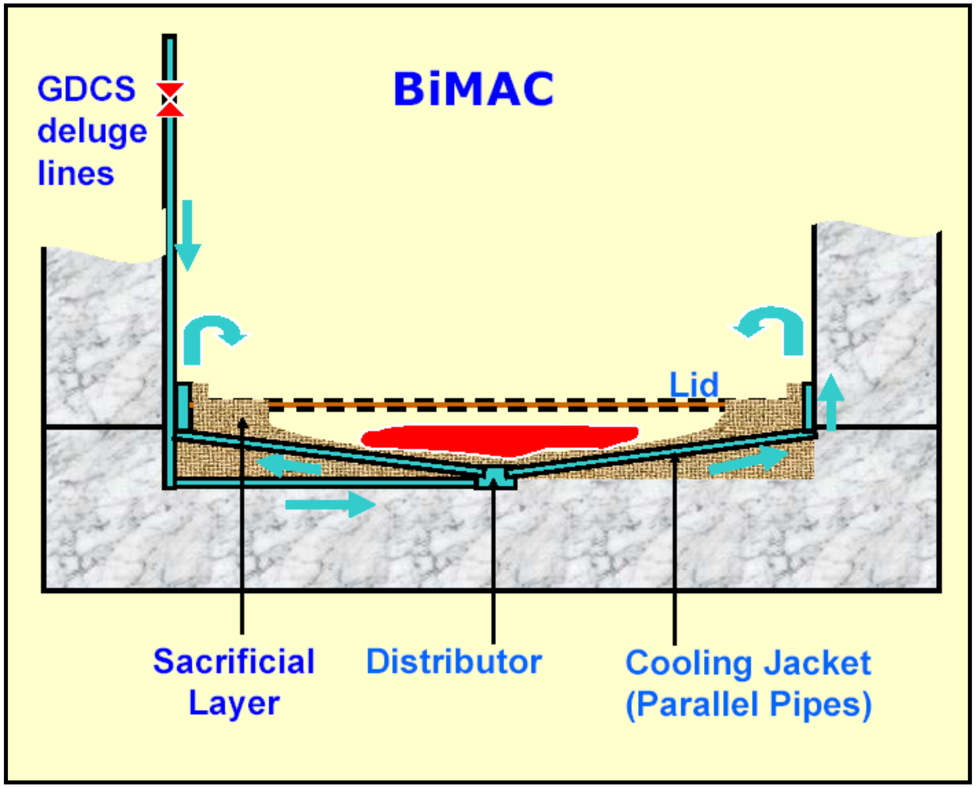
Containment Fragility (500 ºF)

Core Debris Coolability – Ex-Vessel

Basemat Melt Penetration

- Flood lower drywell
  - Fault tree model for actuation
- Large spread area
  - No guarantee that debris is coolable from above
  - Because of this significant uncertainty, ESBWR PRA does not credit this cooling mechanism which was found acceptable in previous certified designs
- BiMAC
  - Local burnout — Confirmatory testing
  - Water depletion — PCCS fault tree model
  - Local melt through — Sacrificial layer

The Basemat internal Melt Arrest and Coolability (BiMAC) device



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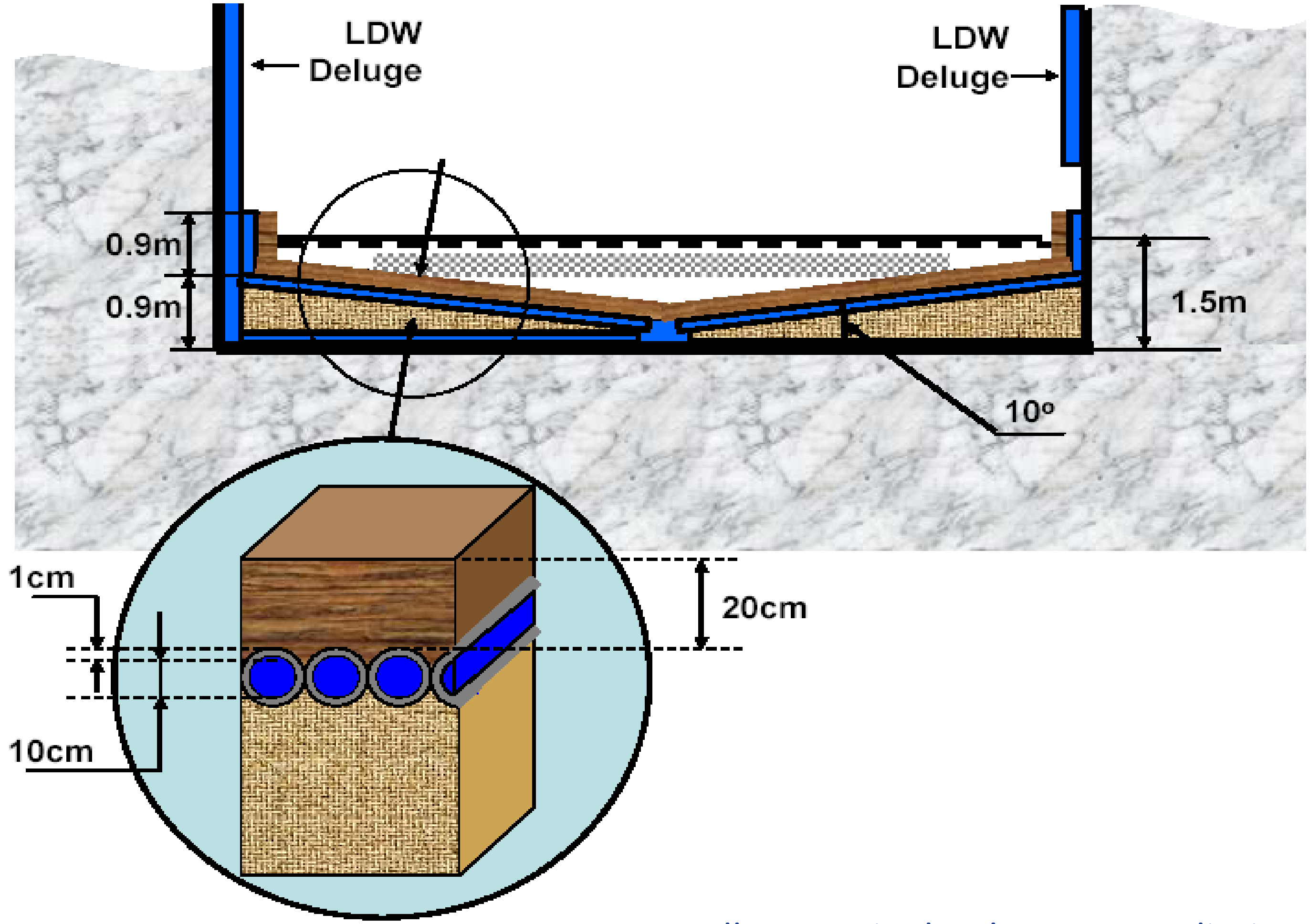
BiMAC Configuration



