ACRST-3422

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards ESBWR Subcomittee

Docket Number: (n/a)

Process Using ADAMS Template
ACRS/ACNW-005
SUNSI Review Complete CWA
2-12-08

Location: Rockville, Maryland

Date: Thursday, January 17, 2008

Work Order No.: NRC-1972

Pages 1-316

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

TR04

DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

January 17, 2008

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, taken on January 17, 2008, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

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

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

MEETING

+ + + + +

ESBWR SUBCOMMITTEE

+ + + + +

THURSDAY,

JANUARY 17, 2008

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

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

MEMBERS PRESENT:

MICHAEL CORRADINI	Chairman
SAID ABDEL-KHALIK	Member
WILLIAM J. SHACK	Member
J. SAM ARMIJO	Member
SANJOY BANERJEE	Member
DENNIS C. BLEY	Member
THOMAS S. KRESS	Member

MEMBERS PRESENT: (cont'd)

JOHN D. SIEBER Member

ROBERT E. UHRIG Member

GRAHAM B. WALLIS, Consultant

GARY HAMMER, Designated Federal Official

TABLE OF CONTENTS

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

(8:29 a.m.)

CHAIRMAN CORRADINI: So let us begin. I will read a similar introduction, just in case we have new people in the audience.

So, again, this is the second day of a meeting on the ESBWR Subcommittee. My name is Mike Corradini, Chair of the Subcommittee.

Again, today we have other members in attendance, Said Abdel-Khalik, Sam Armijo, Sanjoy Banerjee, Otto Maynard, Bill Shack, Jack Sieber, and we expect Dennis Bley. Graham Wallis and Tom Kress are also attending as consultants to the Subcommittee. Gary Hammer is the ACRS staff -- is the Designated Federal Official for this meeting.

The purpose of the meeting, again, is to review and discuss the Safety Evaluation Report with open items for several chapters of the ESBWR design certification. We will hear additional presentations from the NRC's Office of New Reactors and GE-Hitachi Nuclear Energy Americas, LLC.

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

The rules for participation -- again, let me review -- have been announced as part of the notice of the meeting, previously published in the Federal Register. Portions of this meeting may be closed for discussion of unclassified safeguards and propriety information. I will just say that if this is the case, I'd like GE or the staff to remind us, so we don't accidentally stray down that path before we have to back up, so we can check that.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting. A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. Therefore, we request that participants in the meeting use the microphones located throughout the meeting room when addressing the Committee. The participants should first identify themselves and speak with sufficient clarity and volume so that they may be heard.

So we will proceed with the meeting, and I guess, Dr. White, you'll start us off?

DR. WHITE: Yes. Good morning.

CHAIRMAN CORRADINI: Good morning.

DR. WHITE: Thank you for having us.

Today we are going to begin a presentation on Chapter 15, the safety analysis. We will be discussing the event classification development, the criteria used, the types of events that we have classified.

We're going to go into AOOs, of course, design-based accidents. We'll talk about radiological consequences of design-based accidents, and my colleagues contributing today -- Wayne Marquino, Craig Goodson, Dr. Pradip Saha, Dr. M.D. Alamgir, and Mr. Erik Kirstein. And I'm going to turn the floor over to Mr. Marquino.

MR. MARQUINO: Now, I think we had a request to go over one of Dr. Saha's slides.

MEMBER ABDEL-KHALIK: Right. Because reading the staff's slide, they indicated that the Chapter 15 review significantly -- was significantly affected by GEH's new proposed reactor power control by varying the feedwater temperature. So I have a couple of questions on the feedwater temperature operating domain map that was presented yesterday -- this particular figure, right.

Now, the line going from point C to point A; at which burnup is that line?

MR. MARQUINO: That was, I believe in end of cycle burnup. So that's the maximum range. At some point in the cycle, the same temperature change might result in a smaller power change.

MEMBER ABDEL-KHALIK: Okay. Do you mean that? So at the beginning -- okay. You may have it backward, I think. So this is end of cycle. So what would be the feedwater temperature required at the beginning of cycle at 85 percent power to get you to the nominal 100 percent power condition?

MR. MARQUINO: Before I answer that, let me say that this map is -- limits the temperature change to a 486 increase, so there may be some points in the cycle where the operator effects a 486 temperature increase, and the power only drops eight percent.

MEMBER ABDEL-KHALIK: But that's what I'm getting at. This is sort of just a simple reactivity balance. You are balancing the power defect against -- in going from 85 percent to 100 percent against the positive reactivity that you get from the decreased void, as you decrease the feedwater temperature. So the that where you start up and where you end up depends on what your moderator void coefficient is and what your Doppler power defect is.

And the question is: how do these things change with burnup in this particular reactor?

DR. SAHA: Wayne?

MR. MARQUINO: Yes.

DR. SAHA: May I interject? May I clarify? This is Pradip Saha from GE-Hitachi Nuclear Energy. Okay. Just for clarification, this is a generalized operating domain that we are proposing for ESBWR. So it really is not tied with any particular exposure level. It is applicable -- this map is basically applicable throughout a cycle.

Now, particular values of, say, DELCPR by ICPR, which is kind of fractional change in the CPR, may vary slightly with the cycle. But operation-wise, the reactor may be operated, depending on the need, on this line any time there is a need for.

MEMBER ABDEL-KHALIK: Okay. The question I'm asking is: if I were to start at point A --

DR. SAHA: Well, yes. For -- assuming that you have reached point A with proper fuel conditioning.

MEMBER ABDEL-KHALIK: Right.

DR. SAHA: Yes.

MEMBER ABDEL-KHALIK: And you're telling me this is at the end of cycle.

DR. SAHA: Not necessarily. That is what

I am trying to clarify. This can happen, say, just -- you have started up the reactor, and then there is a reason to lower power without moving the control rod. It could be the next exchange -- I mean, control rod sequence exchange after three months.

MEMBER ABDEL-KHALIK: My question is really a lot simpler than all of that.

DR. SAHA: Oh, okay.

MEMBER ABDEL-KHALIK: Okay? You have a 66-degree temperature limit on feedwater, and you're saying that that gives you a 15 percent change in power.

DR. SAHA: That is correct, yes.

MEMBER ABDEL-KHALIK: Okay? Now, are you telling me this is at the end of cycle or --

MR. MARQUINO: I don't think they're saying that.

DR. SAHA: I'm not saying -- that's what I want to clarify.

MR. MARQUINO: Let me -- the original calculations that we ran with TRAC to determine what temperature range we were going to use, I think we're at -- with an end of cycle wrap-up file conditions.

DR. SAHA: Maybe we should go back and see, because if I remember most of the calculation was done at MOC, middle of cycle.

MR. MARQUINO: Okay. So you think they were MOC?

DR. SAHA: I think so, in the -- in the NEDO-33338, I think I remember it MOC.

MR. MARQUINO: And we did a range of exposures in the 338 --

DR. SAHA: Yes. And also --

MR. MARQUINO: -- transient analysis.

DR. SAHA: -- from our previous exploration, which is in the DCD, for certain transient we know that MOC is the worst case, or UOC is the worst case. So you use that knowledge also.

MEMBER ABDEL-KHALIK: What I'm trying to find out is: what is the range of delta P --

MR. MARQUINO: Let us get back to you on exactly what exposure point corresponds to the --

MEMBER ABDEL-KHALIK: The 66 --

MR. MARQUINO: -- percent power change. But as you point out, the value will be different at different stay points from a 486 --

MEMBER ABDEL-KHALIK: Right.

MR. MARQUINO: -- temperature change.

MEMBER MAYNARD: I would assume at whatever it comes out to be that you would end up with limit on temperature and power that would be a part of your operating and maybe tech specs or whatever, such that your safety analysis takes the worst case points into account.

MEMBER SIEBER: That's right.

MR. MARQUINO: Yes. And that's the purpose of this diagram is to establish an envelope within which the plant can operate.

MEMBER SIEBER: But you can operate any place in that envelope and be in compliance with the regulations and your technical specifications. You're just explaining one technique that allows you to move around in that envelope. Is this information in the DCD?

MR. MARQUINO: No.

MEMBER SIEBER: No. Okay.

MS. CUBBAGE: I have --

MEMBER SIEBER: So it's not required.

CHAIRMAN CORRADINI: Yes, I think this is the point. Said wanted a clarification. I think we've got the clarification, but staff has just received the report, and it --

MS. CUBBAGE: Right. And it is -- I have it with me today. I can transfer it on stick to Gary, so --

MEMBER SIEBER: But it seems to me that, since you're within bounds with regard to the safety evaluation, as long as you're inside that curve, wherever you end up in there is -- satisfies the requirements for that reactor.

MEMBER ABDEL-KHALIK: That's what I'm trying to find out, whether they can be within bounds at all --

MS. CUBBAGE: The intent of the presentation yesterday was just to give you a hint that this is coming. We're not asking for any formal feedback on this issue. I mean, I understand the interest, but at this time we are not asking for feedback on it.

CHAIRMAN CORRADINI: So I guess the -- I think for all of us I guess, when it's appropriate, we'd like to see the --

MS. CUBBAGE: Absolutely. Yes.

CHAIRMAN CORRADINI: Okay.

MEMBER ABDEL-KHALIK: Thank you.

MEMBER ARMIJO: But basically, the bottom line is that -- at least I want to make sure I understand it -- the area is burnup-dependent, that area will change depending on burnup.

CHAIRMAN CORRADINI: They are looking for the envelope that's --

MEMBER MAYNARD: That's no different than for any of the other accidents. You have to evaluate it. You have to look at what is the worst case: beginning the life -- middle of life, what conditions, low temperature, high temperature, for each accident.

MEMBER ARMIJO: I just want to make sure that the -- and the maximum reduction in power that you can get by this technique is of the order of 15 percent.

DR. SAHA: That is correct.

MEMBER ARMIJO: It's not going to be 20, 25 percent, at any other time in the cycle?

DR. SAHA: Probably not. Around 15 percent.

MEMBER ARMIJO: It's around 15, okay.

MR. MARQUINO: So the analogy to the power flow map on the operating plants is that -- the operator, there is points in the cycle where the slope of the power flow map is different. Okay? And changing core flow might put the core on a trajectory that moves it outside the power flow map.

But the operator doesn't do that because that's part of the plant's license, and he operates within the plant's license. So from the same basis, if there was a core which 15 F, temperature change, produced an eight-degree power change, the operator is not going to increase the feed temperature up to 500 F to get a 15 percent power change, because this envelope is the licensed operating condition for the plant.

MEMBER ARMIJO: Okay.

MEMBER ABDEL-KHALIK: Hopefully, that -- I guess maybe the topical report will have the information on how the Doppler power defect changes with burnup, and how the moderator void coefficient changes with burnup.

MR. MARQUINO: Do we have thermal hydraulics?

DR. SAHA: If I may clarify, this particular report -- NEDO-33338 -- even the title indicates it is basically safety evaluation. So there is another report, Initial Core Report, I guess, from the nuclear side. I think in that report, I don't quite remember the number of that --

MS. CUBBAGE: The transients?

DR. SAHA: No. Yes.

MS. CUBBAGE: Or the core? The initial core or the initial core transients?

DR. SAHA: Initial core design.

MS. CUBBAGE: Okay.

DR. SAHA: I think 333326, probably, yes. That has got much more neutronics or reactor physics kind of information. The report that we are talking about, 33338, has got more safety analysis, because we want to find the safe operating region.

MR. SHUAIBI: Let me. If I could just give --

MEMBER SHACK: Okay. Well, just wait until we look at it.

MR. SHUAIBI: Yes, just very quickly, just give you a status on where we are in terms of reviewing this. As Amy indicated earlier, I mean, this is -- this presentation was just to introduce the topic to you, just to let you know that this has just come in. We're looking at it. We, the staff, have not gone through this topical report yet and done our evaluation.

We have not asked RAIs yet on this topical report, so you'll get a similar presentation as you've gotten on the other topics on this topical report when that time comes. So you'll see the kind of evaluation that we've done, the questions that we've asked, how we're -- you know, what open items we may have at that point in time. So --

MEMBER ABDEL-KHALIK: But, you know, the reason why this whole discussion started is there is a statement here that says Chapter 15 review significantly affected by GEH's new proposed reactor power controls by varying the degree feedwater.

MR. SHUAIBI: Right. And we will need to look at that and make sure that if there are any negative impacts that we've addressed them, and that we have resolved them, and we will let you know how that comes about. I agree with you. I agree. We're in agreement, I think.

MEMBER SHACK: Okay. Thank you.

CHAIRMAN CORRADINI: Back to the program.

MR. MARQUINO: Well, thanks for the introduction process, and I'd like to thank the ACRS members and the NRC staff for their thoughtful review of our design and the professional discussion we had yesterday. I will cover the first part of Chapter 15, the safety analysis chapter for ESBWR.

And Chapter 15 starts with a classification of events. We have four event classes -- anticipated operational occurrences, or AOOs which are expected during the life of the plant. This includes normal operation and evolution, startup, shutdown, and unplanned occurrences and failures, like load rejections.

Design basis accidents is another class, and these are primarily limiting events for evaluation of dose consequences to show the mitigation capability for systems. Special events are evaluated to show acceptance to regulatory criteria, and these events are specifically required by NRC regulation or 10 CFR. And the acceptance criteria are specifically defined for each event.

Infrequent events is a subset of accidents, and they are documented. In Chapter 15, 45 events are identified and analyzed, and Appendix 15A is the event frequency calculations for --

MR. WALLIS: It wasn't clear to me why you would have entered this new category when it's not -- what purpose does it serve?

MR. MARQUINO: That leads me right into my next slide.

CHAIRMAN CORRADINI: Perfect.

MR. MARQUINO: We designed improved reliability into our ESBWR and ABWR plants. We have three control channels typically in our fall-tolerant infill controllers. We have multiple sensors that input to those controllers, so that a sensor failure can't cause a transient.

So a sensor failure won't cause a transient, a controller failure won't cause a transient, and then, if there -- what we can't do as much about is the mechanical failures in the plant, like a valve failing open or closed, or a pump spuriously increasing in speed or decreasing in speed.

So what we've done in those areas is use multiple actuators, so that if -- if we have, say, 12 bypass valves, and one of the valves fails to open on demand, the effect is not as severe.

MR. WALLIS: So the purpose is to show that it's a better plant, because some of the accidents are unlikely and have very low consequences? Is that the purpose?

MR. MARQUINO: That's the purpose. I think this is a win-win situation for the public and the utilities. The public benefits because there is fewer initiating events, and the utility benefits because this class has different acceptance criteria from the AOO class, so that we can improve the fuel economics of the plant.

MR. WALLIS: So by not calling them accidents, you can say that your plant has fewer accidents than other plants? The potential for fewer accidents, is that the idea?

MR. MARQUINO: Well, in --

MR. WALLIS: It's a better plant in some way.

MR. MARQUINO: In the PRA -- actually, we don't take a lot of credit for this in the PRA. There were some questions from the ACRS about that, and we don't take a lot of credit in the PRA, but we specifically want to take credit in the CPR evaluation for this.

Another benefit is improved availability. A plant operates for a longer fraction of the cycle.

Next slide.

CHAIRMAN CORRADINI: I think we are going to keep on coming back to this, because I am still cloudy, but let's keep on going.

MR. MARQUINO: Okay. In general, I want to go through -- you see, I'm going through this pretty quickly, and then we'll see what discussion points you want to hear more about. And after the staff presents, if you have more questions, we're prepared to answer them. If we can't answer them on the spot, come back.

15.1 is the nuclear safety operational analysis. It's similar to failure modes and effects analysis. This material predates the PRA, so you'll see it in operating plants, FSARs, as well. It is not as detailed as a PRA.

The purpose of this is to document the primary success path credited in the safety analysis, and then that feeds into the tech specs. There has been some interaction with GE and the NRC on the tech specs, asking, how did we develop the tech specs? How do you know that the system, structures, components and the tech specs are adequate? And we point back to this evaluation, and, when necessary, we make changes to it.

For example, the control rod drive hydraulic system, the high capacity system that we talked about yesterday, is not a primary success path in the safety analysis, because the ICEs and the safety-related ADS and GDCS systems back that up in terms of water level inventory.

But that's not too clear in our Chapter 15 analysis, so the staff is asking us about it, and we've got to clean it up to make sure that that is clear, and the tech spec representation was right.

Next slide, please.

15.2 is the first safety analysis section in Chapter 15, and throughout the rest of my presentation, I'll use braces and italics to indicate limiting events. The section demonstrates that ESBWR meets all the AOO acceptance criteria., specifically, the critical power ratio that indicates a good heat transfer condition to ensure clad integrity is maintained such that 99.9 percent of the fuel rods do not enter transition boiling.

MR. WALLIS: Is it true that this -- the AOOs don't really invoke or use any of the special safety features of the ESBWRs, such as the gravity-fed cooling, and so on? They're just like normal BWR AOOs?

MR. MARQUINO: The GDCS and the ADS systems, that's true. We specifically have designed the plant to avoid actuation of those systems. We use the IC for the loss of feedwater-type events in AOOs.

One of the interactions we had with the staff was on the safety limit CPR. That is part of our analytical method for previous plants, but it's not part of the TRACG analytical method. So we did not include a safety limit CPR in the tech specs. The safety limit was 99.9 percent of the fuel rods avoid transition boiling.

The staff requested that we put a safety limit CPR in the tech specs to provide them regulatory oversight on fuel changes, and we've added a steady state safety limit CPR back in the tech specs.

Reactor pressure --

MEMBER ABDEL-KHALIK: Given the uncertainty in the applicability of the GEXL correlation to the GE-14E fuel, how can you do that now?

MR. MARQUINO: Well, that GEXL correlation is kind of plug-and-play in our safety analysis. So yesterday, in Chapter 4, you were informed by Russ Fawcett on the conservatism that we expect, and the tests that we're going -- that we've conducted to confirm it. And you're going to get a test report, we're going to confirm that correlation, and, if necessary, we can change the correlation and rerun the safety analysis. And we don't expect a perturbation to the operating limit on that. We think it will -- the new tests will show the operating limit is conservative.

MEMBER ABDEL-KHALIK: So the point is, you may have to revisit all of this if it turns out that you have to modify the GEXL correlation based on the new full-scale testing of the GE-14E bundle?

MR. MARQUINO: Possibly. But it's a low risk.

Reactor pressure, SRV actuation is

avoided. I'll get into more detail on that in a minute. Core water level, the core remains covered, with no ADS required for any of the anticipated occurrences.

Next slide, please.

Because we designed the plant for natural circulation, the vessel was much taller. We've added an eight-meter high chimney that replaces the upper plenum in current plants. That chimney is filled mostly with steam.

In the event we isolate the steam lines or the turbine trips and sends a compression wave back, that volume is available basically to cushion the pressurization. So we're able to avoid SRV actuation in AOOs. This event shows the pressure increasing about .6 megapascal in a vessel isolation. It would have to increase another 1.0 megapascal before we would open an SRV.

Next slide, please.

Similarly, we have to do an ASME overpressure protection analysis to show that we have adequate SRV capacity. In that event, we have to assume a failure of the first scram signal, MSIV position. In addition, we've conservatively assumed the feedwater pumps trip and the IC fails.

The feedwater pump trip is assumed, because the feedwater would spray cold water in the vessel dome and drop reactor pressure. So to minimize the uncertainty in this analysis, we just assumed the pumps trip.

If that -- so given that we've bottled up the reactor and disabled all -- most of the mitigation features, the pressure is going to increase to the SRV setpoint. It takes -- it still takes about 38 seconds for that to happen. And when it happens, if even only one SRV opens, it's sufficient to stop the pressure increase, and there is no dynamic overshoot in pressure, as most of the earlier plants have.

So this also feeds into the CPR response for the pressurization events, like load rejections. We see very low CPR consequences for those events.

MEMBER SIEBER: That's all due to the size of the reactor vessel: the fact that you've been able to lessen the effect of the -- all of these parameters?

MR. MARQUINO: Yes. And most of the new volume is filled with steam, to cushion pressurization.

Section 15.3 is the infrequent event section, so this is the event class that was added.

Here we show that the radiological consequences are less than 2.5 rem TEDE.

MR. WALLIS: I didn't understand this at all. I mean, you have events where there is no fuel damage, and then you assume 1,000 fuel rods are damaged. It doesn't make any sense to me.

CHAIRMAN CORRADINI: I think they're required to do that.

MR. WALLIS: But it doesn't make any sense, though. It's ludicrous, so it --

CHAIRMAN CORRADINI: Well, I'm sorry.

MR. WALLIS: -- it doesn't have to --

CHAIRMAN CORRADINI: I should let you explain. I'm sorry.

MR. WALLIS: The thousand is just some number picked out of the air when the real number should be close to zero or zero.

MR. MARQUINO: No. In -- well, in the licensing analysis, this -- there are some events in this class, or there's one event in this class that would fail about half that many fuel rods.

MR. WALLIS: There is one event in here.

MR. MARQUINO: Yes.

MEMBER ARMIJO: What event is that?

MR. MARQUINO: Realistically, it's the

loss of feedwater heating, assuming failure of the SRI.

MR. WALLIS: Because you've gotten into -- you've got into -- to go beyond nuclear boiling, although you don't uncover. Is that what it is or --

MR. MARQUINO: Right. Right.

MR. WALLIS: Okay.

MR. MARQUINO: And that event is slow, so that -- that condition would exist long enough that there actually might be fuel failure.

MR. WALLIS: So this thousand is something imposed on you by the regulation?

MR. MARQUINO: No, it's not. A thousand was set by analyzing the events, calculating the number of rod failures, and then picking a number that bounded the actual rod failures for the dose consequences.

MR. WALLIS: And so it gives you a bad image, though. I mean, it looks rather superficially when you read this stuff - it says there's a thousand fuel rods damaged when, in fact, it's not true for most of these events.

MEMBER BANERJEE: Are there events where you get significant fuel rod damage?

CHAIRMAN CORRADINI: I think he is going

to come -- are you going to come to this in the presentation, or is this the best place to ask these questions?

MR. MARQUINO: This is the best place to ask these questions.

CHAIRMAN CORRADINI: Okay. So can you repeat the bounding event, so that we're all on the same page?

MR. MARQUINO: Okay. There are two events of concern in this category -- loss of feedwater heating, assuming failure of the highly reliable SRI and SCRRI function. You see the event frequency is something like once in 4,000 years, that order of magnitude. And then, the other event of concern is a pressurization event, load rejection with failure of all the bypass valves.

They have similar CPR changes, but the pressurization event is terminated by a scram very quickly. So, realistically, there wouldn't be any fuel rod failures in that event considering all of the time and temperature data that is available.

CHAIRMAN CORRADINI: So remind me of your acronym. So the first one is limiting. So loss of feedwater heating and failure of?

MR. MARQUINO: Of the select -- okay,

there's two acronyms together -- SRI, select rod insert. That's like a scram of a subset of the blades, about 10 -- I think it's eight blades in the SRI function, and it staggers. There's more detail on the DCD about it.

SCRRI is S-C-R-R-I, select control rod run-in, and that's an electrical insertion of --

CHAIRMAN CORRADINI: With defined motion control?

MR. MARQUINO: Yes.

CHAIRMAN CORRADINI: Okay.

MR. MARQUINO: Of a large number of blades.

CHAIRMAN CORRADINI: So this has to be a failure of both.

MR. MARQUINO: Yes.

MEMBER ARMIJO: Okay. And what happens to the fuel? Is it a DNB-type failure mechanism, or is it a clad strain failure mechanism? What is the mechanism?

MR. MARQUINO: It's a DMBCPR concern.

MEMBER BANERJEE: VNV means it's --

MEMBER ARMIJO: Oxidation.

MEMBER BANERJEE: No, no. It's not a dryoUT. It's really a blanket of bubbles forming on the fuel in water.

MR. MARQUINO: Yes.

MEMBER BANERJEE: Or is it a dryoUT?

MR. MARQUINO: Okay. It's a point I think Dr. Saha wants to correct me on.

DR. SAHA: Yes. This is Pradip Saha from GEH. I just want to clarify, you know, we do -- we have a very, very conservative assumption. We assume that, as soon as a rod goes into boiling transition it fails. We all know that that is not true. I just want to --

MEMBER BANERJEE: Yes. But what we are asking right now is; what sort of a boiling transition is it?

DR. SAHA: It gets a dryout time, because we use a GEXL correlation, which is --

MEMBER BANERJEE: But what -- do you actually have a dryout mechanism here, that you don't have lots of water in the core, or not in that local region?

MR. WALLIS: How does it dry out if it's covered with water?

MEMBER SIEBER: It can't.

MEMBER BANERJEE: Is it film boiling? Explain to us what it is.

CHAIRMAN CORRADINI: I was going to say the correlation is exceeded.

MEMBER BANERJEE: That doesn't -- that is not what we are asking. What is the mechanism? What is the mechanism --

DR. SAHA: Okay. The GEXL correlation, as we all know, it is a critical quality boiling correlation, and this has got, I don't know, maybe 20 or 25 constants.

MR. WALLIS: The symptom you get is that the temperature begins to increase?

DR. SAHA: Correct.

MR. WALLIS: But it doesn't say it goes up very high.

DR. SAHA: No, not very high. That is why I have come here and explained that, as soon as this GEXL correlation limit is exceeded, which Professor Corradini --

MR. WALLIS: It assumes.

DR. SAHA: -- said it rightly, then we assume that there is fuel failure, which is highly conservative. That's all.

MR. WALLIS: What kind of damage do you then assume happens?

DR. SAHA: Okay. Maybe we are --

MR. WALLIS: That is also --

MR. MOEN: This is Steve Moen from GEH. When you go back and look at the testing that we do for the GEXL correlation, what we're looking for is -- or what we do is a gradual power increase until you start to see the temperature shoot up.

When the temperature is shooting up, that is the onset of film boiling. And typically, it's an unstable situation, because you still have quite a bit of water in the channel. But, yes, it's really quite fun to watch.

MR. WALLIS: So it is film boiling. It's not a dryout, then.

MR. MOEN: It's not a dryout, no. But that's the point -- that's the point at which we assume that fuel failure occurs.

MR. WALLIS: Because dryout tends to be not quite so sudden and abrupt and --

MR. MOEN: Yes. If you've got real dryout, you're actually at much higher powers.

MEMBER SIEBER: Yes, you're on your way.

MEMBER ARMIJO: The failure mechanism that is going on is accelerated oxidation of the cladding at that point. Is that it, or is it a clad strain failure?

MR. MARQUINO: Well, we don't postulate a failure mechanism at this point, because we -- to get into further justification of which rods fail and which rods don't fail, to go to a time and temperature basis of the analysis, that would involve model development, NRC review. We simply --

MEMBER ARMIJO: Well, you are silent on the mechanism. You said it exceeds the correlation. We count the number of rods that exceed the correlation. We say they're failed.

MR. MARQUINO: Yes.

MEMBER ARMIJO: And you have a gap release.

MR. MARQUINO: Yes. I'll defer to 15.4 to talk about the dose. Well, I'll defer to the 15.4 section to talk about the dose analysis.

MEMBER BANERJEE: So let me ask you again, because I want to be sure, there is lots of water around still when this is happening, because it's a film boiling transition.

MR. MOEN: That's correct.

MEMBER BANERJEE: All right. That clarifies it. So it is not a dryout transition, then. Let's not call it dryout.

MR. MOEN: Correct. Okay.

MEMBER ABDEL-KHALIK: So let me follow up on that. For this, say, a loss of feedwater heater -- heating transient, at what elevation do you reach the minimum CPR?

MR. WALLIS: It must depend on time of cycle.

MR. MARQUINO: Near the top of the fuel bundle.

MEMBER ABDEL-KHALIK: Is it near the top?

MR. WALLIS: It's rather --

MR. MARQUINO: Near the top of the fuel bundle.

MEMBER ABDEL-KHALIK: So it may still be a dryout.

MR. WALLIS: It may still be a dryout.

CHAIRMAN CORRADINI: I don't think they know. I think those --

MEMBER BANERJEE: We are not getting a straight answer, then, about what the mechanism --

CHAIRMAN CORRADINI: But I think -- I guess -- just to interpose, I mean, that's -- this is all interesting, but I think their approach is -- is bounding in the sense that they go -- they go across the correlation, they assume failure, they assume gap release, and look at the worst case. And then, if they fit, they're okay, they move on.

MEMBER ABDEL-KHALIK: Provided, of course, that they are entirely within the range of the correlation.

MEMBER ARMIJO: Very conservative.

MEMBER BANERJEE: Depending on the mechanism, they can --

MEMBER ABDEL-KHALIK: I don't know what full-scale testing --

MR. WALLIS: Radiation heat --

MEMBER ABDEL-KHALIK: -- whether you are within the full range of the correlation.

DR. SAHA: This is Pradip again, Pradip Saha from GEH again. Let me just clarify, we all know, when we say transition boiling, does not mean it is all steam. You know, maybe there is just a vapor film at the wall, at the heated wall, and there are still entrained droplets in the core of the flow. Some of the droplets, they come back to the wall again.

So when we do the testing, you know, full bundle testing, basically whenever the temperature goes up beyond the normal, or when you get nuclear boiling, by say 20 degrees or 30 degrees Centigrade, and then declare that it has now in the dryout.

So dryout does not mean all steam. So that's all I wanted to --

MEMBER BANERJEE: So your criteria for dryout is a temperature rise and not a rate of temperature rise?

DR. SAHA: I think as far as I know -- and, again, you know, these are the details about the testing procedure and all of that --

MEMBER BANERJEE: That's very important.

DR. SAHA: -- and that's --

CHAIRMAN CORRADINI: We're going to have to go back and look at this when we do the Stern Lab report --

DR. SAHA: That's correct.

CHAIRMAN CORRADINI: -- via the staff.

DR. SAHA: That is correct.

MR. WALLIS: So you can prevent all of this by scramming the reactor.

CHAIRMAN CORRADINI: Yes.

MR. WALLIS: You just don't want to do it. You want to --

CHAIRMAN CORRADINI: They assume the failure. That's what they said. There's two additional failures -- the SR something and the SC something.

MR. WALLIS: It's not the scram that fails. It's not an ATWS.

MR. MARQUINO: Well, in terms of scram, there might not be an automatic scram in this event, because the power level approaches -- in our TRAC analysis, it comes up slightly higher than the scram setpoint in some cases. And initially, we -- in the equilibrium core analysis in the DCD, we didn't credit the scram in that case. So there might be an operator action to effect this scram.

MEMBER ABDEL-KHALIK: So what was the basis for selecting the 115 percent high flux strength setpoint?

MR. MARQUINO: That is based on our operating experience. It has enough margin that noise doesn't cause inadvertent trips. It allows us to have some mild transients and not initiate a trip in the BWR.

MEMBER SIEBER: Local transient particularly.

MEMBER ARMIJO: Do you do a clad strain analysis in that event, in feedwater heater at 116 percent?

MR. MARQUINO: Yes. That's one of the RAIs I think we've got from the staff. We did clad strain analyses for the AOO events, the MOPs and TOPs, mechanical overpower and thermal overpower analysis.

Craig, do you have anything to add to that?

MR. GOODSON: Not that I recall.

MEMBER ARMIJO: You know, if you remember, just roughly, is it far less than the one percent strain criteria that you get during this event?

MR. MARQUINO: These two events, I don't think we have an issue.

MEMBER ARMIJO: But you did calculate it. There is a number someplace?

MR. MARQUINO: I have to check on whether we did an exact calculation or we just looked at the heat flux change in the event. These two events are pretty global, so the local peaking effects aren't too bad in terms of the LHTR.

The SRI and SCRRI features of a plant are what cause us to do a specific clad strain evaluation, because those produce local peaking and LHTR increases. The power shifts to the top of the fuel, and that is where we're doing specific strain evaluations.

MEMBER SIEBER: But the fact remains is you don't go above 2,200 degrees, right? And you don't oxidize more than 17 percent. You are still coolable when you're done, which is a basic requirement.

MR. MARQUINO: That's right. And this --

MEMBER SIEBER: Even if it doesn't trip.

CHAIRMAN CORRADINI: So can we get to this, unless this is the point that we shouldn't do it. I guess I wanted to understand -- the radiological consequences is pinned, because it is still a consequence for an AOO or for a DBA? That is where this infrequent event gets me fuzzy.

MR. MARQUINO: This is not the consequence for a DBA. This is 10 percent of the consequence of a DBA.

MR. WALLIS: Right. So you have defined a new regulatory category?

MR. MARQUINO: No. No. It was in -- it was in the regulations already, and I think other -- and I think --

CHAIRMAN CORRADINI: If this a better thing for the staff to discuss, we can wait.

MS. CUBBAGE: It's a fraction of the dose limit, so it -- there is precedence, and GE proposed the 2.5 rem criteria. The staff has not disagreed with that --

CHAIRMAN CORRADINI: Okay.

MS. CUBBAGE: -- proposal. And then, they selected the thousand rods as a measure to ensure that they did not exceed 2.5 rem.

CHAIRMAN CORRADINI: Okay, fine. Thank you.

Go ahead. I'm sorry.

MR. MARQUINO: All right. In this category of events, the water level is not a particular concern. There is a special event, station blackout, which bounds all of the events in this class.

Similarly, the pressurization is not a big concern. The event that pressurizes the highest is the load rejection with failure of all the bypass valves, but there is still no SRV actuation. So it is bounded by the ASME overpressure analysis event.

Next slide, please.

And I will turn it over to Erik Kirstein to go over the dose analysis for ESBWR.

MEMBER SIEBER: One quick question. Under those circumstances that you mentioned, with the core completely isolated, even if it's tripped, you've got decay heat, and eventually some safety valve somewhere will lift, right?

MR. MARQUINO: The IC didn't fail. So even in the load-reject with failure of all the bypass valves, the IC functioned and it would keep the SRVs from lifting.

MEMBER SIEBER: Okay. Thank you.

MR. KIRSTEIN: All right. My name is Erik Kirstein. I'll be discussing -- briefly discussing Section 15.4, the radiological consequences of design basis accidents.

You can see in the first bullet we have listed the various DBAs that we have considered in 15.4. You'll notice the control rod drop accident. Actually, we did not -- as we discussed yesterday, we didn't calculate the dose consequences of the control rod drop accident.

However, I guess in this context, we'll talk about the 15.3 thousand-rod failure accident. We followed the methodology. The thousand rods that failed probably did not -- the dose consequence at calculation of the methodology of the control rod drop accident, as specified in Regulatory Guide 1.183.

In the next bullet, you can see, as I had mentioned, the dose calculations that we have calculated in 15.4 were performed in accordance with the guidance with Regulatory Guide 1.183, the NUREG-

1465 alternate source term.

The dose criteria that we had to meet --

MR. WALLIS: Well, let's go back to this again. I mean, is this one of these regulatory things again where you are assuming something unrealistic? What is the real fuel damage during these events?

MR. KIRSTEIN: There is no fuel damage in --

MR. WALLIS: Well, where does the radiation come from? What does all this dose come from?

MR. KIRSTEIN: It comes from reg guide 1.183.