All Numerical Values are Preliminary

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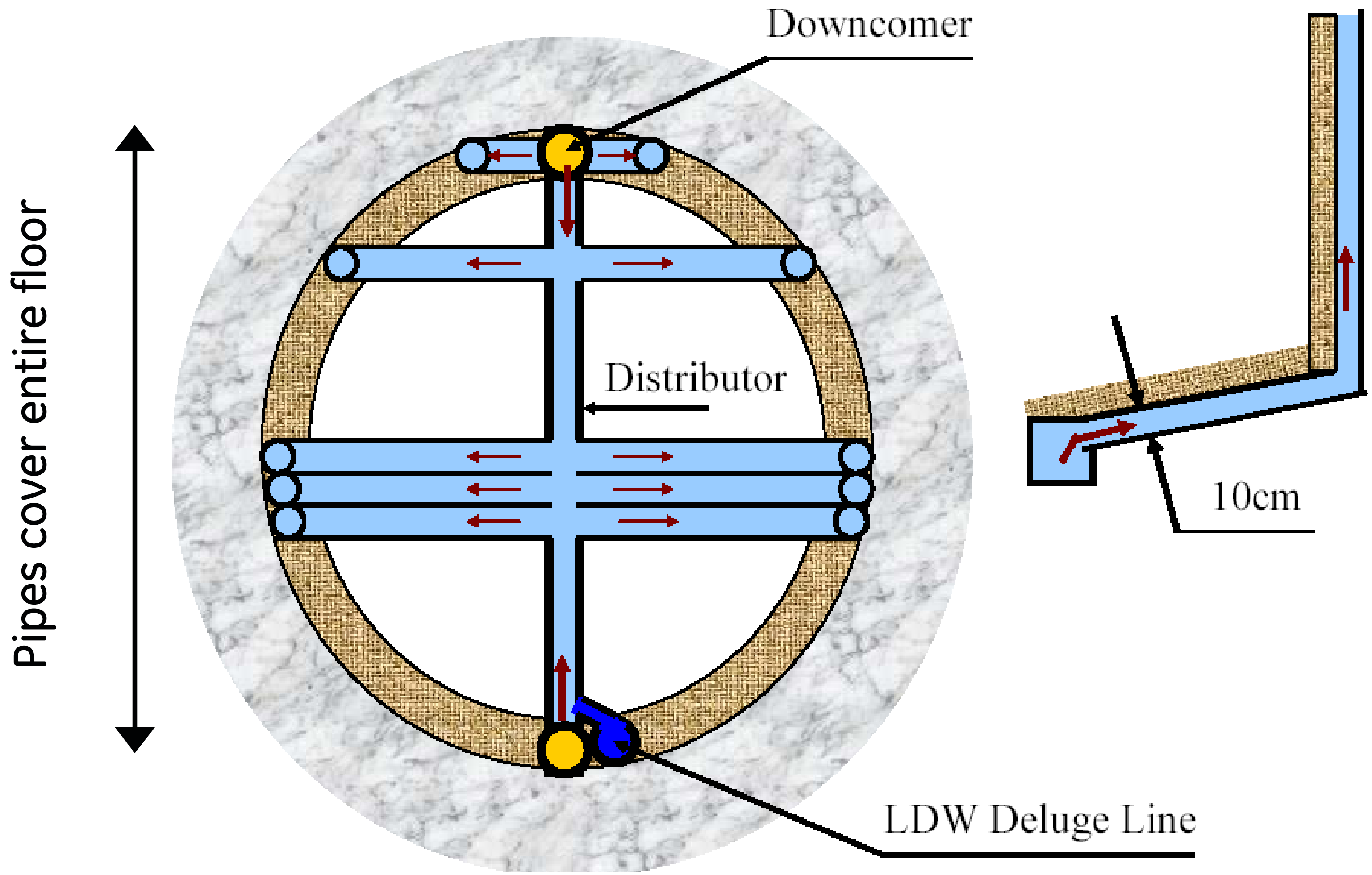
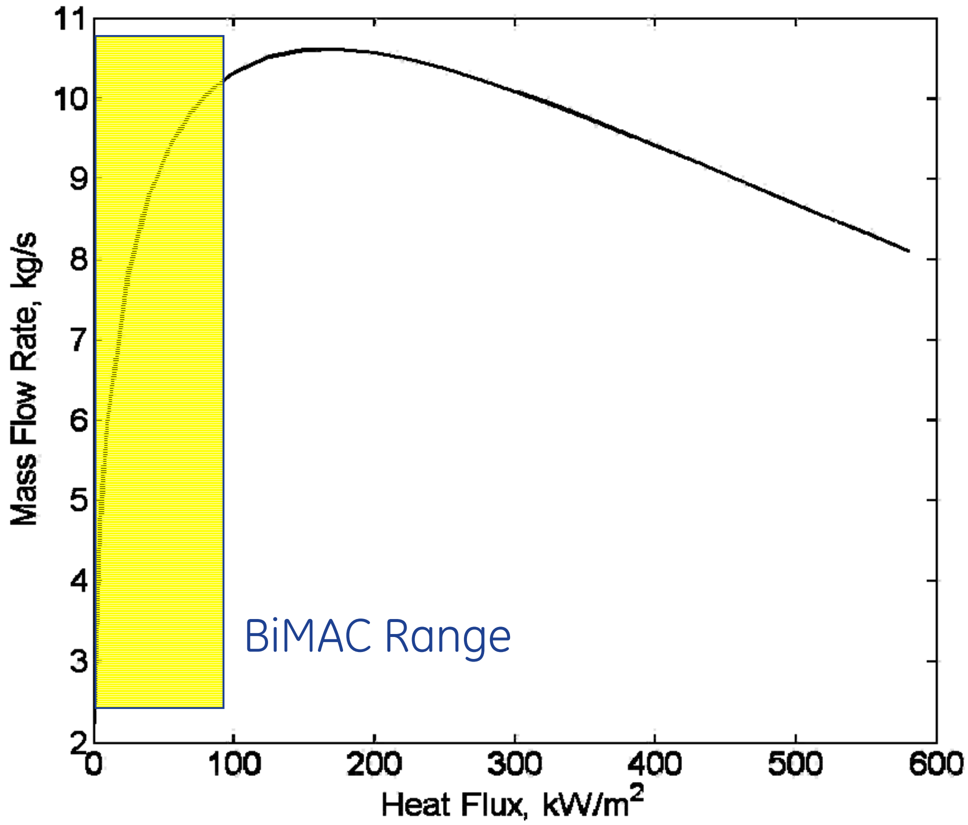
BiMAC Flow Path