MR. MARQUINO: Okay. Well, I think some of you were working in the nuclear industry in the '70s, and there was a lot of focus on fuel rod heatup during LOCA events. And I forgot to bring my burst fuel rod, because we -- we were doing tests to show the fuel rod would heat up and balloon out, and then you get a burst and oxidation on both sides. And we had to qualify our models for all of that, and that is the licensing basis of the current plants as --

MR. WALLIS: Well, we've all seen the pictures and things.

MR. MARQUINO: -- as you say. On the

other hand, ESBWR keeps water over the core in all of the events. But in dose consequence terms, the regulatory guides require us to assume significant core damage and --

MR. WALLIS: Well, this seems to me ludicrous.

MR. MARQUINO: Well, you know, considering Three Mile Island, I understand the philosophy --

CHAIRMAN CORRADINI: I think the staff has an input.

MS. CUBBAGE: They are required by regulation to evaluate the dose.

MR. WALLIS: But if the regulations are ludicrous, they shouldn't be enforced. They should be changed.

MEMBER SIEBER: Well, then, we need to get a rulemaking.

MS. CUBBAGE: What I'd like to say is, you know, I know you're seeing that the ESBWR has a large margin to core uncovery for a design basis LOCA. But we don't allow --

MR. WALLIS: Not when it covers something for the public which says --

MS. CUBBAGE: -- people to melt the core for any plant.

MR. WALLIS: -- there are going to be accidents that irradiate people when they don't. It doesn't make any sense, does it?

MEMBER SIEBER: That's where SOARCA came from.

MR. WALLIS: Right.

CHAIRMAN CORRADINI: I think -- I think what the staff is saying politely is this bounds it. And the effort to make it more precise is --

MS. CUBBAGE: It's the balance between prevention and mitigation.

MEMBER KRESS: These are design basis accidents, and that's what they are for -- to develop the design. They don't have anything to do with reality.

MEMBER BANERJEE: It's the wrong discussion.

MR. WALLIS: Well, I am just protesting.

CHAIRMAN CORRADINI: Once again.

MR. WALLIS: I guess I have to be quiet, but I am really mystified by what you're doing.

MR. KIRSTEIN: I think you have a potential helper. I like what I'm hearing.

(Laughter.)

The resulting doses that we've calculated for design basis accidents meet the criteria of -- the regulatory criteria of 10 CFR 50.34A and GDC-19 for the control room operators. And as we've pointed out -- well, in dose space, we do deal with a lot of conservatism, and what we've done to add a level of conservatism is; all of the accidents, with the exception of the LOCA, we conservatively assumed no credit of the control room emergency --

MR. WALLIS: Why don't you call them IEs? Then, you might be able to reduce this?

(Laughter.)

MR. KIRSTEIN: But, yes, we assume no credit for emergency charcoal filtration for all of the accidents, with the exception of the LOCA.

For a little bit more detailed discussion of the accident scenario that we considered in the LOCA, I'd like to turn it back over to Wayne Marquino.

MR. MARQUINO: The ESBWR containment system removes some fission products in a LOCA event. They would plate out on containment structures, the walls of the containment. Some would be transported into the PCC, because there's a flow through that from the steam generated by the core, and be removed in the condensate of the PCC.

To quantify that, we used the MELCOR code to calculate a fission product removal coefficient, and we investigated a range of scenarios with different thermodynamic conditions, because those conditions affect the removal and the release -- the conditions relative to when the release occurs affects the removal and the overall effect.

The specific scenarios we looked at included low pressure core failure LOCA, specifically a bottom drainline LOCA, with failure of the IC, SLCS, GDCS, and we assumed the ADS system worked. So we have a leak at the bottom of the vessel. The ADS system functions and depressurizes the vessel, but then no other water comes in, and eventually we get core damage.

Consistent with the alternate source term --

MEMBER BANERJEE: So the equalization line doesn't work here?

MR. MARQUINO: Right, right.

MR. WALLIS: So there is real core damage, then.

MR. MARQUINO: Right, right. So we --

MEMBER SIEBER: Sooner or later it doesn't work.

MR. MARQUINO: So we assume multiple

multiple failures to the --

MEMBER BANERJEE: Why do you presume so many failures? Is there a reason for it?

MR. MARQUINO: Because, consistent with the alternate source term methodology, which --

MR. WALLIS: You keep assuming failures until you get a source. That's again ludicrous, isn't it?

MR. MARQUINO: So this --

MR. WALLIS: You might as well just assume the source and forget about what the accident is, right?

MEMBER BANERJEE: So let me understand. The GDCS fails, the equalization line doesn't open, and you have a bottom drainline failure or something like that.

MR. MARQUINO: Bottom drainline break, yes.

MEMBER BANERJEE: Break, okay. So this is the scenario.

MR. MARQUINO: Yes.

CHAIRMAN CORRADINI: But something eventually works.

MR. MARQUINO: Yes. The alternate --

CHAIRMAN CORRADINI: Or else we go into

another regime.

MR. MARQUINO: Yes. So where we draw the line between this evaluation and the PRA with, you know, failure, core on the floor, is we recover core cooling just before the bottom head failed. So we ran the MELCOR code until it predicted the bottom head failed, and then we ran it again and turned the ECCS systems on just before that.

MEMBER BANERJEE: So what is the scenario now? What starts to work at this point?

MR. MARQUINO: Then, we turn everything on.

MR. WALLIS: Well, why does that work? Everything else didn't work. Why does this suddenly work?

CHAIRMAN CORRADINI: I think they're developing a stylized scenario to test their fission product removal system in containment.

MR. WALLIS: That's all they're doing.

CHAIRMAN CORRADINI: It's not supposed to be --

MR. WALLIS: There's nothing realistic about it, whatsoever.

CHAIRMAN CORRADINI: That's the impression I get.

DR. WHITE: We are causing it to fail.

CHAIRMAN CORRADINI: Staff seems to be okay with that interpretation.

MEMBER BANERJEE: But there is no physical mechanism. I mean, you are doing this to get the timings, right? I mean, you are going through this scenario to get the timings. So to get realistic timings, but then is that a realistic scenario when things come back on due to something happening or --

MR. MARQUINO: Well, I'd say operator action would be --

MEMBER BANERJEE: Okay.

MR. MARQUINO: -- the thing that -- you know, that would make this like a -- I'm not a PRA expert, but, you know, let's say this -- this is probably like a 10^{-7} event.

MEMBER BANERJEE: Well, yes, forget it. I mean, you are going through this at a stylized scenario, so it has to be a stylized scenario as to how the cooling comes back on.

MR. MARQUINO: Yes.

MEMBER BANERJEE: So operator action brings it back on --

MR. MARQUINO: Yes.

MEMBER BANERJEE: -- in some ways.

MR. MARQUINO: Yes.

MEMBER BANERJEE: And how many hours do you have for that?

MR. MARQUINO: Well, that -- again, there is not -- it's not that we investigated, well, if this happened, how long will it take the operator to act? Because the --

MEMBER BANERJEE: Well, let's say how many hours before the bottom of the vessel starts to fail. How many hours is that?

MR. MARQUINO: We're talking like two hours, three hours.

MEMBER BLEY: We're asking questions that make this sound like a real scenario, and my impression is --

CHAIRMAN CORRADINI: It's not.

MEMBER BLEY: -- you're turning switches to get the source term you want.

CHAIRMAN CORRADINI: Right.

MEMBER BLEY: You would be better off not to say everything you did, just said we dummied up the source term.

MEMBER BANERJEE: No, because they want the timing.

MEMBER SIEBER: They actually have to do

it, though, because you have to make sure you didn't miss one that's more severe.

MR. WALLIS: Well, I'm very puzzled because I looked -- I thought in Chapter 15, I was going to see analysis of accidents.

CHAIRMAN CORRADINI: That was in Chapter 6.

MR. WALLIS: Well, so -- I know I saw it in Chapter 6, too. But Chapter 15 seems to be in a different world all together.

CHAIRMAN CORRADINI: Well, but I think that's a function of the system is that they said that it's not uncovered, so that they still have to go through and show that all of their various systems are designed with some limit. So in some sense, they are developing --

MR. WALLIS: They don't protest at that when --

MEMBER BANERJEE: Defense in depth.

CHAIRMAN CORRADINI: I don't think the staff would listen to the protestations for very long. That's what I --

MR. MARQUINO: We did -- we had some good interactions with the staff, you know, from -- we submitted our Rev 0 in August, and I think in

September or October we had a phone call from Jay Lee, and we started discussing this, and we had meetings with them.

So we've gone through all of the regulations with them, and in order to have a challenge to the containment, the containment is supposed to contain radioactivity in the event, okay? It's leak-tight, and we have passive removal mechanisms here. We don't have a standby gas treatment system. So this is how we demonstrate that everything is going to be okay in our containment, even if --

MR. WALLIS: That makes a lot of sense, if it's defense in depth that you're talking about. But don't call it a LOCA analysis, and don't call it an analysis of an accident.

MEMBER BANERJEE: No. They are calling it containment fission product removal system.

MR. MARQUINO: Yes. I think what we need to clean up or clarify is that the design basis LOCA doesn't produce any fuel failures, but in spite of that this is what we do for the dose analysis, and it's conservative. We have a few words like that in Chapter 15, but we should probably make it clear.

CHAIRMAN CORRADINI: That might be good.

MR. SHUAIBI: I guess in terms of the regulatory structure and how we deal with these kinds of things, we can take a shot at that when we're up at the table.

CHAIRMAN CORRADINI: Okay.

MR. SHUAIBI: We'll try to explain why it is that we do things that go beyond where we think the Chapter 15 and how the AOOs and the accidents take you. It is defense in depth, but we'll take a shot at trying to explain them.

CHAIRMAN CORRADINI: Move ahead.

MR. MARQUINO: Okay. So we have these three different scenarios to look at how the passive fission product removal works under different conditions. We have significant core damage in all of the scenarios, as I said, and we recover ECCS just before the lower head fails.

MEMBER BANERJEE: I guess what Graham was concerned about, and in a way we are, is when we first saw this, you know, concept, we had the impression this was going to be a lot safer than anything we have seen.

There is nothing going to happen at LOCA, the core is never going to uncover, and all of these advantages that we are really very far from dryout limits, and there are very few things that will give us problems, the passive system was working fine. We didn't need -- we needed blowers, and all this sort of stuff.

Now, when you tell the story this way, that doesn't come out, that this system is way beyond what we've seen in terms of its safety implications, because nothing happens during a LOCA.

MR. MARQUINO: I agree with that. I'm kind of frustrated that we don't have the opportunity to present a more nominal evaluation.

CHAIRMAN CORRADINI: Well, you haven't shown us the PRA yet, so don't worry. You'll have your chance.

(Laughter.)

MEMBER BANERJEE: You know, PRA is okay, but what you really want to say is, nothing happens during a loss of coolant accident.

MEMBER MAYNARD: Chapter 15 is more about evaluating, I guess, the regulatory requirements and meeting the regulatory requirements is a safety analysis of, this is what we really expect to happen. It's to show the conservative in meeting the bounding analysis, meeting the regulatory requirements on what have to be assumed.

CHAIRMAN CORRADINI: Right.

MEMBER MAYNARD: You end up, if you meet those requirements, that you are safe. But it's not a safety analysis in the -- going through and trying to --

MR. WALLIS: That's what it's called. It's called safety analysis.

MEMBER SIEBER: It's not a realistic analysis.

MEMBER MAYNARD: But that's not what the applicant --

CHAIRMAN CORRADINI: So here's the analogy. I think we have to move on, but here's the analogy. If I took a trigger reactor, a university research reactor, and I -- and all non-power reactors have to do a safety analysis. It would be very interesting to see their Chapter 15 equivalent, which is they have to assume all of the water disappears, and they have to go to air cooling. How did the water disappear from a 40-foot pool? Doesn't matter. That's how I have to develop a source term to determine boundaries. It's essentially that.

MR. WALLIS: Yes. But this does a great disservice to the future of the country. If you're trying to make politicians make decisions based on --

CHAIRMAN CORRADINI: You must have read my e-mail.

MR. MARQUINO: I guess, if I may, one thing --

MEMBER BANERJEE: Well, I think it does a disservice to the concept. And it doesn't come across as being --

CHAIRMAN CORRADINI: But I think Mr. Marquino's point, and I think we've got to move on, is that perhaps they can rewrite how the DCD is presented, but I do think, by regulation, they must show this -- that they are bounded on the regulation.

MEMBER SIEBER: Then, it has got to be written in a legal different way to show that.

MR. KRESS: And regulations specify that you can use this source term, alternative source term, in your analyses or not, if you can justify another source term. It is so hard for most plants to justify a different source term. It's easier just to go ahead and use it and show that you meet these stylistic accident conditions, which are in the regulation. You have to meet the regulations. That's the rule.

MR. WALLIS: It's like saying a patient goes in the emergency room, you've got to treat cancer whether the patient has cancer or not.

MR. KRESS: No, it's not exactly that.

MEMBER MAYNARD: I don't think that's a good analogy, because that may be if you're trying to qualify whether the hospital is capable of treating cancer or not, but it's not getting to the patient. I think this is important but not -- not for the ESBWR. I mean, we're talking about changing regulations, and they are talking about complying with the current regulations. I think we need to --

MR. KRESS: We would have gotten rid of all of this if we would have got our version of the technology nuclear --

(Laughter.)

CHAIRMAN CORRADINI: Let's go on.

MR. KRESS: We tried our best, you know.

MEMBER BANERJEE: Well, at least it should be presented as a defense in depth argument.

MR. KRESS: It's meeting the regulations as they are written.

CHAIRMAN CORRADINI: So can we -- I think we've got to let the -- our colleagues from GEH move on.

MR. MARQUINO: Okay. Before I leave this slide, I just -- because the staff is going to talk about this, I want to briefly mention scenarios 2 and

3. Scenario 2 is a high pressure core failure LOCA. Again, it's a bottom drainline break failure of the -- of all of the systems, including ADS, so the vessel doesn't depressurize. It's got a hole in the bottom. It's squirting the coolant out. The core uncovers. The core failure is at a higher pressure, and, again, then we recover the ECCS systems, depressurize, and let the systems flood the core.

Scenario 3 is no LOCA, no break, no high pressure systems, loss of AC power and feedwater, IC, SLCS, and ADS. And, again, we let the accident progress until just before bottom head failure, and then we allow the systems to function and reflood the core.

Okay. Now, Mr. Kirstein is going to cover the pH evaluation.

MR. KIRSTEIN: Yes, one quick slide. We considered the pH in containment pools, formation of acids. We credited SLCS injection for buffering to keep the pH up. A couple of contributors to decrease -- to the pH analysis were the degradation of cable due to radiolytic conditions of containment, and also production of nitric acid, among others.

And the evaluation of pH in containment pools, we intend on revising that for DCD, Revision 5.

MR. KRESS: Any effect of the fission products?

MR. KIRSTEIN: I'm sorry?

MR. KRESS: No, no, not radiation, just the effects of the fission products themselves. A lot of them are --

MEMBER SIEBER: They're chemicals.

MR. KRESS: Yes.

MEMBER BLEY: What is leading you to revise it, by the way?

MR. KIRSTEIN: I'm sorry?

MEMBER BLEY: What is leading you to revise it in the next DCD? Is there specific chemical reactions or something you're accounting for you didn't before?

MR. KIRSTEIN: I believe one change we do have to make, and it's not necessarily a pH consideration, I believe the NUREG-1465, the alternate source term, also forces us to enter the alternate source -- the source term into the suppression pool in conjunction to containment. And we didn't do that for the prior revision.

MR. MARQUINO: Yes. And, frankly, there is an error in our analysis, and we didn't consider the radioactivity in the suppression pool. We only had the suppression pool air space, so we have to revise it.

MR. WALLIS: Does the suppression pool take out a lot of the fission products in your analysis?

MR. MARQUINO: Yes.

MR. WALLIS: A huge amount.

MR. KIRSTEIN: Yes. Once again, there is some guidance in, I believe SRP 6.5.5, that provides a maximum decontamination factor of 10. In our MELCOR analysis, we've actually shown that the decontamination factors are considerably higher. But, once again, we've reverted back to the --

MR. WALLIS: At the time of the reactor on Long Island, which operated for a day, there was a claim that the factor was much bigger than that -- enormous.

MR. KIRSTEIN: Yes. We've seen some ranging from a couple thousand to orders of magnitude greater.

MR. WALLIS: That's right.

MR. KIRSTEIN: Once again, from a regulatory standpoint --

MR. WALLIS: And you are forced to assume 10.

MR. KIRSTEIN: Yes.

MR. KRESS: Even 10 is useful, because it gets a lot of it. But the issue is whether or not you reevaporate iodine out of there, and that depends on the sources of radioactivity and the pH of --

MR. WALLIS: And the pH.

MR. KIRSTEIN: Okay. I would like to turn it over now to my colleague to the right, Dr. Alamgir. He will discuss DCD Section 15.5.

DR. ALAMGIR: 15.5 is special events, and its purpose is to show compliance to the regulatory acceptance criteria.

I will be talking about TRAC analysis of -- in summary form -- for limiting ATWS events, followed by a confirmation to CFD of boron mixing in the ESBWR bypass spaces.

MR. WALLIS: I'm sorry. There were two events about control rod withdrawal during refueling and during startup. Did you talk about those at all? Are they part of the -- they're part of the accident analysis, aren't they?

MR. MARQUINO: They are in 15.3. There's a rod withdrawal error event in --

MR. WALLIS: It's another one of the things you're forced to assume, or is this a realistic thing, or what is that?

MR. MARQUINO: The rod withdrawal?