Natural Convection in BiMAC



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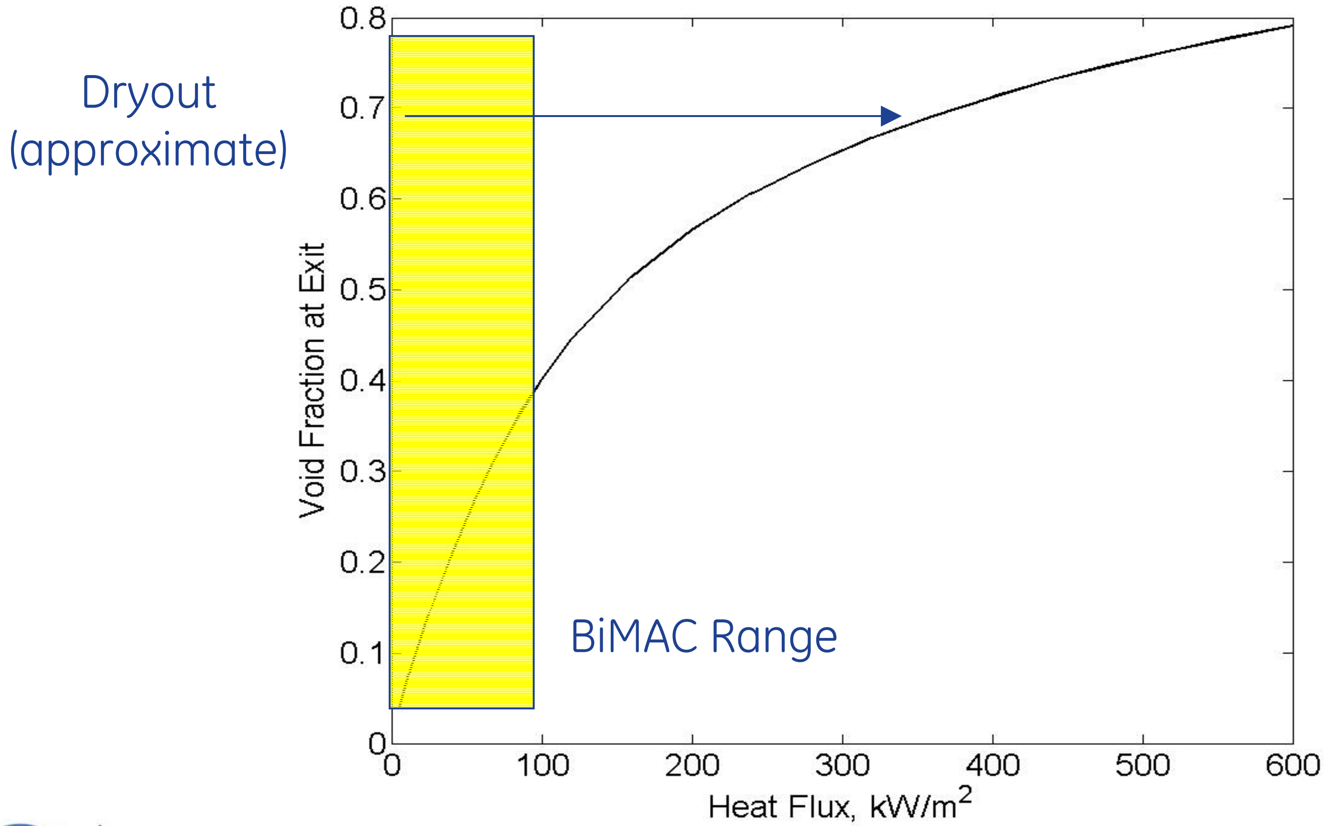
Wetting of BiMAC Horizontal Channels



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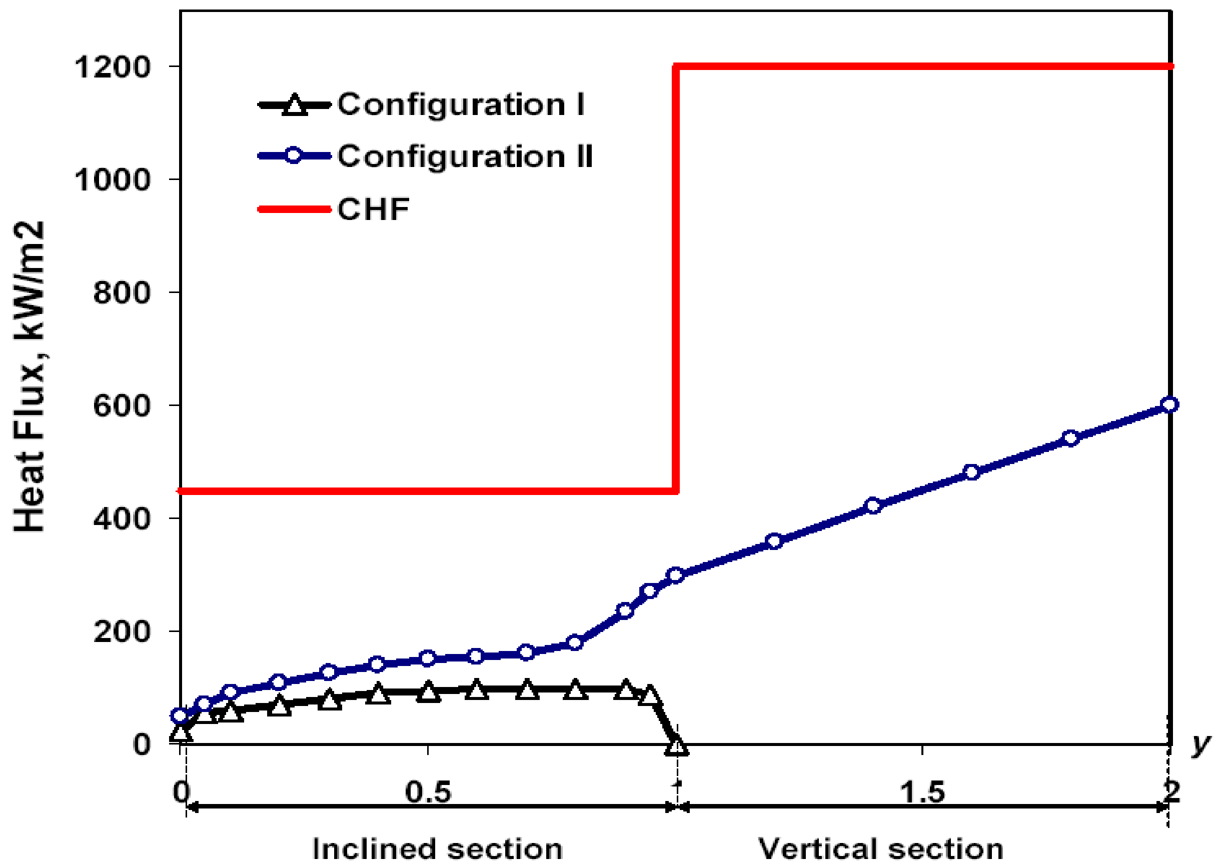
Thermal Loads against Coolability Limits in BiMAC Channels



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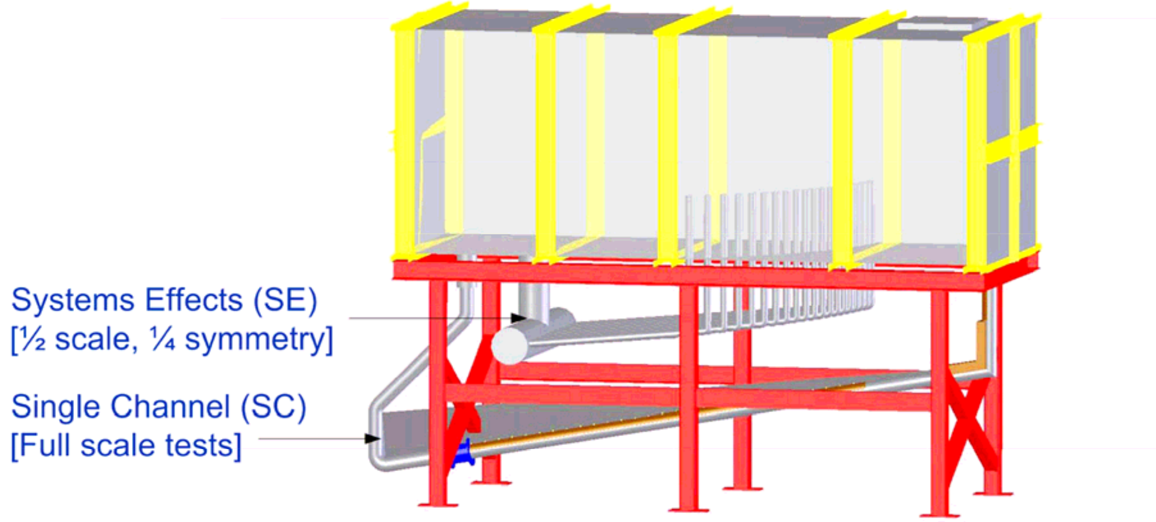
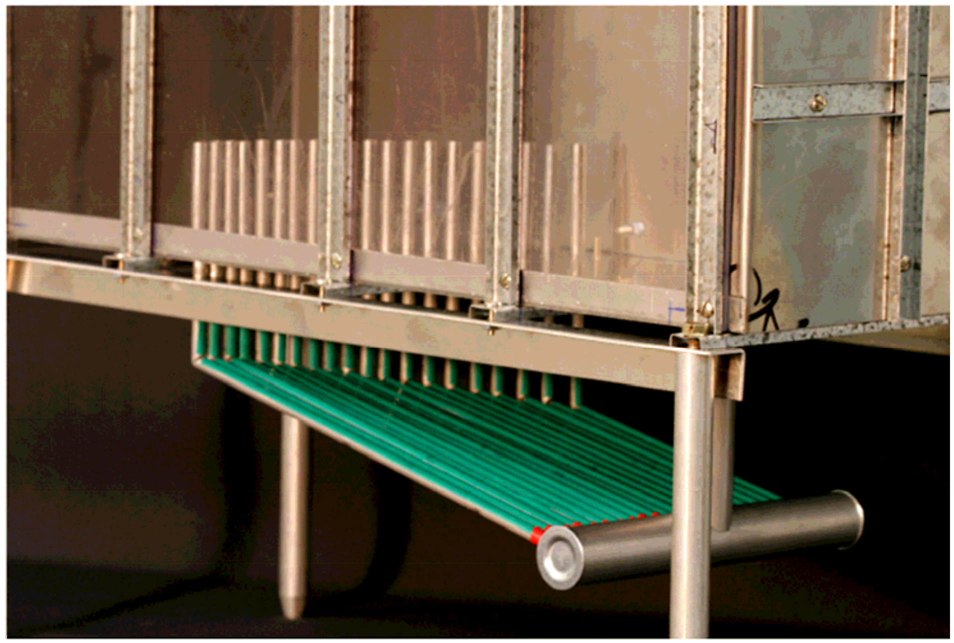
BiMAC Thermal-Hydraulic Testing

Results provided in NEDE-33392P

- Demonstrates that the analytical results presented on the previous slides are bounding
- Even a few degrees of subcooling greatly enhances the performance of the BiMAC
- Staff is reviewing this document to close a significant open item

Test Overview





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High Pressure Melt Eject

Direct containment heating

- Assume bounding physical parameters for HPME
- Pressure suppression containment absorbs dynamic load