MR. WALLIS: Yes, during startup or during refueling. You are supposed -- it's not a very good thing to do, withdraw rods during --

MR. MARQUINO: No, it's not.

MR. WALLIS: Something you have to assume, or what is that?

MR. MARQUINO: Well, no, it's -- we are using a probability treatment on it, and it's an infrequent event. We've had some staff questions about what happened at the Japanese plants, and we see two differences. One is their procedure compliance --

MR. WALLIS: So this is another defense in depth thing. It might happen; that's why you have to see what the consequences are.

MEMBER BANERJEE: Well, it has happened. It has a slip problem, yes. Several times.

MR. WALLIS: So we don't need to worry about how likely it is. We just need to say that you've analyzed it and you find that this -- you meet the TEDE requirements, is that it?

MR. MARQUINO: Yes.

MR. WALLIS: We don't need to discuss the probabilities of it at all. No? All right. Fine.

MR. KRESS: Do you lower the water level in the core to deal with the ATWS?

MR. MARQUINO: Yes. Yes.

MR. KRESS: And do you need that when the SLC operates, or the SLC shuts it all down?

MR. MARQUINO: Well, we -- the SLC could bring the reactors subcritical with the water level up high. It's much more effective with the water level low and that's factored into, say, the pool temperature here.

MEMBER BANERJEE: What do you mean by SLCS-bounding? I guess, Mohammed, you explained this to us, right?

DR. ALAMGIR: I haven't gotten to that slide yet, but --

(Laughter.)

MEMBER ARMIJO: You probably will never get there.

DR. ALAMGIR: The specific line you are looking at?

MEMBER BANERJEE: Just the title.

DR. ALAMGIR: This is a limiting event.

MR. WALLIS: You'll have to speak to the mic.

DR. ALAMGIR: Yes. I think I'm speaking

to that.

MR. WALLIS: Okay.

DR. ALAMGIR: This is a bounding case where we are assuming that the mitigation is to the standby liquid control system, and other -- there are other systems available for mitigation of ATWS, such as alternate rod insertion, FMCRD electrical run-in, feedwater run-back, which is of course a precursor to the SLCS injection, and then the boron itself.

Does that answer your question?

MEMBER BANERJEE: Yes, okay.

DR. ALAMGIR: Back to the slide on the screen. Here we are seeing the key results of acceptance, against acceptance criteria, measured in terms of three locations -- the integrity of the vessel, the integrity of the containment, and the fuel integrity.

Now, before I compare those results, I want to mention that we have analyzed limiting cases by choosing events, special events, and the key special event here is the main steam isolation valve closure. We have also analyzed nominal cases, which means that, for example, the power is 100 percent as opposed to a bounding case where the power is 102 percent.

There are other additional bounding inputs that we have considered in the calculation. For example, feedwater enthalpy has been increased to 105 percent. So we have pushed the limit for these MSIV closure transients.

MR. WALLIS: Do you know how to analyze the mixing of the boron with the other water?

MEMBER BANERJEE: He is going to tell us.

DR. ALAMGIR: I am going to show you a -- we have --

MEMBER BANERJEE: I'm sorry.

MR. WALLIS: You're going to show us. Okay.

DR. ALAMGIR: We have a TRAC analysis where we do a conservative calculation in order to define what conservative is.

MR. WALLIS: Okay. Thank you.

DR. ALAMGIR: And then, we back it up by showing a realistic analysis.

MR. WALLIS: So you are bounding assumptions about the SLC mixing, as well.

DR. ALAMGIR: That's correct.

MR. WALLIS: Okay.

MEMBER MAYNARD: I believe the staff has also done some confirmatory analysis or review of the mixing, too.

MS. CUBBAGE: Yes.

MR. WALLIS: But presumably, if they use CFD, that's not bounding, that's realistic.

MS. CUBBAGE: I just wanted to clarify that we did run some CFD, and we are going to talk about that if we get a chance to come up.

(Laughter.)

CHAIRMAN CORRADINI: Fair enough.

DR. ALAMGIR: I want to provide a disclaimer that our safety analysis has been provided by our GRC consultant associate. I am not a CFD expert, but I can always talk about thermohydraulics and mixing.

MEMBER BANERJEE: Same thing.

(Laughter.)

DR. ALAMGIR: This particular slide show that -- I would like to stand up and teach. It's more comfortable that way. Thank you.

So here we show that the vessel pressure is below the SRV surface level 3C, 1,300 psi, and we are at 1,364 for the MSIV bounding transient. For the containment, we show that the suppression pool temperature is much less than the acceptance criteria of 121 C.

MEMBER ABDEL-KHALIK: I know this is the result for this particular transient, but which transient gives you the highest suppression pool temperature?

DR. ALAMGIR: This is the one.

MEMBER ABDEL-KHALIK: This is the one that gives you the highest suppression pool temperature?

DR. ALAMGIR: It has more power.

MEMBER ABDEL-KHALIK: Now, at 163 degrees, the partial pressure of steam is 5 psi. And if I look at the transient that was presented yesterday, the highest pressure in the containment was about 53 psi. So that means the partial pressure of non-condensables is about 50 psi. Does that make sense?

MR. WALLIS: That makes sense.

DR. ALAMGIR: You saw the LOCA results yesterday?

MEMBER ABDEL-KHALIK: We saw the steam line break, yes.

DR. ALAMGIR: Okay. This is an ATWS simulation where we do -- do calculate the total pressure in the containment, and it is below 45 psig, the design.

MR. WALLIS: Where does it come from?

MR. MARQUINO: I am not clear on the

question. Are you asking about the LOCA containment pressure, or the ATWS containment pressure?

MEMBER ABDEL-KHALIK: I was trying to find out where we stand with this transient, so he told me first that this transient produces the highest containment temperature.

DR. ALAMGIR: In ATWS.

MEMBER ABDEL-KHALIK: In ATWS, okay.

MEMBER MAYNARD: For special events.

MEMBER ABDEL-KHALIK: All right. So let's focus on those. You're telling me that for this particular transient the total containment pressure was 45 psi. Is that correct?

DR. ALAMGIR: That's the design limit. It's below that. The numbers are below that.

MR. WALLIS: Well below that.

MEMBER BANERJEE: So what was the -- what was the maximum containment pressure?

DR. ALAMGIR: Can you please look up? I don't --

MR. WALLIS: You don't have it?

DR. ALAMGIR: We'll be able to provide it. You have it on -- it's in the DCD as well. It's one of the key output parameters.

Should I go on? Thanks.

The fuel -- in this case, this is a scenario where the fuel heats up. Again, whether it said DNB or dryout, there is little -- they are not -- I feel it is not a DNB of the PWR TYPE.

PARTICIPANT: It's high void fraction.

DR. ALAMGIR: Yes. We know it's high void fraction from the void calculation, which is void fraction of 90 percent plus.

And the PCT is -- limit is 2,200 F. We have about 1,560.

MEMBER BLEY: Close to an ATWS.

DR. ALAMGIR: Yes. And very little oxidation. So very, very safe in terms of ATWS performance.

Next slide, please.

MEMBER BANERJEE: And no ATWS instability.

DR. ALAMGIR: We have analyzed ATWS instability cases.

MEMBER BANERJEE: Is there a separate subject or --

DR. ALAMGIR: It is included in special events, and we showed that when we perturb during a -- for example, a loss of feedwater accident, the oscillations die out very quickly.

There is an RAI that we talked about,

staff talked about yesterday, related to --

MEMBER BANERJEE: Right. It was referred to yesterday.

DR. ALAMGIR: Yes. And that is in process.

MEMBER ABDEL-KHALIK: I guess you are in the process of looking up what the maximum containment pressure is?

MR. MARQUINO: Yes.

MEMBER ABDEL-KHALIK: Thank you.

MS. CUBBAGE: Wayne, is it 29.9?

MR. MARQUINO: Yes, sounds right.

MEMBER ABDEL-KHALIK: So let me, then, ask: which transient, aside from ATWS, gets you closest to the limit on the maximum suppression pool temperature?

DR. ALAMGIR: The overview is -- Wayne has the overview. I can give you some numbers, but --

MR. MARQUINO: Do you mean which non-LOCA -- which non-LOCA transient besides ATWS produces a high containment pressure?

MEMBER ABDEL-KHALIK: Correct.

MR. MARQUINO: I can't think of any, because the -- what is producing the high pressure -- well, the pressure in this case is discharge to the pool through the SRVs. That heats the COLA, and purging the drywell of non-condensables through the SRV flow. So some of the SRVs discharge into the drywell, and the steam flow will bring non-condensables into the wet well air space. So we've got a warm pool and compressed low air space.

But you -- you know, we avoid SRV opening in ESBWR, so --

MR. WALLIS: Well, I think what happens is that the non-condensables are in the wet well, and so they get compressed in there. So that's how you get the high pressure.

MEMBER ABDEL-KHALIK: Well, that's what I'm trying to figure out, whether the --

MR. WALLIS: The drywell is full of steam, right? That's the way you get a high pressure.

DR. ALAMGIR: We've put conservative assumptions. We assume all of the non-condensables is in the wet well.

MR. WALLIS: That's right, so it's the -- that's why they get -- that's how the pressure gets so big. All of the non-condensables is going to the wet well. It's a much smaller volume than they started at, so they are compressed.

MEMBER BANERJEE: You probably just make

a conservative assumption there.

DR. ALAMGIR: In addition to not allowing the pool to mix.

MEMBER BANERJEE: Not allowing the pool to mix?

DR. ALAMGIR: I mean, the SRV. I'm sorry, the suppression pool, after the SRV discharge, we don't let it mix.

MR. MARQUINO: But that -- but for ATWS, we mix the pool.

MEMBER BANERJEE: Yes, you must.

DR. ALAMGIR: I mean, there is no active system or anything like that.

MEMBER BANERJEE: No, but --

DR. ALAMGIR: Natural separation, natural convection, whatever you call it.

MEMBER BANERJEE: I am puzzled by this now. If you are only getting a 5 psi pressurized, due to the saturation, is that a mixed pool temperature, or is it the pool surface temperature that --

MR. MARQUINO: We go up to --

MEMBER BANERJEE: Go back to the previous slide.

MR. MARQUINO: No. We go up to 29.9, so we're increasing the pressure about 15 psi, and the split is, like, 5 due to the saturation pressure increase and 10 due to the compression.

MEMBER BANERJEE: But that's assuming a well mixed pool, isn't it?

MR. MARQUINO: It is, yes.

MEMBER BANERJEE: That's what I thought. Otherwise it's too small.

MR. MARQUINO: Yes. The reason we have concerns about stratification in the LOCA is --

MEMBER BANERJEE: It's a different problem.

MR. MARQUINO: -- it's coming in in point -- like three-quarters of a meter within the surface in the long term. In this ATWS, it is discharging either through the vents or through SRVs, and it's coming in lower in the pool.

MEMBER BANERJEE: Right. So it should mix up the pool.

MR. MARQUINO: Yes.

DR. ALAMGIR: There is no active mechanism that --

MEMBER BANERJEE: But that's sufficient.

DR. ALAMGIR: Yes, that's sufficient.

Thanks for clarifying, Wayne.

All right. Now I'll transition to the CFD analysis, but before that let me mention why we consider TRAC analysis for the same MSIV ATWS transient as bounding.

In the TRAC calculation, if we -- can you please put up Figure 4.1.1 from DCD? We will first show a format, and then show how the TRACG analysis has been configured to make it bounding for boron mixing.

MR. WALLIS: Well, how does TRAC make it subcritical, if it doesn't let anything in?

DR. ALAMGIR: Well, there is a -- I will just show you that. In general, let me just try it this way -- that if you consider the core shroud as the outer circle, then from the center line of the core to the core shroud we divide it into three segments, three rings, with proportionately an equal number of bundles.

We block -- SLCS comes -- boron comes in in outer ring. We block the outer ring all the way, except near the core plate where there are leakage holes into the bundle, so it can flow down in the peripheral bypass and then go into the fuel bundle, but not directly into the center of the core radially. That's what we define as conservatism in TRAC. We do not let boron migrate radially other than -- in TRAC, other than to go down and then go --

MEMBER ABDEL-KHALIK: Do you do a sanity check on TRAC results and do an overall mass balance on boron?

MR. MARQUINO: Yes. And let me add something. We have test data for boron injection at several different locations -- injecting into the lower plenum, injecting into the upper plenum, injecting into the jet pumps. There is full-scale data and scale data, but we don't have data at exactly the elevation that we inject at for ESBWR. So --

MEMBER BANERJEE: What elevation is that?

MR. MARQUINO: That is the lower part of the core bypass region. So it -- going back to the SLC --

MEMBER BANERJEE: Do you have a little diagram or something?

MR. MARQUINO: Let me --

MEMBER BANERJEE: Maybe it was shown, but --

MR. MARQUINO: You know, if we switch computers --

MS. CUBBAGE: Hold on, hold on, hold on. He's got it.

MR. MARQUINO: So while they're bringing

that up, we have two SLCS systems. They come in from opposite azimuths to the vessel. They go into the shroud, and then branch, split and branch, so that at four locations, 90 degrees apart, we have a vertical pipe in the peripheral bypass area. The peripheral bypass is the space between the outermost fuel bundle and the core shroud, and then we also distributed axially, so at four locations on that vertical pipe there is a nozzle that injects the boron tangentially to the shroud. And we'll show you some CFD --

MEMBER ARMIJO: Well, you've got 16 points of entry for boron --

MR. MARQUINO: Yes.

MEMBER ARMIJO: -- the way you describe it.

MR. MARQUINO: Yes.

MEMBER BANERJEE: And tangentially, not radially.

MR. WALLIS: It's injected into the downcomer, isn't it? Or does it go --

MR. MARQUINO: It's in between the bypass.

MR. WALLIS: But shouldn't it be injected into the core, not into the bypass?

DR. ALAMGIR: Here is how it works. There are two pipes that come in, penetrate the core shroud.

MR. WALLIS: Right.

DR. ALAMGIR: Then, each pipe becomes a semi-circle or a sparger.

MR. WALLIS: In the bypass.

DR. ALAMGIR: Inside the bypass, just inside the bypass.

MR. WALLIS: How does it get from the bypass to where it does some good?

DR. ALAMGIR: That's what we'll show. Then, at the end of this semi-circle are injectors, and there are four elevations at which --

MR. WALLIS: But it has to get down, and then up, and into the fuel somehow.

MR. MARQUINO: That's right. So to understand why we do that, the BWR ATWS emergency procedures direct the operator to lower water level, and we actually have an automatic feedwater run-back in ESBWR to do that.

MR. WALLIS: Yes.

MR. MARQUINO: So during the -- at the time the boron injects, the water level is low, and we've stopped circulation from the downcomer into the core. So if we inject it into the downcomer, the boron wouldn't get in.

MR. WALLIS: Oh, okay.

MR. MARQUINO: So we considered that this location -- and what we've done, then, is set up an internal natural circulation loop between the bypass and the fuel channels. There's holes at the bottom of the fuel bundles that let flow come in from the bypass. So that's why our design is the way it is.

MR. WALLIS: But it relies on some internal mixing inside the core to somehow get that --

MR. MARQUINO: Yes.

MR. WALLIS: -- stuff from the outside into the middle.

MR. MARQUINO: Right. Right.

MEMBER BANERJEE: You don't directly inject it into the core in any way. It just comes into the bypass.

DR. ALAMGIR: The peripheral bypass.

MR. MARQUINO: Yes.

MEMBER BANERJEE: Peripheral bypass.

DR. ALAMGIR: Yes.

MR. WALLIS: It might be better to spray it in the top.

MR. MARQUINO: Well, the BWR 5 and 6 plants have a high pressure core spray over the upper plenum, and they inject the boron there. But, again --

MEMBER BANERJEE: You've got chimneys now, right?

MR. MARQUINO: We have chimneys. We don't have that sparger. And, additionally, when you spray it there, because the flow is coming out of the core, it is going to -- some if it is going to get pushed out and go down anyway. So that's why we have the design --

MR. WALLIS: Have you got boiling going on during all of this process?

MR. MARQUINO: Yes.

MR. WALLIS: So CFD isn't going to do you much good.

MR. MARQUINO: No, it's single phase in the bypass region.

MR. WALLIS: Okay, in the bypass.

MEMBER BANERJEE: There is no boiling in the bypass?

MR. MARQUINO: No.

MEMBER BANERJEE: In these conditions?

MR. MARQUINO: No.

MR. WALLIS: Okay. Well, I guess we can -- this is a subject to investigate.

MEMBER BANERJEE: Okay. So can you show us -- you don't have a little diagram of this injection system anywhere?

MEMBER SIEBER: There is a schematic of it.

DR. ALAMGIR: I think we went into --

MEMBER BANERJEE: He is talking about a sparger with a nozzle at the end. I mean, it is quite a complicated-sounding system.

MR. MARQUINO: We can get it up. I've got it on my computer. Is Jerry here? Because I --

MEMBER BANERJEE: Well, you can do it later.

MR. MARQUINO: We can do it another time, if need be. After a break, we'll get something up.

MEMBER BANERJEE: All right.

DR. ALAMGIR: So just stay with the DCD --

CHAIRMAN CORRADINI: Switch back to your --

MEMBER ARMIJO: That's a torturous path, to go through all of those gaps.

MEMBER BANERJEE: Yes. The only thing is that we'd like to see the layout to understand how realistic a CFD calculation might be, or how realistic even TRAC's assumptions might be.

MR. MARQUINO: Okay. Do you --

MEMBER BANERJEE: To understand the

geometry of these events.

MR. MARQUINO: Do you want to --

MEMBER BANERJEE: Later.

MR. MARQUINO: -- take a break or let us like flip computers or something?