Local liner failures

- Liner anchorage prevents release path

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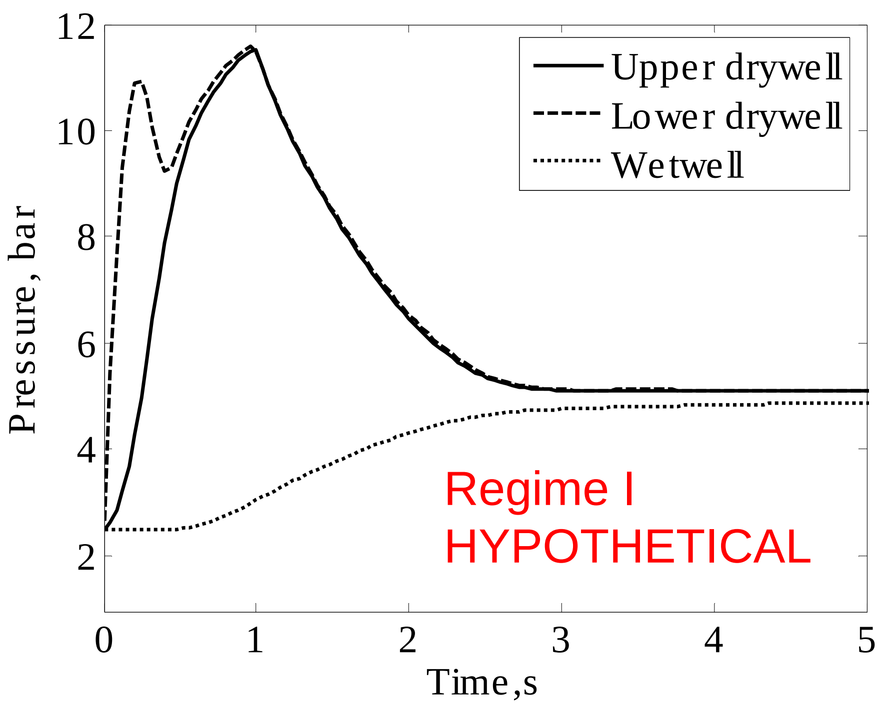
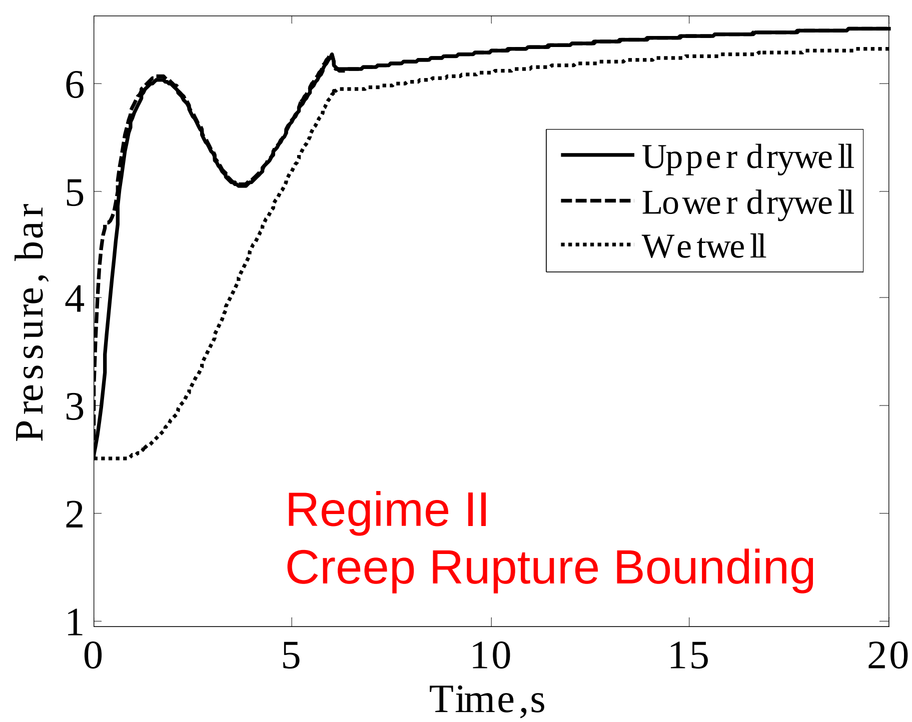
Quantification of DCH Loads

Identified three dynamic regimes

Used complete space (up to all fuel, Zr, and SS) to bound independently each failure mode





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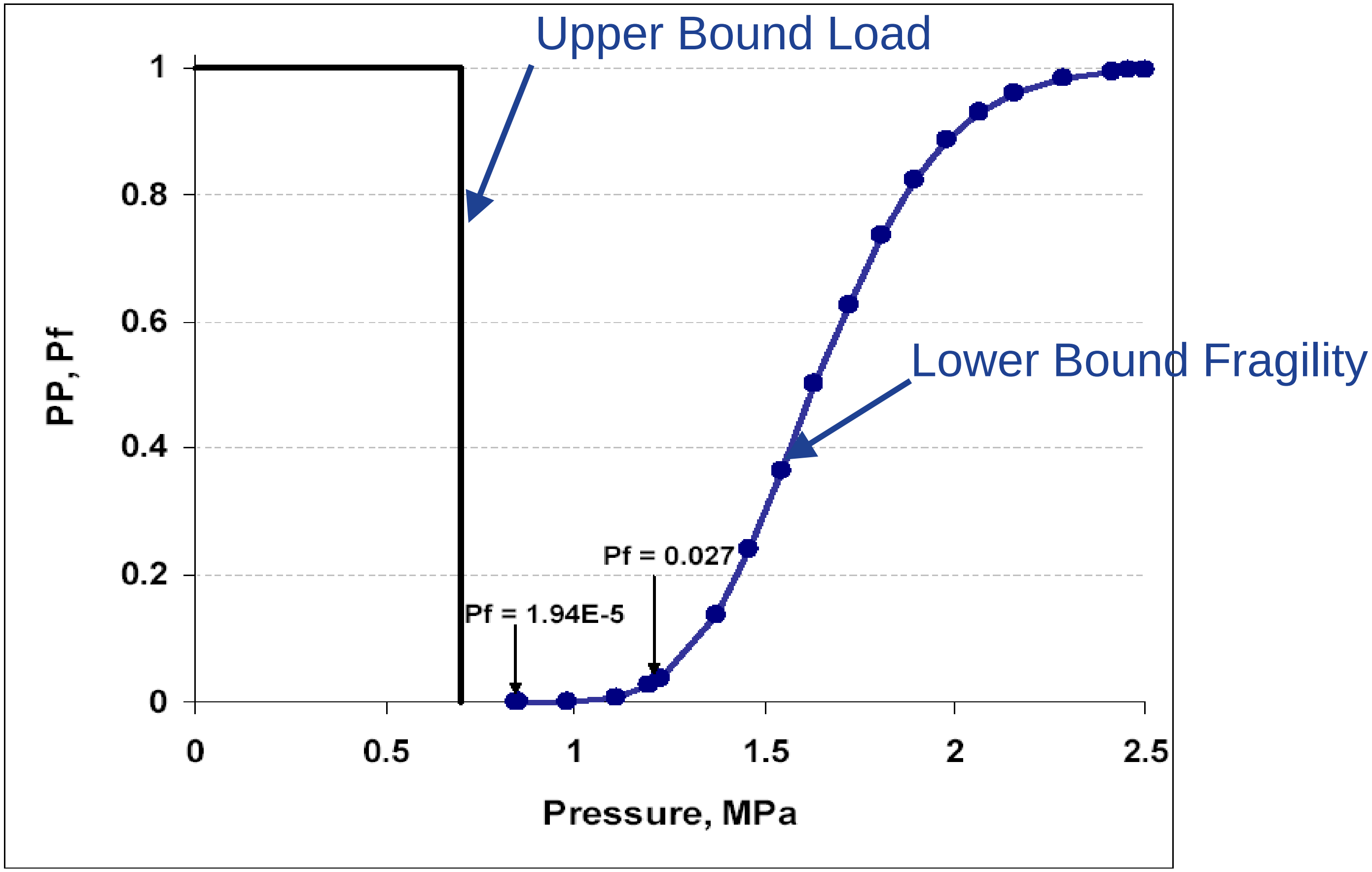
Regime III Expected (not shown)

Minimum (Bounding) Margins to Energetic DCH Failure



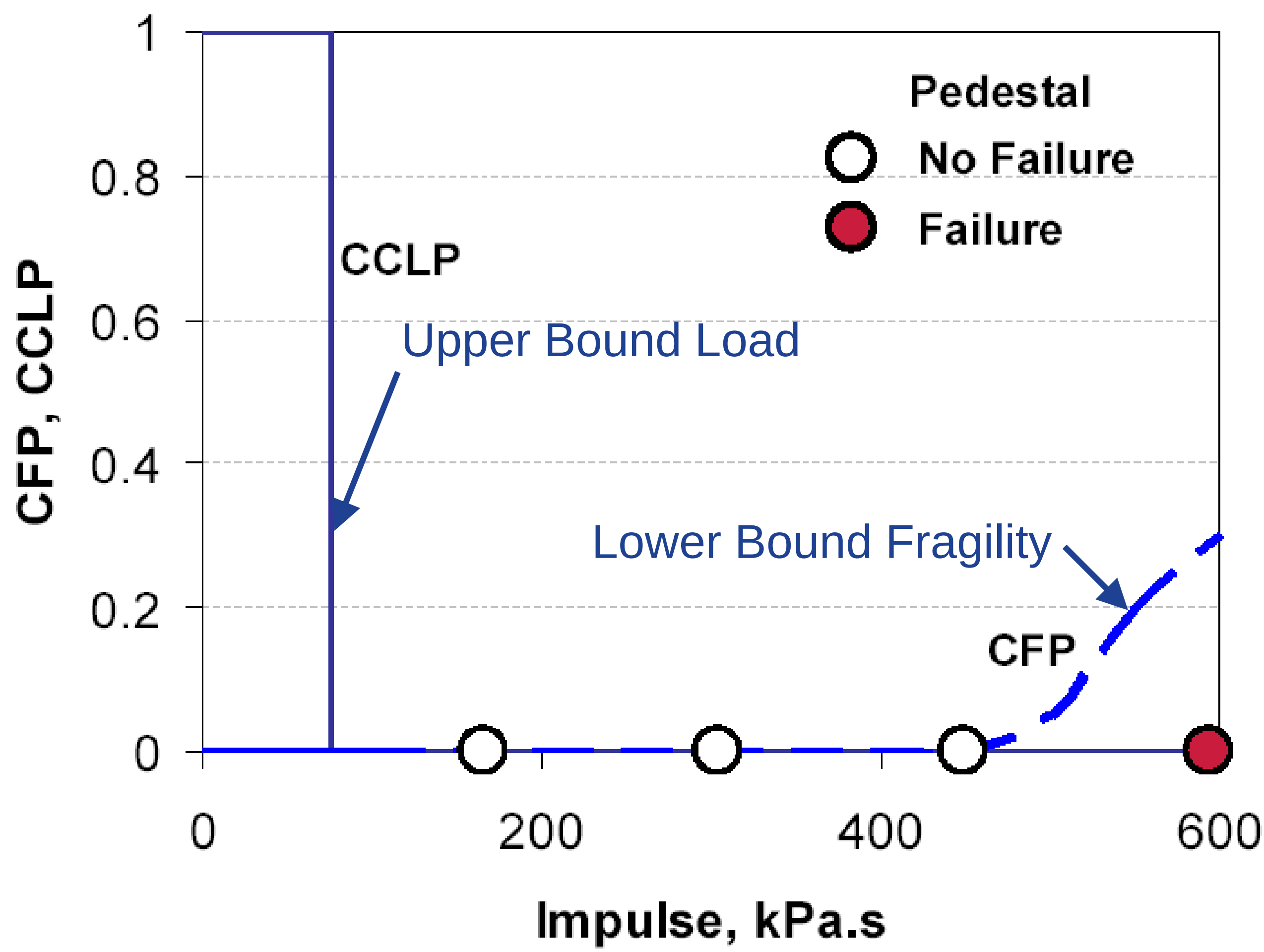
Fuel Coolant Interaction

Ex-vessel steam explosion

- Damage pedestal wall
  - Very deep, subcooled pool in LDW
- Damage BiMAC pipes
  - Deep, subcooled pool in LDW
- Minimize water in LDW prior to vessel breach
  - BiMAC does not require pre-flooded LDW