MEMBER BANERJEE: No. I think --

CHAIRMAN CORRADINI: We want you to finish by 10:10.

(Laughter.)

MEMBER BANERJEE: Give us the results right now, and then we'll discuss the realism of the results later. So let's see the bottom line first.

CHAIRMAN CORRADINI: Can we go back to your presentation?

DR. ALAMGIR: I was going to say, if you are going to show the geometry, then we don't need it. I was going to say where the jets are and --

MEMBER BANERJEE: Yes. Why don't you show us where the jets are. That's fine.

DR. ALAMGIR: So if you imagine a circle circumscribing this core, that will be the core shroud. The pipe that brings the SLCS fluid is the point over here. Comes in through this non-uniform area, so it would come in here, one pipe, branch out into --

MR. WALLIS: It goes through the core shroud, then.

DR. ALAMGIR: I'm sorry?

MR. WALLIS: It does go through the core shroud.

DR. ALAMGIR: Yes. And then, there are two pipes. One coming in from this side, the other coming from the opposite side.

MR. WALLIS: And that's how it's diffused through the core?

DR. ALAMGIR: I will show you where the injectors are first, and then -- then, it branches out into a sparger, which is a semi-circle, a sparger. It ends up -- one end of the sparger ends up in -- along these flaps, just like that, and the other end vertical along that flap. And so there is a corresponding pair.

This sparger then ends up with a nozzle that has two injectors.

MR. WALLIS: Which points inwards.

DR. ALAMGIR: Which then they are at a slightly -- in an angle more, so they don't inject normally, don't inject slightly in an angular fashion. Two sets of injectors right along these flaps.

MR. WALLIS: The ideal that it penetrates through there or not?

DR. ALAMGIR: Through the spaces. I guess to be able to spray or inject in this region, and then hopefully it will get through these, and it does.

MR. WALLIS: Hopefully?

DR. ALAMGIR: And it does.

MR. WALLIS: Hopefully?

DR. ALAMGIR: Yes.

(Laughter.)

You always hope for the best, and then you --

(Laughter.)

CHAIRMAN CORRADINI: Prepare for the worst, hope for the best.

MEMBER BANERJEE: The spargers themselves, of course, have holes in them, right?

DR. ALAMGIR: The spargers are -- they don't have holes, but they end up with --

MEMBER BANERJEE: Why do you call them spargers, if there are no holes?

CHAIRMAN CORRADINI: It's the header.

DR. ALAMGIR: It's the header.

MEMBER BANERJEE: Okay. Terminology. I thought the thing had little holes and then two nozzles, so now it's just a header.

DR. ALAMGIR: Header with nozzles at the end.

MEMBER BANERJEE: At the end, okay.

DR. ALAMGIR: And there are four such elevations, so four such headers. The top-most one is at the middle of the bypass, height-wise, elevation-wise.

MEMBER BANERJEE: Okay.

DR. ALAMGIR: So we end up with 32 holes.

MEMBER ARMIJO: So the issue is migration of that boron through the gaps between the bundles.

DR. ALAMGIR: Correct.

MEMBER BANERJEE: Well, it is -- also, it goes down the bypass and comes up from the bottom, right?

DR. ALAMGIR: It can do -- realistically, it can do both.

MEMBER BANERJEE: Yes.

DR. ALAMGIR: Go down as well as migrate.

MR. WALLIS: And what's happening? Is it that it's boiling in the core, or at some level -- up to some level?

DR. ALAMGIR: A single phase.

MR. WALLIS: It's all single phase?

DR. ALAMGIR: In the bypass. But --

MR. WALLIS: No, in the core. It's got to get into the core, so it's got to go into a boiling region of some sort.

DR. ALAMGIR: Correct.

MEMBER BANERJEE: Can you show us the geometry of the system that is feeding the bottom? What does it look like, or describe it to us?

DR. ALAMGIR: Yes.

MEMBER BANERJEE: From the bypass to the core inlet.

MR. MARQUINO: I think the best thing is for us to get through the slides. We have a movie, and then, if we can get this material together that you're asking for and show you.

MR. WALLIS: Maybe another day. We have to investigate this.

MR. MARQUINO: Yes. Well --

CHAIRMAN CORRADINI: I think you should finish up, because you guys want to show a video of the -- of a simulation, is that correct?

DR. ALAMGIR: A slide first, and then two --

MEMBER BANERJEE: But just in words, can you just describe how it's coming in?

CHAIRMAN CORRADINI: Let's do it in words later. Let's move on. I really think we've got to finish.

DR. ALAMGIR: Realistically, or in TRAC conservative analysis? Which one?

MR. WALLIS: Realistically.

DR. ALAMGIR: Realistically, what I would expect. And I have seen the animation, and that's how it looks like. Convection is the dominant mode, not diffusion. Let me clarify that.

MR. WALLIS: Okay. Diffusion would take forever.

DR. ALAMGIR: Any cooling for diffusion for TRAC, I know it takes forever, yes.

You would expect that more of it will go down readily because of -- it's heavier, and then spread out to the core plate, across the core plate, and then find the holes in the lower part of the bundles.

It will also fall down like a jet, try to find the spaces convenient to it, and eventually reach towards the center line, affecting the bundle.

Now, boron negative reactivity, whether it's inside the bypass or inside the core, is -- doesn't really matter. But if it goes really inside the core, its effect is right away. So what we will see is the CFD analysis for boron is only for the spaces external to the channels boxes.

We also show how it is ingested into the channels. That is the scenario --

MEMBER ARMIJO: In this analysis, the boron doesn't get inside the channel. There is no way that the boron can get in, or --

DR. ALAMGIR: We are showing how it --

MEMBER BANERJEE: It can from the bottom.

DR. ALAMGIR: Yes. We are showing how it reaches the leakage holes, and how much of elemental boron is ingested into the bottom. But not what happens when it goes inside.

MR. WALLIS: In fact, the control rods aren't there, most of -- it helps it to get in, is it?

DR. ALAMGIR: The case we analyzed with all rods out. Also, we analyzed the sensitivity case where all rods are in for a particular --

MEMBER BLEY: Some rods are in.

MR. WALLIS: I think they blocked the flow passage.

DR. ALAMGIR: Because some rods were in, and then -- but not --

CHAIRMAN CORRADINI: So can we move on with the presentation?

DR. ALAMGIR: Yes. We will go to the slide that has two red curves, please, in the presentation.

MS. CUBBAGE: All right, all right, all right.

MR. WALLIS: I think we're spending time on this because it's a realistic case where something bad might really happen.

MEMBER BANERJEE: Unlike the other scenarios we have seen.

DR. ALAMGIR: Okay. Let me clarify a couple of things. One is that we are just bringing your recollection. The case I just made, the TRAC -- in TRAC analysis, the outermost ring is solid. I mean, the -- not the outermost, the second ring is solid. That means it cannot penetrate radially into the bypass. It has to go down and come up.

Therefore, here what we are showing is the red curves are CFD analysis, the black curve is TRAC, and we are showing mass of boron first in the bypass as a function of time. And 185 seconds is approximately the time, or 190 seconds, when the SLCS system is turned on.

We are seeing that in CFD analysis the mass is much more than in TRAC, because in TRAC, we don't allow it to migrate radially.

MR. WALLIS: What does this do to criticality? Can you show that on the map, too?

DR. ALAMGIR: That is in DCD.

MR. WALLIS: Oh, it's in the DCD. But that's what really matters, isn't it?

DR. ALAMGIR: Yes, we have enough negative reactivity insertion, so --

CHAIRMAN CORRADINI: They are just showing -- the way I view it is you are showing the bounding analysis of TRAC shows reactivity insertion. Reality is probably much better.

DR. ALAMGIR: Right. We are showing a delayed and less --

MR. WALLIS: TRAC does almost nothing.

MEMBER MAYNARD: Yes, I wouldn't even use it.

MR. WALLIS: TRAC makes it go down and come up again.

DR. ALAMGIR: Go down and then approach the leakage holes and come up.

MR. WALLIS: Is that included in this curve here?

DR. ALAMGIR: On the right-hand side?

MR. WALLIS: Does this include the other

way it goes in?

DR. ALAMGIR: I will explain the difference between the two curves.

MR. WALLIS: But TRAC seems to be showing almost nothing going in at all. So there's just --

DR. ALAMGIR: The left-hand curve is the mass of boron in the bypass spaces. The right-hand curve shows the mass that is going into the channels through the leakage holes.

MR. WALLIS: Almost nothing.

DR. ALAMGIR: Total mass, simulated mass.

MR. WALLIS: So TRAC says that it doesn't work.

DR. ALAMGIR: No, that's --

PARTICIPANT: TRAC says it goes up by about three kilograms.

DR. ALAMGIR: No. She should understand that this is the actual elemental mass of boron, not just the liquid carrying it. So --

MR. MARQUINO: TRAC says that enough goes in to shut the core down within about a minute.

DR. ALAMGIR: I would say about 120, two minutes.

MR. MARQUINO: Okay. Two minutes. TRAC says the core shuts down in two minutes.

MR. WALLIS: But on the figure it seems to be putting in almost nothing. I mean, one or two kilograms. It's enough?

MR. MARQUINO: It doesn't take much.

DR. ALAMGIR: Even then it does shut it down.

MEMBER ARMIJO: Well, what would you have to do to TRAC to make it look more like the CFD results? You've done a lot of artificial things with TRAC.

MR. MARQUINO: So let me explain why we in this case --

MEMBER ARMIJO: But it shuts it down. Does it shut it down?

MR. MARQUINO: Yes.

MEMBER ARMIJO: Okay.

MEMBER ARMIJO: What is the boron mass kilogram that shuts it down? You know, draw a horizontal line. At what point does TRAC shut it down?

DR. ALAMGIR: If you look at --

MEMBER ARMIJO: Is it 1 or .5 or where?

DR. ALAMGIR: About 320 seconds we shut down in TRAC.

CHAIRMAN CORRADINI: I think what they're asking, though, is --

MR. MARQUINO: How many kilograms --

DR. ALAMGIR: If you look at the area under this black curve, that is equivalent to the --

MR. MARQUINO: -- zero kilograms.

DR. ALAMGIR: -- to the mass, so --

MR. MARQUINO: 3.0 kilograms.

MEMBER ARMIJO: Well, TRAC never gets there.

MEMBER BANERJEE: This is not area --

MR. MARQUINO: I'm sorry. I'm sorry.

MR. WALLIS: You don't get three on the right there. On the right you get about one or one and a half or something.

MR. MARQUINO: Yes, it's like one and a half. Right.

MR. WALLIS: Well, maybe we need to look at this separately another day.

CHAIRMAN CORRADINI: I would suggest they move on. We'll look at this separately. I have it listed.

DR. ALAMGIR: So, in summary here, it lists -- summarizes --

(Laughter.)

That's fine. I needed a break.

The conclusions are that there is increased radial transport in the realistic CFD analysis, great amount of boron entering the fuel bundles compared to TRAC, and that that affects the shutdown of the core. It's faster.

MR. WALLIS: So what do you propose to argue now? That you should use CFD?

DR. ALAMGIR: We propose to argue that our TRAC analysis is conservative, so, therefore, the numbers we have provided in DCD that show certain margin is even better with the realistic analysis.

MEMBER BANERJEE: Well, we will have to look at this very carefully.

MEMBER ARMIJO: Well, maybe I missed the point. But by looking at your chart, I'd say that you won't be able to shut it down if you depend on that analysis. But there must be a line there that I'm missing that says --

MR. UPTON: Way, this is Hugh Upton with GEH. Are you guys being misled? Because what's plotted here is just the boron mass in the inner ring, in the inner core.

MR. WALLIS: The inner core. Well, basically, you should --

MR. UPTON: So it's not the total mass.

MR. WALLIS: -- fuel core and other parts of the core.

MR. MARQUINO: There's a lot more boron that's in the peripheral.

MR. WALLIS: Other parts of the core.

MR. UPTON: Correct.

MR. WALLIS: So if you would plot it -- if you had plotted the reactivity, that might have helped us.

MEMBER BANERJEE: I think this is too superficial for us to read any --

DR. ALAMGIR: And let me clarify the driving reason for showing this plot is that there has been some curiosity in terms of whether boron will be able to penetrate.

MR. WALLIS: Right.

DR. ALAMGIR: And that this --

MR. WALLIS: But you have experiments, do you, and you have CFD, which -- just experiments?

DR. ALAMGIR: We have experiments in -- yes.

MEMBER BANERJEE: It's pretty hard to -- well, to do experiments -- I mean, CFD with boiling stuff. So if the bypass -- in that bypass region, we are not boiling, then it might be more realistic.

DR. ALAMGIR: That is the case.

MEMBER BANERJEE: Okay.

DR. ALAMGIR: We'll move on to the first movie, which is -- which will show jet 1.

MR. WALLIS: Is this a movie of CFD or of TRAC?

DR. ALAMGIR: This is the CFD calculations, and that shows the lowest injector, and it will show two of the nozzles on the side and about 30 to 45 seconds, how the boron spreads into -- these are from outside to the center of the core.

MEMBER BLEY: On that other chart, when you say inner core, how small a region are we talking about?

DR. ALAMGIR: There are three rings. If you divide 1,132 by three, that's the number of bundles roughly in each.

MEMBER BLEY: Okay. Is the red the boron?

DR. ALAMGIR: Okay. So let's turn it on again. I didn't look at the --

MR. WALLIS: Do you have a time scale here somewhere?

DR. ALAMGIR: Yes. Not on this one, but --

MEMBER BANERJEE: It must be 320 seconds.

MR. WALLIS: But you say some of it comes in and goes out again, isn't that --

DR. ALAMGIR: Okay. So the injectors are in these two corners, upper end of the pipe. And you see the red injectors that inject the boron.

MR. WALLIS: It's interesting. You put a pipe in one place, and then you take it all the way around and then inject it somewhere else.

DR. ALAMGIR: And it spreads out along the periphery, then inward. And we can pause it at any moment you want.

MR. WALLIS: So when is it subcritical? Almost right away, when the yellow gets in there?

DR. ALAMGIR: From what we know in TRAC --

MR. WALLIS: I'm a bit surprised that the red is sort of fluctuating. It goes in and out again, and it also seems rather like a heartbeat. What code did you use?

MEMBER BLEY: What is the effects -- I can't read the scale, but --

DR. ALAMGIR: The scale is .1, and this is zero.

MEMBER BLEY: Yes.

DR. ALAMGIR: And so red, yellow, and orange, those are good.

MR. WALLIS: And green is what you need to make it subcritical, is it, or --

DR. ALAMGIR: That is not really superimposed -- timing, and so on, mass of boron. But we see -- it's possible to --

CHAIRMAN CORRADINI: I think we should move on, and I think this is a topic we will want to investigate further in a separate get-together.

DR. ALAMGIR: How about a free movie? I have a second one.

CHAIRMAN CORRADINI: Okay.

DR. ALAMGIR: Let's get --

MEMBER BANERJEE: Amuse us.

CHAIRMAN CORRADINI: Not too much amusement today. We want to --

DR. ALAMGIR: Critical slides on an injector, just five degrees offset. So you see the four injectors, they are injecting, and you see that they go in and then slosh around.

MR. WALLIS: So it flows along the core plate and --

DR. ALAMGIR: Yes, and also at the location of the injectors.

CHAIRMAN CORRADINI: This is still external to the subassemblies.

DR. ALAMGIR: External to the subassemblies, yes. One more time, Dr. White, and then my curiosity will --

MR. WALLIS: It seems to really build up at that -- whatever that place is that is part way in there.

DR. ALAMGIR: That is the center of the core. It's --

MR. WALLIS: That's the center of the core there? Which -- no, the place there. What is this other blue bar there, the big blue bar?

DR. ALAMGIR: Oh, this -- we are looking at an offset, a five-degree offset, so we are probably seeing --

MR. WALLIS: What is that big bar there?

MR. MARQUINO: I think that is where the -- so the thin lines or gaps where you're looking at the space between the sides of a channel, and there is one place where a channel is exactly lined up.

CHAIRMAN CORRADINI: It sliced it. So you are looking at it longitudinally rather than width-wise, that's all.

MR. WALLIS: Oh, okay. So it's artificial. It doesn't mean much.

MR. MARQUINO: So this CFD analysis has

proved that if you inject a dense fluid into a less dense fluid, the dense fluid will settle at the bottom.

MEMBER ARMIJO: That gravity works.

(Laughter.)

CHAIRMAN CORRADINI: Okay. Are you -- what's next?

MR. MARQUINO: We're done with the CFD. I think we have one slide on the other special events.

CHAIRMAN CORRADINI: Well, that would be good. I was told that you guys wanted to show a CFD of your special events.

DR. ALAMGIR: Dr. White just pulled up another one, and, as we close, this is as if you are inside a soft drink can looking at the rim, and it's coming at you.

MEMBER BANERJEE: X-rated color fiction.

CHAIRMAN CORRADINI: So did you want to show a simulation of another special event?

MR. MARQUINO: No.

CHAIRMAN CORRADINI: Oh, okay.

MR. MARQUINO: No, we just have one slide on the other special events in 15.5.

CHAIRMAN CORRADINI: Okay.

MEMBER BLEY: But just to make sure -- if we never looked at this again, it's GEH's claim that even with TRACG and all of the conservatisms that you put in, and the way you set it up and run it, you can shut this plant down.

MR. MARQUINO: Right.

DR. ALAMGIR: Yes.

MEMBER BLEY: The CFD just says you are very conservative, but that's -- you don't need it.

MR. MARQUINO: Right.

MR. WALLIS: Well, I think with TRACG you keep removing conservatisms until it works, and then you still have some left.