Pedestal Failure Margins to EVE

1 to 2 m Subcooled Pools



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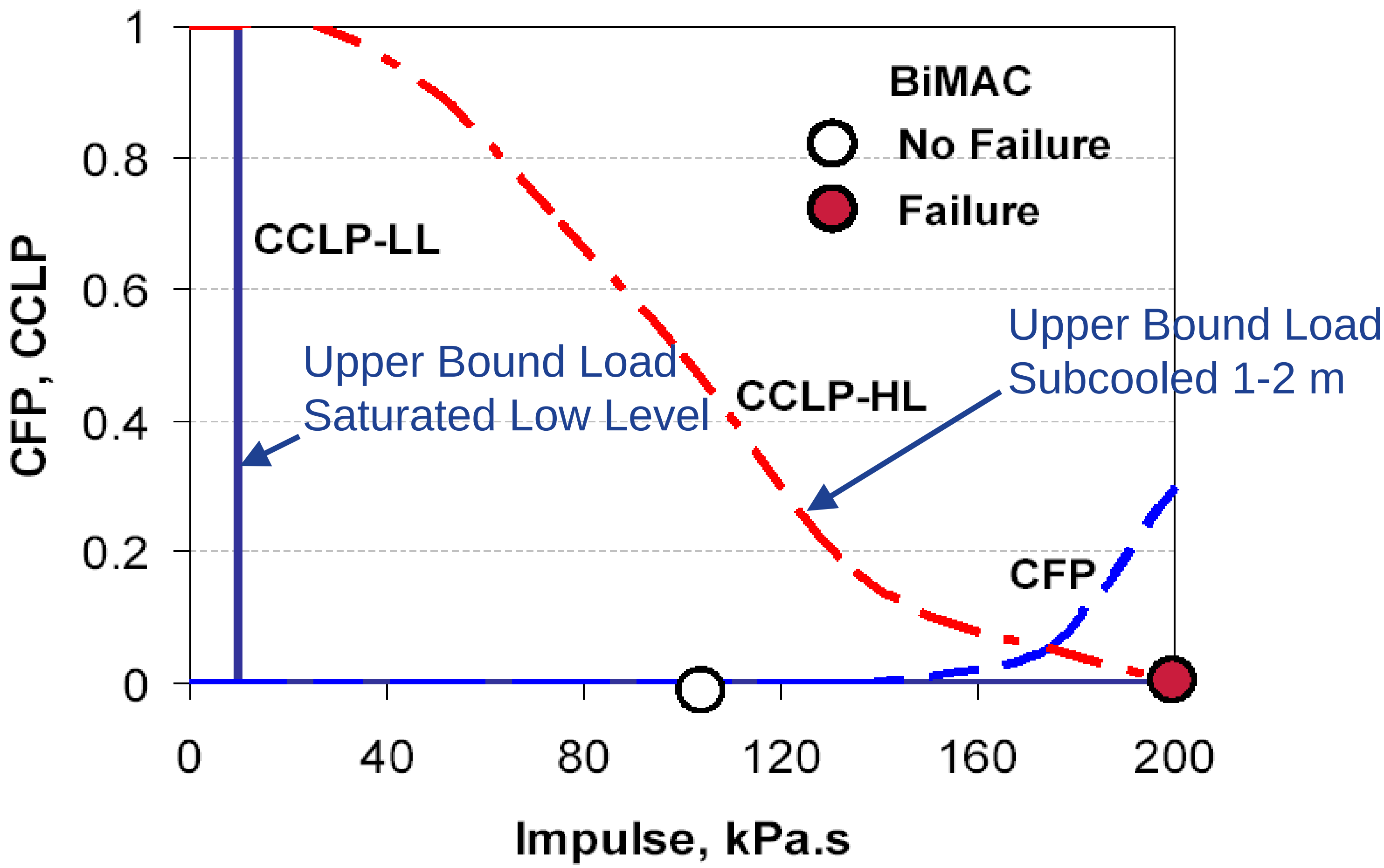
BiMAC Failure Margins Due to EVE
1-2 m subcooled pools



Containment Overpressurization – Long Term

Containment systems mitigate this threat

- Passive Containment Cooling System
- Vacuum breakers
- Active RHR systems
- Venting – treated as large release in Level II

Treated probabilistically using fault tree models

Conclusions

Most open items have been resolved

BiMAC test report still under review

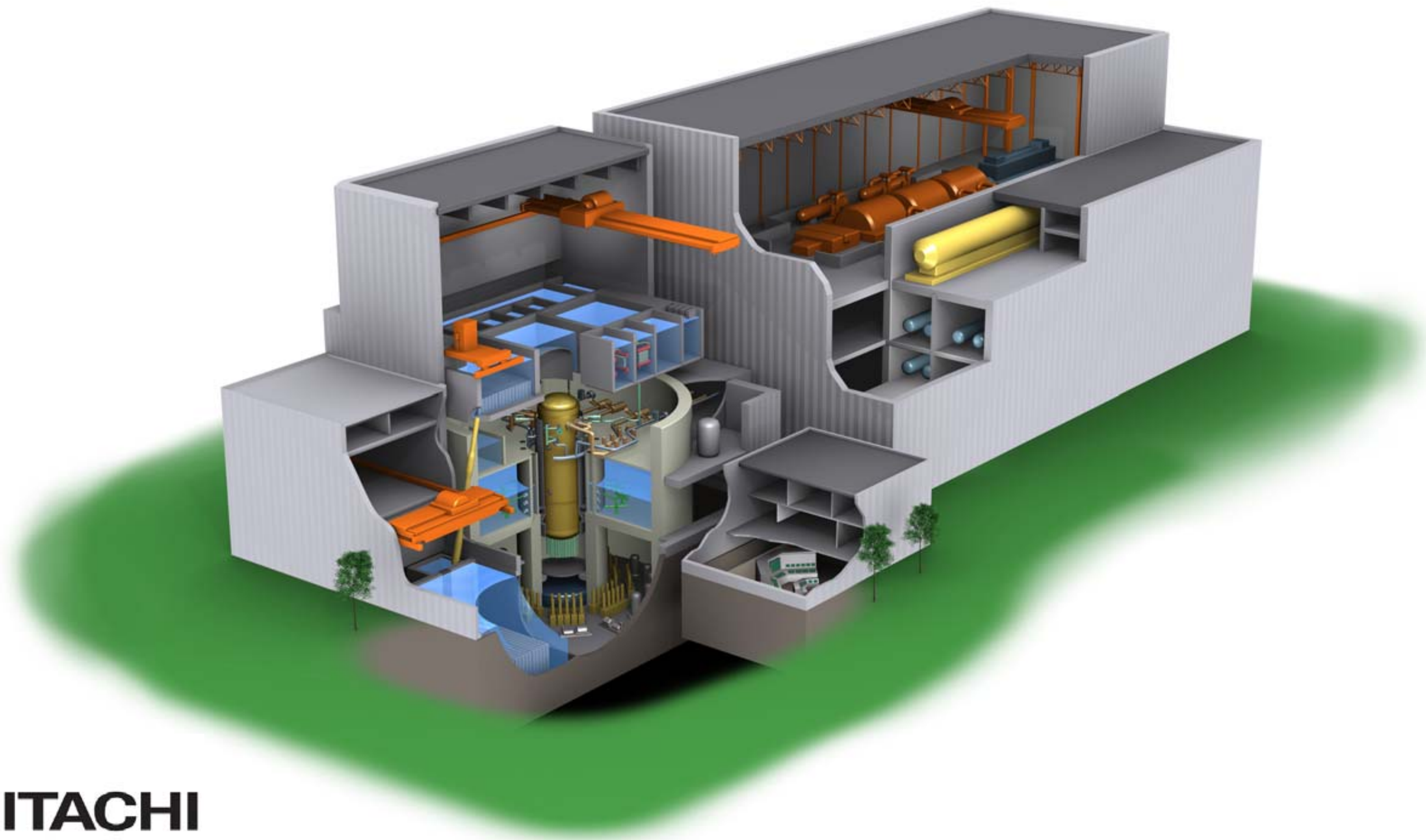
~ 30 questions received last week

With closure, ESBWR severe accident evaluations expected to be determined acceptable for design certification

ESBWR PRA Focused Review

GEH PRA Team

August 21 - 22, 2008



GEH PRA Team Representatives

Rick Wachowiak

Gary Miller

Glen Seeman

Jonathan Li

Justin Howe

Lou Lanese

Meeting Purpose

Gain an understanding of the technical quality of the ESBWR PRA

Review the degree of completeness of the ESBWR PRA

Investigate details of the ESBWR PRA

Accomplished through a detailed review of four selected sequences

HITACHI

Quality and Scope

Required elements in a PRA depend on the application

RG 1.200

- "… the staff's recognition that the PRA needed to support regulatory decisions can vary (i.e., that the "scope, level of detail, and quality of the PRA is to be commensurate with the application for which it is intended and the role the PRA results play in the integrated decision process")."