MR. MARQUINO: Yes. To be truthful, there was numerical diffusion -- before we did this blockage, when we compare it to the test, it was numerical diffusion, so we put the blockage in, and the blockage is very conservative but it still meets the acceptance criteria, so we're good.

MS. CUBBAGE: All right. Last slide in.

DR. ALAMGIR: Oh, yes. What's summarized here are the special events, some of the measures against acceptance criteria. The one level limiting event is station blackout. It is just summarized in here.

For the overpressure plant design, the --

it's the MSIV isolation position scram event that gives us pressures below 110 percent of design. Then, the maximum pressure in the vessel for an ATWS we showed was about 1,360, much less than the surface level C, 120 percent, which is 1,500 psig.

And plant maintains good -- lower temperature in containment and in the suppression pool, and containment pressures are below the design limit. So that is a summary of special events.

Thank you for listening.

MR. MARQUINO: Just to summarize, there is also two appendices in 15, the event frequency calculations in 15A and the radiation source term in 15B.

Next slide.

Chapter 15 shows that ESBWR meets all of the regulatory requirements for AOO, special events, and DBAs.

MR. WALLIS: So some of those frequency things will be very iffy. Predicting when someone is going to remove control rods during refueling must be extraordinarily difficult to do realistically.

MR. MARQUINO: I would agree that probably some of the human factor probabilities have the most uncertainty with them. Concerning ESBWR's design for lower event frequency, we developed an infrequent event category and included it in the licensing basis for the plant. ESBWR's passive safety features and large vessel produce a slower dynamic, relative to previous designs.

MR. WALLIS: You've done something -- I mean, you've done a very good job, thermal-hydraulically to design, but most serious events seem to involve human error. Have you done something really serious to reduce the probability of human error?

MR. MARQUINO: Yes. We have a large human factors engineering effort going on. I don't think you've reviewed Chapter 18 yet.

MR. WALLIS: No.

MR. MARQUINO: But we are doing things like developing -- there is like 40 simulators on different computers.

MR. WALLIS: Have you made it very simple to control, difficult to make mistakes, and that sort of thing?

MR. MARQUINO: Lots of water.

MR. WALLIS: Okay. We'll hear about that.

MR. MARQUINO: That's the key.

CHAIRMAN CORRADINI: Okay.

MR. WALLIS: That's probably the most important thing.

CHAIRMAN CORRADINI: Other questions for the members?

MR. WALLIS: A lot of water above the core.

CHAIRMAN CORRADINI: We'll take a 10-minute break. Back at 10:30.

(Whereupon, the proceedings in the above-entitled matter went off the record at 10:20 a.m. and resumed at 10:32 a.m.)

CHAIRMAN CORRADINI: Why don't we begin? I was told that I've erred on the side of 15 minutes is the canonical time, but we've got most of everybody back, so let's get started.

Mr. Bavol? Bavol?

MR. BAVOL: Bavol.

CHAIRMAN CORRADINI: Bavol. Excuse me. You'll start us off?

MR. BAVOL: Yes, I will.

CHAIRMAN CORRADINI: Okay.

MR. BAVOL: Good morning. For those of you who were not present at yesterday's presentation, my name is Bruce Bavol. I'm the lead project manager for ESBWR design certification review for Chapter 15, Transient and Accident Analysis.

Our team of reviewers will be briefing the Subcommittee today on the ongoing review of ESBWR DCD, and the following sections are going to be covered, 15.1, Introduction; 15 Alpha, Event Frequency Determination; 15.2, Anticipated Operational Occurrences; 15.3, Infrequent Events; 15.4, Accident Analysis; and then we'll be talking about ATWS and boron mixing. And also, we are going to be answering the Committee's questions as we go along.

I would also like to note that 15.4, Jay Lee will be speaking on Chapter 6.5, as was discussed at yesterday's meeting.

I'd like to reiterate, Amy Cubbage is the lead -- the team leader for this project, Chapter -- or for the ESBWR project, and the lead technical reviewers are going to be George Thomas, Dr. John Lai, Dr. Lambrose Lewis, Jay Lee, Ben Parks, and Chris Boyd from Research.

This slide indicates a summary of the regulations and guidance, pass through that one. And Chapter 15, RAI Status Summary, is as follows. The original number of RAIs started out at 119. We resolved 94, and currently we have 25 open items.

With that, I would like to introduce

George Thomas and Section 15.1.

MR. THOMAS: Good morning. I want to talk about these four topics, the slide pages on the ESBWR, and the events of evolution and the acceptance criteria and the analysis method and the requirements.

So ESBWR GEH eliminated more than 10 activeESF systems. Also, there were four I&C channels for the safety systems, and there were triple processors for the control systems. And all the I&C in the ESBWR are all pivotal, so because of all this we agreed that the event frequency will be much less than the current operating boiling water reactors.

MR. WALLIS: What do you mean it's expected to be less? Do you mean you're going to hold them to higher standards?

MR. THOMAS: Because they've got this N minus 2.

MR. WALLIS: Just a general statement. Does it mean anything in terms of regulation?

MR. THOMAS: The regulations don't --

MR. WALLIS: Do you want new reactors to have a lower frequency? Is there any kind of an expectation in terms of numerical values?

MS. CUBBAGE: That wasn't meant to be an expectation.

MR. WALLIS: Just --

MS. CUBBAGE: It was meant to say that we agree with GE's --

MR. WALLIS: Just a kind of general statement. It's not a regulatory statement of any sort?

MR. THOMAS: It's a staff that did it, you know, based on the --

MR. WALLIS: But does it imply anything in terms of how you're going to regulate?

MS. CUBBAGE: No.

MR. THOMAS: No.

MR. WALLIS: No, it doesn't. Okay. Thank you.

MR. THOMAS: In the regulation, right.

Okay. The next one.

This terms the AOOs, infrequent events, DBA, all these terms came before for -- I just want to say all of these terms are defined in our standard review plan, the new standard review plan which we issued in March. So these terms are already commonly known, actually.

Next one.

This table gives the details of the criteria and the frequency of each category. Okay?

And for this we assumed the pump is going to operate for 100 years instead of 60 years. So the events, you know, the AOOs, actually define which can have a more than 10^{-2}. Okay?

The infrequent will be less than 10^{-2}, and the criteria for both AOOs and infrequent events are -- there is no core inquiry. But the pressure is different, the RPV pressure. For the AOOs, the criteria is that it should be below 1,375 psig, but for infrequent events that can go up to 1,500 psig. So there is a difference between these two categories.

And we had a problem in accepting this estimated criteria of 1,500 psig. We went to have discussions with GE. And we made a decision, because according to ASME Section 11 requirement, you know, if the RPV pressure exceeds 1,375 psig, then they had to do the inspection and the analysis. So which one -- that one we said, okay, you know, that can go up to Level C for these infrequent events.

CHAIRMAN CORRADINI: But your judgment -- I just want to make sure I understand your judgment. Your judgment was because the frequency is small --

MR. THOMAS: Right.

CHAIRMAN CORRADINI: -- was lower, you allowed them to come up to the criterion of 1,500.

MR. THOMAS: Level C limit.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. THOMAS: Next one.

For the special events, you can see the criterias are different on a case-by-case basis. Station blackout, ATWS, you know, they all vary from each case. You know, it's all different.

CHAIRMAN CORRADINI: But in some sense, just to make sure I understand, too, with the infrequent events, it was a staff judgment to come down to 2.5 rem.

MR. THOMAS: Right.

CHAIRMAN CORRADINI: Of the TEDE --

MR. THOMAS: Right.

CHAIRMAN CORRADINI: -- versus --

MR. THOMAS: Right.

CHAIRMAN CORRADINI: Okay.

MR. THOMAS: That's a very small fraction of the 25.

CHAIRMAN CORRADINI: Yes, I understand.

MR. THOMAS: 25 is the limit.

CHAIRMAN CORRADINI: Sure.

MR. THOMAS: So we only have a very small --

MR. WALLIS: You're accepting this, or is this the GE-Hitachi proposal?

MR. THOMAS: What?

MR. WALLIS: You are accepting this 2.5, and all that sort of thing? Are you allowed to do that?

MR. THOMAS: We've got -- the limit is 25, so we are saying that it is --

MR. WALLIS: You are accepting this new category of accidents. Is this going to appear in the regulations somewhere?

MR. THOMAS: Yes. The regulation says it should be -- can go up to 25 rem.

MR. SHUAIBI: Because there is not a regulation -- there is not a specific regulation on every AOO and transient that is analyzed in Chapter 15. So this is -- your question is: is this their proposal, or is this something that we are accepting? It's both. They proposed it.

We went through a long discussion with GE about what this means and what it means in the context of the frequency of the event and the consequences of the event. And what we're briefing you today on is that they proposed it, we've gone through that discussion, we're accepting it.

MR. WALLIS: You are accepting it.

MS. CUBBAGE: And it is consistent with regulations and other regulatory practice of similar situations.

MR. WALLIS: So it has been done before?

MS. CUBBAGE: Not exactly, because we haven't licensed an ESBWR before. But there are similar situations where there is precedence for having an event that is not a design -- the design basis event that has a dose criteria that is a fraction of the Part 100 limits.

MEMBER ABDEL-KHALIK: How do these -- how does this accident category compare with the Condition 3 category in the whole ANS accident classification scheme?

MR. THOMAS: The BWR, we don't really follow that standard. We mostly --

MEMBER ABDEL-KHALIK: I understand.

MR. THOMAS: You know, we are following the regulations, and in the regulations there are really two categories, AOOs and the accidents.

CHAIRMAN CORRADINI: I think what he's asking you is -- that might be true, but did you happen to compare?

MEMBER ABDEL-KHALIK: Yes. Right.

MR. THOMAS: In our standard review plan, we -- they are not having this standard at all. I don't think the NRC endorses this standard. You know, in the old SRP, the standard was not there.

MEMBER ABDEL-KHALIK: Okay.

MR. THOMAS: Okay. This is the same approach we always use in the Chapter 15. High frequency events can have a small consequence, and the lower frequencies can have more severe consequence. So this concept is not new at all, because they are always this way from the beginning. So we are not deviating from this approach.

Most of the events in Chapter 15 are all outlined the Part D, and we are going to talk about Part D today in the afternoon. And our position is that, you know, all AOOs and the infrequent events identified in the SRP, which are applicable for ESBWR, should be analyzed. And we don't do the Chapter 15 review or base it on a PRA. We are doing, you know, deterministic type of review.

So even though we calculate the event frequency, we don't do that review based around PRA. And when the COL applications come, then are we going to do only the limiting case, if they don't change the fuel. If they keep the same 14E, then the same thing, you know, then they are allowed to do all these events again in the COL stage. They have to do only the limited cases.

Now, Dr. John Lai will talk about the event frequency. Oh, sorry, I've got one more, right? Yes. Right.

MR. WALLIS: There was something you said in your SER, the draft, that TRACG was not qualified for these new kind of events, the IEs? And there seemed to be -- the implication seemed to be that they can't use it for --

MR. THOMAS: I think this afternoon we are going to cover Chapter 31. At that time, we will go through TRACG for --

MR. WALLIS: Well, I read on page 5 that TRACG is not qualified for this new category of events, these IEs. So how can they use it for --

MR. THOMAS: No. In the subject of the topical report, most of the events there are analyzed, AOOs. They are not --

MR. WALLIS: Yes. But now there is a new category for which you can't use TRACG, apparently.

MR. THOMAS: Yes. That is one of the open items in Chapter 31.

CHAIRMAN CORRADINI: Can we get a clarification from the staff about that?

MS. WILSON: Yes. Hi, Dr. Wallis. It's more of a semantic thing. When the topical report for TRACG on AOOs was submitted, I don't think at that time GE had created the new category and separated the events out. So the events that TRACG is qualified for covers the infrequent events, but the topical report just hadn't been updated to that point, so just that -- the language --

MR. WALLIS: Maybe it needs to be --

MS. WILSON: -- was not updated.

MR. WALLIS: -- more clearly stated, then, because I got the impression from what I read in your draft SER that you couldn't use it for -- it hadn't been qualified for AEs. I mean, that maybe just needs to be clarified.

MR. DONOGHUE: I think you've got to understand that we are writing an SE that was based on Rev 3 and some preliminary information. And, you know, now as more information is coming in, yes, we have to update it. Right.

MR. THOMAS: Okay. We had a couple of issues. You know, we went through this. Initially, we did not want to put the safety limit of CPR in the technical specifications, and they want to put only the criteria. And we went through our discussions with GE, and GE agreed to the safety limit in CPR. So that was an issue we spent a lot of time.

And this one, ASME Level C issue, I already talk about that one.

CHAIRMAN CORRADINI: So could you take a bit of time, just a minute, about the third bullet? So what was -- I remember reading about this, but I didn't appreciate the difference. GEH was suggesting that acceptance criteria of 99.9 for fuel rods, and your response was what?

MR. THOMAS: We wanted a numerical value in the technical specification displayed in the current plants, so that if there is -- in regulatory actions, we had to put a penalty for the MCPR. So that whenever you do a licensing action, we change the safety limit MCPR.

CHAIRMAN CORRADINI: So the SLMCPR --

MEMBER BANERJEE: They want a spec on that.

MR. THOMAS: Right.

CHAIRMAN CORRADINI: Right. The spec -- but it's a different spec. GEH was proposing a different spec, which unless -- I'm trying to understand the subtle difference. It would avoid the same problem. The --

MR. THOMAS: They don't have any number there. They only say this criteria, 99.9 percentage of the fuel rods would be expected to avoid boiling transition.

CHAIRMAN CORRADINI: Right.

MR. THOMAS: They didn't want to put any number there. So we --

CHAIRMAN CORRADINI: That's a number. That's just a different way of expressing the number. I'm not --

MR. THOMAS: No, no, that was the criteria. That's not the actual number.

MEMBER BANERJEE: I think it is a lot easier to deal with the way they are doing it.

MR. THOMAS: Right. Mostly it comes with a -- I think it most likely may be like 1.19, and the operating limit will be like 1.30. So there is a lot of margin, and, you know, so that number 1.19 can be there for, you know, a long time, if they don't, you know --

MEMBER BANERJEE: And you will put your uncertainty on that number specifically, right?

MR. THOMAS: No, that comes with the number.

MEMBER BANERJEE: And then, you will

put --

MR. THOMAS: And we --

MEMBER BANERJEE: -- your penalty on that.

MR. THOMAS: -- we will review that number, and we --

MEMBER BANERJEE: If necessary, yes.

MR. WALLIS: Now, this SLMCPR is something that is plant-specific, isn't it?

MR. THOMAS: Yes.

MR. WALLIS: And I have always been mystified by them.

CHAIRMAN CORRADINI: So let me just -- I'm still not there yet. I'd like to hear from GEH about this.

MR. MARQUINO: Okay. A lot of the discussion with the staff had to do with the fact that there is not a DNBR meter or a CPR meter in the plant. And they pointed out the part of 10 CFR that requires -- it says something like a plant parameter must be measured and be a safety limit.

So we weren't asking for a change in the 99.9 value, but it was discussion about how is that measured, and where we compromised on was to put a safety limit, steady state CPR value in the tech spec as the safety limit CPR. And if we make a significant fuel change where we want to change that number, that allows the staff to review the justification of the change.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. SHUAIBI: Dr. Corradini, I guess the short answer from our perspective is that by putting safety limit MCPR in the tech specs it allows more regulatory control over the changes that they could make. They would have to come in for review if they make certain changes when we have safety limit MCPR in a tech spec, whereas if you put 99.9 percent, the way it's worded in there, it gives more flexibility. So that was kind of the discussion and debate that we went through.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. THOMAS: Just a bit on the temperature operating domain. We already had discussions about this yesterday, and this will come back under our Chapter 15 review, so --

CHAIRMAN CORRADINI: We'll come back to this.

MR. THOMAS: Yes, right. Dr. John Lai will talk about this.

DR. LAI: Yes, my name is John Lai. I am in the PRA Branch for reviewing ESBWR and boiling water related PRA issues. I am going to talk about the staff evaluation of Chapter 15 Alpha, just that appendix.

I actually was hoping GE, you know, would make a presentation before me -- that, you know, you won't be the first one to hear me talking about that.

There are three methodologies used to determine the infrequent event frequency. The first one is the initiating event is modeled in the ESBWR PRA. The number is directly taken from the ESBWR PRA. The example is like for a turbine trip we have an initiating event frequency there, just taken directly from the PRA.

But in some instances, the more detail is required, then additional analysis, not giving the PRA, are conducted. For example, for the turbine trip with total turbine bypass valve failures, so that gets into a little bit more detailed evaluation, is presented in 15 Alpha, 15A.

The second one is the event frequency is determined on the actual BWR, with experience. But, you know, GE takes the credit for the new design. For instance, for stuck open lead valve frequency, they are not using the numbers directly from the operating experience. They are taking the credit of the new designs. I don't know if I need to get into the detail on that or not. Yes?

CHAIRMAN CORRADINI: No.

DR. LAI: No?

CHAIRMAN CORRADINI: I understand what you're saying.

DR. LAI: Okay.

CHAIRMAN CORRADINI: Keep on going.

DR. LAI: All right. The next slide, please.

The third one is, for events involving multiple hardware failures or --

MR. WALLIS: Wait a number. this frequency -- the only criteria you have is that it's lower than 10^{-1}, 10^{-2}.

DR. LAI: Exactly.

MR. WALLIS: Is the only criterion.

DR. LAI: Right.

MR. WALLIS: It's not very difficult to meet that.

DR. LAI: Right. So --

MR. WALLIS: So it's not a very useful criterion.

DR. LAI: Yes. My job is just, you know, verify that, for all of these IE --

MR. WALLIS: But the real criterion for this category is consequence, isn't it?

CHAIRMAN CORRADINI: No. No, it's frequency.

MR. WALLIS: How do you decide --

CHAIRMAN CORRADINI: This is selection criteria.

MR. WALLIS: How do you decide it's not a design basis accident?

CHAIRMAN CORRADINI: Frequency.

MR. WALLIS: Frequency? Consequence doesn't come into it?

CHAIRMAN CORRADINI: If it's too frequent, you're going to put a more stringent requirement on it.

MR. WALLIS: If you had a frequency -- so that an infrequent event could be worse in consequence than a DBA?

CHAIRMAN CORRADINI: No. One-tenth the consequence.

MR. WALLIS: Oh. So the consequence is really what matters? The one-tenth the consequence is what really makes them different.

CHAIRMAN CORRADINI: So the curve that you don't want to go to in the technology-neutral framework is the perfect way of thinking about this. Frequency, consequence -- they are going down a step, and they've said that their plant accident is low enough frequency that they are allowed to go to a different regime of consequence.

MEMBER KRESS: Makes a lot of sense.

CHAIRMAN CORRADINI: Makes a whole lot of sense. Remember that, that we liked so much?

(Laughter.)

Just teasing with you.

MR. WALLIS: The DBA is going to be worse, right? DBAs can be worse. That's what makes them different.

CHAIRMAN CORRADINI: Yes.

MR. WALLIS: Okay. Thank you. That's the real thing that makes them different.

MEMBER KRESS: And you have to throw in sigma failure criteria.

MR. WALLIS: Because these infrequent events could have a very, very low frequency, right?

CHAIRMAN CORRADINI: By definition, they are infrequent. They are bounded, right? Let's go.

DR. LAI: The third methodology is for events involving multiple hardware failures or human errors. The event frequency is based on conservative estimates of the hardware failures, including the common cause failure, CCF, and the human errors, the events. Using this methodology are a lot of feedwater heating, also with the control rod run-in, and inadvertent shutdown of cooling function operations.

The staff reviewed all the 16 infrequent event frequencies, and we issued the two RAIs, and they have been subsequently resolved. So we found the results are acceptable.

Okay. If there are no more questions, I can introduce Dr. Lois.

DR. LOIS: Thank you. It seems to me that just about everything I had to say has already been discussed. Chapter 15.2, the AAOs and all that's been said in 15.3 for 15.2, which has been pointed out a number of times, is still a work in progress. We still have some responses to receive.

We already received -- resolved some of our original RAIs. However, they are not reflected in my couple of slides that I have coming up.

As Mohammed Shuaibi pointed out, this is based on Rev 3 of the DCD, and Rev 4 is out, and Rev 5 is forthcoming, which is not reflected in what --

MR. WALLIS: Can I go back to my argument here? Why isn't a LOCA an IE? It doesn't have any consequences. It's infrequent, so why couldn't it be called an IE?

CHAIRMAN CORRADINI: We're not asking what consequences it has. We're asking what consequences it's allowed to have.

MR. WALLIS: Oh. So the whole thing is an imaginary game again, right?

CHAIRMAN CORRADINI: Well, it's a limit. It's a limit.

MS. CUBBAGE: The ESBWR is being licensed under our traditional licensing regime, our traditional regulations. They are deterministic. GE simply justified having a greater consequence for some traditional AOOs based on their lower frequency.

MR. WALLIS: What matters here --

MS. CUBBAGE: Everything else is --

MR. WALLIS: What matters to me is not your games you are playing. It's what perception the public has when they look at what you're doing. You have defined a new class of accidents. You are saying that the -- that they are somehow different. And then, you are saying there are a certain kind of stylized accidents which we still call DBAs, for reasons which are not clear to me.

You are changing the words which describe your job. And that to me is a very important thing. You can't just casually do it.

MS. CUBBAGE: Okay.

MEMBER SIEBER: They will still be AOOs, right?

MR. DONOGHUE: When you say you -- we casually did something, you know, we changed the SRPs. We went through a process that involved public interaction. So, you know, I think we are doing things in accordance with the regulations. We have modified our guidance. We followed the procedures to modify the guidance, and that's what we are using for this review. I understand, you know, your point, and there are, you know, mechanisms to use to change the requirements that we are supposed to satisfy. But that's what our reviewers are using -- the regulations and the guidance that are in place. Okay?

MR. MARQUINO: I have to stick up for the staff here.

(Laughter.)

This is an area where the regulations were very complex, and we had to go through them, together with the staff, and GE was asking for something that was non-traditional. But we believe that it is covered by the current regulations, and we were able to work through to agreement eventually.

And to answer your specific question about DBAs, basically, what we are doing here is, as Amy said, there was a set of events called AOOs, and some of the events that were in that bin weren't really AOOs by the GDC definition, which is expected during the life of the plant.

So all GE was asking for is these events really aren't AOOs, and we can show you that they are not AOOs, and we want to move them into something else with relaxed acceptance criteria. And we are able to work through and do that.

MEMBER BANERJEE: But did you need the relaxed acceptance criteria?

MR. MARQUINO: In terms of needs, our customers would like these relaxed acceptance criteria, because it gives them better fuel economics.

CHAIRMAN CORRADINI: But why would -- I mean, logically, if I have something -- if I have something that is not going to occur once in the plant lifetime, but once in 100 plant lifetimes, why wouldn't I allow for a relaxed acceptance criteria? I don't want to impose the consequence of an AOO --

MEMBER BANERJEE: I'm only asking a rhetorical question.

CHAIRMAN CORRADINI: Oh.

MEMBER BANERJEE: Did you --

MR. MARQUINO: Well, we could have licensed the plant with a higher operating CPR limit, and there would be more fuel bundles required every refueling outage because of that.

MEMBER BANERJEE: So you get relaxation on the OLMCPR.

MR. MARQUINO: Yes.

MEMBER BANERJEE: Is that what you were looking for?

MR. MARQUINO: Yes.

MEMBER BANERJEE: Okay. That actually explains why you are doing it.

MR. MARQUINO: But, Dr. Wallis, I also want to add that for a LOCA --

MEMBER BANERJEE: Nobody does stuff for nothing.

MR. MARQUINO: Dr. Wallis, I also want to add that the frequency of a LOCA is not just less than 10^{-2}. It's much less than that. So if you want to put numbers on, what's the frequency of a LOCA, and what's the frequency of an infrequent event, it would be less than 10^{-2}, but it would be much less, so you may want us to go 10^{-4}, or something like that, to say it's a DBA. So there is -- it makes sense what we're doing.

MEMBER BANERJEE: So how much do you gain on the OLMCPR?

(Laughter.)

From 1.4 to 1.3, or something like this?

MR. MARQUINO: It's about .05. If you look in Chapter 15.3 --

MEMBER BANERJEE: .05.

MR. MARQUINO: Yes. We have the deltas in 15.3, so you can look at the worst delta in 15.3, the worst delta from 15.2, and that's what we're gaining.

MR. WALLIS: So this is a relaxation of the regulations that enables you to do something you couldn't otherwise do.

MR. MARQUINO: Not a relaxation of the regulations. It's within the -- it's sort of the traditional BWR licensing basis. It's a change to that, but it's still within the regulations.

MEMBER BANERJEE: It's based on our frequency argument now.

MR. WALLIS: Within the regulations, if you didn't have these IEs --

MR. MARQUINO: Yes, because we would be conservatively putting IE events in the AOO category.

MEMBER BANERJEE: For the IE events, the OLMCPRs are not calculated the same way, because the frequencies are different. Therefore, the uncertainties are different, and everything changes, right?

MR. MARQUINO: Yes. Now you are getting into the details of the analysis for the IEs. We set the operating limit based on the AOO events, and then we will do checks on the IE events to make sure that that 1,000 fuel rod failure number doesn't change as we come up with future core designs.

MR. WALLIS: Have you gone through that procedure, or is it still to come?

MR. MARQUINO: No. Well, we've gone through it for the equilibrium core and the initial core.

MEMBER BANERJEE: For the IEs.

MR. MARQUINO: Yes.

CHAIRMAN CORRADINI: Okay. Go ahead.

DR. LAI: Actually, to echo what Marquino said, a review of 15.2, the AOOs indicate that number one, the number of frequencies implied number of these events. And, number 2, that the design is sometimes more forgiving than the classical BWRs that we already have experience with.

Okay. Let's go on to the 15.3. For the frequent events, we essentially analyzed them, or reviewed them rather, like what classically in the standard review plan is referred to as an accident, regardless of what GEH -- what they call them.

The, of course, LOCAs you can review separately, and what was said before -- the operating limit for the MCPR is 1.3. As far as we are concerned, as far as this review is concerned, these values assumed -- and going back to Dr. Wallis' argument before -- the topical report for the -- on which this is based and the analysis was done has not reached us.

Mainly we assume that that report is correct, that that -- the code on which this analysis was based will turn out to be okay. It's in that context that we are stating that the margins of the ESBWR with respect to the upper limit are larger than what --

MR. WALLIS: But this OLMCPR does change from plant to plant, doesn't it?

DR. LOIS: That is with the fuel change, eventually. What is reviewed there is the equilibrium plant that Mr. Marquino referred to --

MEMBER BANERJEE: But is this partly due

to the fact that some AOOs have moved to the IEs now?

DR. LOIS: Yes, that's part of it. Yes.

MEMBER BANERJEE: There is, of course, other aspects, too.

MR. MARQUINO: Well, the other aspect is what we were -- we have written down, that we want to see the -- with the 14E fuel, we want to see the data.

MEMBER BANERJEE: Right.

DR. LOIS: In that case, then let me concentrate on some of the differences we had, and the arguments and the questions that we've asked GE. There are two transients -- the regular load ejection and the pressure regulator failure -- that they developed, for obvious reasons if you think about it -- very sharp power peaks. And the DCD did not contain an analysis of that either for the clad stress or possibly fuel melting. Those questions have been answered in the Rev 4, which is not included here in this review.

Next one.

The other problem we had with this is the DCD stated that either these were impossible, not going to happen, or inconceivable if you wish, and some of them they said, "Well, yes, it may happen. However, it will be prevented with the extensive instrumentation and the design of the plant."

As Mohammed Shuaibi pointed out yesterday, we asked GE to analyze them, find out what the consequences are, what the frequencies are, and then we will decide how to dispose of them, and where in that stage --

MR. WALLIS: It is very difficult to estimate the frequency of something like this. It is very difficult to estimate the frequency.

DR. LOIS: Well, John Lai might have a response to that.

DR. LAI: The staff -- in my section, we are looking to this analysis by GE. GE's approach is by using the -- we call it function linking analysis. Eventually, just take in consideration all the data amount possible, and come up with the initiating event.

MR. WALLIS: So this analysis has been submitted, and you're reviewing it now, or is it in progress? Finished?

DR. LAI: This would be considered an AOO?

DR. LOIS: No, these are IEs. Which is actually the classical --

MR. WALLIS: Because the frequency is low --

DR. LOIS: Yes.

MR. WALLIS: -- you hope.

MEMBER BANERJEE: In spite of the fact that it has occurred certainly in Japan, well, that is one of the reasons that we are going to --

DR. LAI: The Shika reactor, is that right?

MEMBER BANERJEE: -- in 1999. However, of course, this design is different from the --

MR. WALLIS: So it's --

DR. LAI: But they also thought it was pretty safe, I'm pretty sure.

DR. LOIS: Yes. As a matter of fact, I went back and I checked and reviewed the argument that the designer of that class of plants were offering and what they said, the words were pretty much alike. The arguments were pretty much the same. So --

MR. WALLIS: It's an IE? It's an IE?

DR. LOIS: It's an IE.

MR. WALLIS: So they have to submit an analysis showing that the consequences are below a certain thing?

DR. LOIS: Yes. Hopefully, that is what is done. Yes. And --

MEMBER BANERJEE: Do you buy these arguments, I mean, in spite of what happened in --

DR. LOIS: We're not there yet, we're in the process of getting to that point. From what we know so far, this is -- I would like to say that this is more resilient to the conventional plans to these transients that we have examined so far.

MR. WALLIS: Okay.

DR. LOIS: And, again, as I said, it is a work in progress. We still expect more information to --

MR. WALLIS: If the frequency became very low, could it become a DBA, and then --it would be allowed to have bigger event consequence?

DR. LOIS: Yes, it already has been decided.

MR. WALLIS: I'm really mystified by this. Again, this is --

DR. LOIS: Yes.

MR. WALLIS: -- if you accepted a much lower frequency than you might want to accept, it could become a DBA, and then you would be -- they would be allowed to have worse consequences?

DR. LOIS: Well, we don't know that yet. And --

MR. WALLIS: But it could be. It could be --

MR. SHUAIBI: Let me try -- I guess let me try to -- let me try to address that. I guess, you know, had they come in and said we wanted to do that, we would have had two years of discussion with them about why is it okay to call something a DBA. We have not gone there, so the what if scenarios, what if they had proposed let's call these DBAs or --

MR. WALLIS: If you don't know what it is, call it a DBA, because that gives you the most stringent requirements for consequences.

MR. SHUAIBI: No. These consequences are not the DBA consequences.

MR. WALLIS: Less stringent.

MR. SHUAIBI: Or less stringent than the DBA requirements.

MR. WALLIS: No. DBA requirements are -- the consequences are more stringent.

MR. SHUAIBI: No, no. I want to make sure -- no. The AOOs have --

MR. WALLIS: That makes no sense. The most infrequent thing should have the biggest consequence, right?

MR. SHUAIBI: It does. We may be talking past each other I guess.

MR. WALLIS: But that means they are the

biggest consequence.

DR. LAI: In addition to which -- what Mohammed said, the standard review plan already names the DBAs, and GE agreed to analyze those named in the standard review plan as DBAs.

Thank you.

MR. WALLIS: Well, they have no -- what is the incentive to make it an IE, then?

MEMBER BANERJEE: For this specific accident, to make it an IE, I mean, this seems a little bit of a stretch, right?

MR. WALLIS: Maybe, maybe not.

MEMBER BANERJEE: Well --

MR. WALLIS: It depends on the design and --

MEMBER BANERJEE: But the experience indicates that designs are fallible in this area.

MR. WALLIS: It has happened, right. It has happened.

DR. LOIS: Well, it depends on --

MEMBER BANERJEE: And we design and say this happens. If you look at the original -- as you say, you read the original Japanese, and the design looks infallible also, and then it fails.

DR. LOIS: Well, this design is different.

MEMBER BANERJEE: It's more infallible.

(Laughter.)

DR. LOIS: This design, it appears to have the frequencies of those events are lower, and the consequences are also lower. So that pushes everything --

MEMBER BANERJEE: The frequencies will be hard to prove, I would think, on this case.

DR. LOIS: Well, I would not argue with this. However, there is some experience in quite a number of those.

MEMBER BANERJEE: There's been a number of events. It's not just Shika. There have been others. I can probably give you a list of the Japanese ones.

DR. LOIS: It's priority work.

MEMBER BANERJEE: Yes. I'm sure you have it, yes.

MR. SHUAIBI: But I guess that's where our questions come from, is we look at what they propose, we, you know, evaluate it to determine whether we accept it or not, and we ask them questions to justify what they propose. And I think that is exactly what Lambros is saying is we know of some events that have occurred, and we want them to look at this in that context and show us and demonstrate and prove to us that this is something that we should accept. We haven't accepted it yet.

MR. LEE: Thank you.

MR. SHUAIBI: Is that --

MR. LEE: Excellent. Thank you.

CHAIRMAN CORRADINI: I'd like to switch out the next group here -- a new team.

Okay. I'd like to introduce Jay Lee, and he is going to be covering Chapter 15.4 and Chapter 6.5.

MR. LEE: Good morning. Yes. As Bruce said, I will be discussing Section 15.4. And I noticed this morning that GE-Hitachi got by with only three slides, and I have only 23 slides, and so --

(Laughter.)

-- this is not right.

CHAIRMAN CORRADINI: Something is wrong.

MR. LEE: I may have too detail in my slides.

CHAIRMAN CORRADINI: So feel free to skip a few.

(Laughter.)

MR. LEE: More detail than what you expected or you anticipated --

CHAIRMAN CORRADINI: Whatever you think

is --

MR. LEE: -- at this stage of review.

Okay. These are the key regulations and the review items we used. The Part 52.47 is, of course, content over application for standard reactor certifications, and the Part 100 is the siting criteria. Part 50, Appendix A, GDC-19, is a control room dose, control room operator dose, to meet 5 rem.

What we did, we used the SRP, the 15.03. This is a relatively new SRP we issued last year. We prepared this for the design certification review and also for the COL application with and without early site permit, and also the COL application with and without design certified reactors.

Under Regulatory Guide 1.183, this is -- we prepared this guide for current operating reactors, but most of guidance was provided in this particular regulatory guide is also applicable to the advanced reactor, like ESBWR. Then, NUREG-1465, this is the excellent source of data, but this goes into more detail in next slide.

Okay. This is a regulation we have. I guess it may answer some of your questions you came up with -- earlier questions you raised. This is direct quotation from the regulation, and this particular wording really appears in more than one place, in 52.47, and also 10 CFR 50 -- excuse me, 10 CFR 50.34(a)(1), and also in siting criteria, 10 CFR 100.

So this particular regulation appears more than one place, and it says that the fission product released assumed for this variation, for siting variation, shouldn't be based upon a major accident. It doesn't say that, oh, this major accident, whether it's a LOCA or a large break LOCA or a small break LOCA, but it's just based on major accident. And, further, it states that --

MR. WALLIS: It says it has to be based on possible accidental events, and if it's something impossible --

MR. LEE: Yes.