Interim Staff Guidance

- "PRAs that meet the applicable supporting requirements for Capability Category I and meet the high level requirements as defined in the ASME PRA Standard (ASME-RA-Sb-2005) should generally be acceptable for DC and COL applications."

Design Certification PRA Objectives

Identify vulnerabilities

Reduce/eliminate risk contributors in existing plants

Select among design and operational features

Confirm design robustness

Identify risk significance of operator actions associated with design

Demonstrate that the plant meets the Commission's safety goals

Show a balance of prevention and mitigation

Show a reduction in risk in comparison to existing plants

Address known design issues with respect to core and containment heat removal systems

HITACHI

Design Certification Not the Last ESBWR PRA

10 CFR 50.71(h)(1) states that no later than the scheduled date for initial loading of fuel, each holder of a COL shall develop a level 1 and a level 2 PRA. The PRA must cover those initiating events and modes for which NRC-endorsed consensus standards on PRA exist one year prior to the scheduled date for initial loading of fuel.

It is not required to submit this PRA to the NRC, but instead should be maintained by the licensee for NRC inspection.

The need for any such submittal or review would be determined by any risk-informed application for which the licensee might wish to use this PRA, such as in support of licensing actions.

Ongoing PRA Upgrade Requirements

10 CFR 50.71(h)(2) states that each COL holder must maintain and upgrade the PRA required by 10 CFR 50.71(h)(1). The upgraded PRA must cover initiating events and modes of operation contained in NRC-endorsed consensus standards on PRA in effect 1 year prior to each required upgrade. The PRA must be upgraded every 4 years until the permanent cessation of operations under 10 CFR 52.110(a).

PRA maintenance and PRA upgrade will be consistent with how they are defined in the American Society of Mechanical Engineers (ASME) “Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications”

HITACHI

ESBWR Design Certification PRA

Meets the scope and quality for certification

Meets the scope and quality for COL given no significant departures from the certified design

Provides a starting point for operating plant PRA

HITACHI

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 19.3 of DCD, Tier 2

Presented by NRO/SPLB

August 21, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 19

Purpose:

- Brief the Subcommittee on the results of the staff's review of the ESBWR DCD application, Chapter 19.3, Severe Accident Evaluations

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Outline of Presentation:

- Applicable Regulations
- SER Technical Topics
- Significant Open Items

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Regulatory Requirements:

- 10 CFR 52.47(a)(8) – comply with TMI requirements
- 10 CFR 52.47(a)(21) - resolve USI/GSI
- 10 CFR 52.47(a)(23) – provide description and analysis of design features for prevention and mitigation of severe accidents
- 10 CFR 52.47(b)(2) – provide an environmental report, as required by 10 CFR 51.55, that addresses the costs and benefits of severe accident mitigation design alternatives, and the basis for not incorporating these in the design to be certified.

Regulatory Guidance:

- Policy Statements on Severe Accidents and Use of PRA
- SECY-93-087, SECY-96-128, and SECY-97-044 - guidance for implementing features in new designs to prevent or mitigate severe accidents
- Regulatory Guide 1.206 and SRP Chapters 19.0 and 19.1

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19.2 of SER: Severe Accident Evaluations

Technical Topics:

- **19.2.2 Severe Accident Prevention**
- **19.2.3 Severe Accident Mitigation**
- **19.2.4 Containment Performance Capability**
- **19.2.5 Accident Management**
- **19.2.6 Severe Accident Mitigation Design Alternatives (GEH documentation in NEDO-33306, Rev 1, August 2007)**

19.2.3 Severe Accident Mitigation

Significant Open Items:

- BiMAC performance test report
  - Response to RAIs19.2-23 S02 and 19.2-25 S02 included a topical report documenting the results of the BiMAC tests.
  - Topical report NEDE-33392 has been reviewed and 27 RAIs issued.

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BiMAC Performance RAIs

- The review focused on:
  - Adequacy of test facility scale for applicability to ESBWR configuration and design.
    - Generally, the test facility adequately scales expected prototypical conditions
    - RAI on the scaling basis of the multi-channel tests.
  - The range of measured test data as compared with severe accident loading conditions.
    - RAIs on relevant tests for near-edge tubes, range of heat fluxes chosen for tests, and other issues.
  - Adequacy of the theoretical predictions as compared to the data.
    - the single tube independent (NRC) theoretical predictions seem to support the experimental measurements.
  - Implications of the BiMAC design on ESBWR operational safety.
    - RAIs on thermal load boundary conditions, the use of CFD simulations to obtain boundary conditions, the structural integrity of Zirconia, effects of crusts on heat loads, and other issues.

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19.2.3 Severe Accident Mitigation (cont.)

Significant Open Items:

- Vacuum breaker performance
  - Further information was requested on vacuum breaker design (including isolation valves), coverage in DCD and ITAAC, and on emergency procedures related to failed vacuum breakers.
  - Responses to RAIs 19.2-6, 19.2-10, and 19.2-11 have recently been received and are acceptable.

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19.2.4 Containment Performance Capability

Significant Open Items:

- Calculated upper drywell liner strain exceeds Level-C limit under conditions of 100% metal/water reaction
  - Response received from GEH for RAI 19.2-86 and issue is resolved.

- Temperature boundary condition for drywell head in finite element model set incorrectly at 110 °F versus drywell air space temp of 500 °F
  - Response received from GEH for RAI 19.2-41 Supplement 2 and issue is resolved.

19.2.5 Accident Management

Significant Open Items:

- Description of the process for developing Severe Accident Guidelines
  - The staff requested additional information on the process that will be used by GEH to develop the Severe Accident Guidelines (SAGs) in RAI 19.2.4-1 and its supplements.
  - A new supplemental RAI has been prepared, asking for the technical basis for ESBWR severe accident management.

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Discussion / Questions