MR. WALLIS: -- you don't have to postulate it, do you?

MR. LEE: Right. Possible accidental events, such as fuel handling accidents, or main steam line break accident, control rod accident -- and I'll discuss those a bit later -- and this regulation further states that with the substantial meltdown of the core and for the source term, it says appreciable quantities of a fission product.

It doesn't say how much of activity is

going to be released, but it just states this quantities and -- so, really, regulation doesn't specify any particular source term, but just mentioned that we have to consider this amount of fission product release into the containment from the reactor core.

And the major accident and possible accidental events that -- just stated in the regulation is listed in SRP 15.3, Reg. Guide 1.183, and the staff -- we listed major accident as a LOCA, loss of coolant accident, typically a large break LOCA accident. And possible accidental events is, like I said, you know, such as main steam line break accident or coolant accident, small line break accident, or some other possible accident.

That regulation also stated that appreciable quantities of fission product released, or substantial meltdown of the core. This is given in the regulations.

CHAIRMAN CORRADINI: So at this point I guess, just to clarify, the way I view this -- and maybe this is an incorrect way, so I guess I'd look for your clarification -- is in some sense the alternative source term is the starting point. And one looks for an envelope of accidents, however nonmechanistic --

MR. LEE: That's correct.

CHAIRMAN CORRADINI: -- that would get you to that source term, and then you look to the containment and the systems within it to show that you can bottle up or --

MR. LEE: Mitigate.

CHAIRMAN CORRADINI: -- that you can mitigate the source term.

MR. LEE: Right. Yes. Like we discussed this morning, GE discussed three particular accident sequences.

CHAIRMAN CORRADINI: Right, right. Right.

MR. LEE: We made MELCOR -- such a way that -- so it will say, yes, you've got fuel melt or core melt. We have to have that fission product in the drywell, you know. That's the starting point for evaluating the deviation.

And this NUREG has, as you know, the four faces of release: CAD release, early SL release -- we discussed this NUREG with ACRS way back in 1994 or so in the 406th and 407th ACRS meeting, and you prepared a letter agreeing with us. We're using this NUREG for the advanced reactor design, and SOL is using only GAP and early invested releases for our evaluation.

So, really, regulatory issue for the review in this particular section, for 15.4, what the reviewer, he or she should keep in mind reviewing this section, is: does the ESBWR design, or any other design, provide adequate irrigation of radiological consequences in the event of a major reactor accident to meet the dose criteria?

Here we discussed this morning about prevention against the mitigation. This prevention is prevention of a core melt. The staff presented yesterday Chapter 6 dealing with ECCS systems, including the isolation condenser and standby control system, gravity drain, gravity-driven cooling system, and automatic depressurization system. Those are all ECCS system, and they are for preventing a core melt.

The mitigation part that I dealt this morning is just the mitigation, and prevention is of course first line of defense. The mitigation is defense in depth. And, Dr. Wallis, you asked this morning that -- where all of this activity is coming from, and this is not realistic to assume this.

But, you know, in the case in point like a TMI accident, the prevention part, they didn't play a role and the mitigation did. So this is strictly defense in depth.

MR. WALLIS: No, I understand that.

MR. LEE: Yes. It's in the regulation.

MR. WALLIS: I understand that.

MR. LEE: We follow that.

MR. WALLIS: So it gives me, you know -- as my colleague, Dr. Kress, said, reason to maybe reexamine what you're doing with regulations. When we get into beyond design basis, we seem to tolerate containment failure probabilities of .1, and yet when we're doing this we don't do anything like that at all.

So the real things that hurt the public are the ones where we should probably be worried about.

MR. LEE: Right.

MR. WALLIS: All of this other stuff, maybe it has an effect on safety, maybe it doesn't.

MR. LEE: Right. And the fission product, the way it's really releasing from the ESBWR reactor design into the environment, we have two release points, which is the containment leak and the main steam isolation valve. Containment leak is the object of the steam pole weight percent, and MSIV leak, which bypass the containment as well as bypass the reactor link, is at 200 cfh. These values are chosen by applicant, and they are in the ESBWR tech spec as a surveillance requirement.

And I understood that you raised a question about the potential leakage from isolation condenser. In the case of isolation condenser, the GE design has four radiation monitors for each isolation condenser pool compartment. There are four of them. And any high radiation signal from two radiation monitors out of the four will cause automatically main steam flow into the isolation condenser, and also condensate return line valve. It will cause -- it will isolate that. And also, the isolation condenser will come in at the LOCA signal before automatic depressurization system come on.

So, really, any steam or water in this condenser is very low in activity to begin with, if any.

CHAIRMAN CORRADINI: So jus tone -- maybe my memory is wrong, but I thought 10 CFR 100 had a containment performance of .1 percent of volume per day, and here you have a leak of .4. I thought it was .5 I read.

MR. LEE: No. The regulation doesn't specify any containment leak. This containment leak rate is strictly chosen by applicant to meet, and it's coming in the few next slides, but --

CHAIRMAN CORRADINI: But you have to have surveillance, right?

MR. LEE: Yes, they are. As I say, they are tech spec values, and they have to test I think every -- every five or 10 years. A certain period they do have to test and meet a requirement. This leakage rate varies with a different reactor design.

Okay. Technical topics of interest is this, that ESBWR design doesn't provide an active fission product mitigation system, such as safety-related spray system, which I believe is most efficient mitigation system to remove a fission product in a containment.

ESBWR, they don't provide any safety-related filtration system other than the ones in the control room that have been built in the system. So like a current operating PWR, all of them has like a standby gas treatment system, which removes the aerosol particulate, a HEPA filter, and they have a charcoal filter to remove iodine. Those are very effective in mitigation -- active mitigation system.

ESBWR, they do not have any such active mitigation system. Instead, the design provides the six -- I listed here the passive fission product mitigations. I'll go each item in subsequent slides, but the first one is the fission product, natural deposition in the containment. This is somewhat similar to the AP600 and AP1000 approach. They also claimed fission product removal by this natural deposition. This plays a very major role in the ESBWR design for removing a fission product.

And the next one is fission product removal by passive containment cooling system. Of course, this is very unique to the ESBWR design inside of containment.

MR. WALLIS: How does it remove? Does it flow into the condensate or something?

MR. LEE: Yes, the subsequent slide will show -- I'll explain in more detail.

Also, they rely on low containment leak rate. In this case, they have a .4 weight percent -- but they -- the fission product holdup in the reactor building, and control room pH water in the containment pools to prevent any iodine reevolution from the water, and also fission product natural deposition in the main steam line and main condensers.

Those are the mitigation that GE depends on their ESBWR design, and I'll go each item in more detail.

The first and foremost important is the fission product natural deposition process in the containment, and which staff performed an independent confirmatory calculation to verify the fission product removal rate proposed.

MEMBER BANERJEE: How did GE perform these calculations?

MR. LEE: GE proposed that calculation in their DCD.

CHAIRMAN CORRADINI: But they used MELCOR also.

MR. LEE: Yes.

CHAIRMAN CORRADINI: That's what I --

MR. LEE: Right.

CHAIRMAN CORRADINI: That's what I think you --

MR. LEE: Doing this work using a MELCOR, we did ask Sandia National Lab to help us to run this MELCOR code and to verify their number. And, in fact, we have two principal investigators from the Sandia is here to assist perhaps any questions you may have.

And this deposition process involves three processes in gravitational settling. This occurs mainly in the containment drywell, containment atmosphere. And the diffusiophoresis, this is the process that mainly occurs in the PCCS condenser and the thermophoresis is.

And the diffusiophoresis is, of course, associated with steam condensation on the heat sink. In this case, it is the heat exchanger tubes.

CHAIRMAN CORRADINI: And then, once it's deposited, would it wash away with the condensate?

MR. LEE: Yes, it will.

CHAIRMAN CORRADINI: Okay.

MR. LEE: And I have the slide for --

CHAIRMAN CORRADINI: That's fine. I just wanted to understand.

MR. LEE: -- later. Yes.

And we used the MELCOR code. Actually, we used the ESBWR specific containment model in the MELCOR code to get the thermal hydraulic conditions, such as drywell pressure and steam and water flow rates and the condensation rates. Those thermal hydraulic conditions came from the MELCOR code.

And also, we performed -- maybe I should say we are performing -- oh, okay, in this case we did perform quantitative analysis of uncertainty in predicting the removal rate using Monte Carlo sampling method. This is -- again, Sandia did it for us, and it shows in the next graph.

This is the accident scenario 1 that GE described this morning. This is the reactor vessel bottom drain line failure. This has -- well, this assumed no isolation condenser, no standby liquid control system, or no gravity-driven cooling systems available. But automatic depressurization system will work, and this is the removal rate we are comparing with the GE values.

MEMBER BANERJEE: Now, you say used in RADTRAD. Is that --

MR. LEE: RADTRAD is --

MEMBER BANERJEE: What is that?

MR. LEE: -- that's the computer code to calculate the dose that GE used, and we would be using also RADTRAD code.

MEMBER BANERJEE: But the black line is --

MR. LEE: The black line is GE values.

MEMBER BANERJEE: How did they calculate that, with MELCOR, the same code?

MR. LEE: Yes, I believe they used the MELCOR code to calculate --

MEMBER BANERJEE: And it was using a different containment model, a different containment nodalization, or what is different between the GE and the Sandia calculations?

MR. KALINICH: Would you like me to clarify this for you?

MEMBER BANERJEE: Yes.

MR. KALINICH: I probably don't need the mic, but if you insist.

CHAIRMAN CORRADINI: They insist.

MR. KALINICH: Never had anyone tell me I'm not loud enough.

CHAIRMAN CORRADINI: This is for posterity, not for volume. This is to get it on tape, not to --

MR. KALINICH: No problem. My name is Don Kalinich. I'm with Sandia National Labs. I work for Randy Gauntt, and I guess -- what's our department called now?

MR. GAUNTT: Reactor Model Analysis.

MR. KALINICH: There we go. And basically what we -- what was done was GE ran a full ESBWR reactor model, so they had the full core package, a containment. They ran the model, MELCOR predicted how the core would fail, what the release would be, how that release would go to the containment, and they calculated a containment removal coefficient.

What we did is we had a separate ESBWR MELCOR model. We took the containment-only portion of that, and then we used the flows between the reactor side and the containment side from the GE model as boundary conditions on our model. So our containment is modeled slightly differently. I mean, you still have a drywell and a wet well, and all of that, but how you nodalize it and what your heat structures might look like, there is some differences. So --

MEMBER KRESS: When you say you use MELCOR, MELCOR has meltdown models, fission product release models.

MR. KALINICH: That's right.

MEMBER KRESS: You didn't do that.

MR. KALINICH: We didn't do that. What we did is -- that's what GE did. GE did a full-on, let MELCOR predict what's going to happen.

MEMBER KRESS: And nothing happens, right?

MR. KALINICH: No. Actually, it does, because they go in and they do -- they walk through this stylized scenario where basically they suppress the GDCS operation, so that they get a core melt. And then, right before they get lower head failure, they turn the system back on, so that you have something --

MEMBER KRESS: So that's where they get their source term.

MR. KALINICH: That's where they get their source term.

MEMBER BANERJEE: But this is the source term coming out of the --

MEMBER KRESS: Out of the containment -- into containment.

MR. KALINICH: In the containment from --

MEMBER BANERJEE: And what about deposition within the system itself?

MR. KALINICH: That's what they calculated.

MEMBER BANERJEE: Yes. No, no, I'm saying within the primary cooling system.

MR. KALINICH: That would be included in their calculation.

MR. LEE: Yes. NUREG-1465, those numbers are already considered.

MEMBER BANERJEE: I'm just trying to understand what you did.

MR. KALINICH: Well, I'm getting to that. Okay? So that's what GE did. What we did is we didn't run a full reactor model, because we wanted to do an uncertainty analysis, and these models take on the order of five to 10 days to run, and we wanted to run 150 realizations. And even with a rack of servers, it's just not tractable to run the full model that way. So what we did was we said, okay, we just want to run the containment side.

So we took a containment-only, just the containment side, and we drove it using the results from GE's work as boundary conditions.

MEMBER BANERJEE: But where was the boundary condition?

MR. KALINICH: The boundary conditions were --

MEMBER BANERJEE: At the break or whatever it was?

MR. KALINICH: The break, the flows from the SRVs, the flows from the DV -- the depressurization valves, the flow back into the reactor out of the GDCS pools. So, basically, if you think about it, if you just kind of drew a line between the containment and the reactor vessel, what we did is anything that was passing in and out as through a MELCOR flow path, we turned into a source or a sink in our containment-only model.

And we have a report where we go in and we say, "Here is what GE's results look like in terms of drywell temperature, drywell pressure," and we compare our results to it to show that we are getting the same sort of behavior. So then what we did is rather -- so the question now is: what source term did we use? We used NUREG-1465, so we applied the NUREG-1465, you know, what fractions come out in the gap, what fractions come out for early in-vessel to the ESBWR, core inventory, and then we just source those directly into the drywell.

So we basically followed the regulatory prescription, and then what we did is we varied the aerosol physics parameters, things like what's the mass median particle size diameter? What's its geometric standard deviation? You know, things having to do with Cunningham Slip Factor. There's about 12 of them, and we have those documented in a report, what we did, how we picked them.

And we ran 150 realizations, and that's what you're seeing here. So this --

MR. WALLIS: Why does it wiggle so much? What's happening to make it bounce around?

MR. KALINICH: That's a good question. And if you guys really want, we could try to sit down and -- Not today. I don't think we want to. But we have a report that explains that.

CHAIRMAN CORRADINI: I think that's what we would like to get when it's appropriate from the staff. But that would be the starting point.

MR. LEE: Yes. It is in draft form right now, and we'll have it final form maybe sometime in --

CHAIRMAN CORRADINI: I'll let Amy tell us when we're allowed to see it.

MR. WALLIS: But something is really happening every time it goes up and down, something to make it happen?

MR. KALINICH: Well, what this is looking at is this is looking at the instantaneous removal coefficient, and so any slight change in the behavior gives you some wiggles in there. And, you know, I mean --

MEMBER BANERJEE: But there are some correlated wiggles.

MR. KALINICH: Well, we actually do -- we actually have an -- we go in and we do a linear regression on the uncertain parameters to see what is driving the results.

MEMBER BANERJEE: So you have an explanation for this? I mean, do you have an explanation why that first dip occurs?

MR. KALINICH: Yes.

MEMBER KRESS: Is this primarily diffusiophoresis?

MR. GAUNTT: I could offer a quick answer to that.

MR. KALINICH: Okay.

MR. GAUNTT: My name is Randy Gauntt, Sandia Labs. A quick answer to that is most of the fine structure that you see there can be traced back to thermal hydraulic nuances in the problem.

MEMBER BANERJEE: And what about the correlated nuances, like all this behavior --

MR. GAUNTT: Well, all of those realizations are using the same thermal hydraulic driving conditions. So --

MR. KALINICH: Yes. The idea is to look strictly at the uncertainty in aerosol physics.

MEMBER SIEBER: That's the spread.

MR. KALINICH: That's right. So this is the spread. So any given realization, it is going through the same thermal hydraulic signature. It's just the distribution of particle sizes for the source look different.

MEMBER BANERJEE: But say about one hour, your removal coefficient is about two orders of magnitude different from GE.

MR. KALINICH: Well, let me explain. The GE curve -- what GE did is they ran one deterministic simulation. They have a curve that probably looks very similar. RADTRAD looks -- says you can have up to 10 constant periods for a removal coefficient. And so somehow they took their data and they said, "This is the stair-step function we are going to put into RADTRAD."

CHAIRMAN CORRADINI: RADTRAD requires bins, and they have --

MR. KALINICH: That's right.

CHAIRMAN CORRADINI: -- an array and it's only 10, and so you've got to decide a number.

MR. KALINICH: That's right. And so all I've done is overlay GE's RADTRAD input, which is derived from a MELCOR model, on top of our 150 realizations to see how they compare. And what we would like to see is that they lay somewhere within the bounds of what our results are, and, if not, then you need to start looking at what is the differences between your models to determine what is going on there. But there is --

MEMBER BANERJEE: If you use the same code and the same thermal hydraulic driving conditions, why do you expect it to be different at all?

MR. KALINICH: It could be different -- well, because we are -- well, the purpose of this was to look at what is the effect of uncertainty in aerosol physics? And we didn't use exactly the same model, like --

MEMBER BANERJEE: Hopefully, both are converted in some sense.

MR. KALINICH: And, in fact, I --

MEMBER BANERJEE: It shouldn't make any difference at all.

MR. KALINICH: What makes me kind of happy about this analysis is the fact that even though we didn't use exactly the same sort of containment nodalization, we get results that are very similar. So that's -- it's nice to know that, you know, you go in and you change that, and you don't get results that are widely divergent. It makes you feel comfortable that your models are reasonable.

MEMBER BANERJEE: Okay. Well, thank you.

MR. KALINICH: But that's basically what you are looking at here is 150 realizations of our work with GE's single deterministic realization laid over top of it.

MEMBER KRESS: Each determination uses a constant shape factor?

MR. KALINICH: Excuse me.

MEMBER KRESS: Each determination keeps the shape factor constant?

MR. KALINICH: Yes. The shape factors don't vary with time. They vary between realizations.

MEMBER KRESS: They vary between realizations.

MEMBER BANERJEE: If I understand, you varied these 12 parameters within -- what you said were sort of three parameters and the problem within a certain range in some way that --

MR. KALINICH: It would depend -- like, for example, the mass median particle size diameter, we used the triangle distribution with a lower bound of .1 micron, a peak of two, and a max of five. And, you know, like I said, each one of those -- there is the distribution and there is an explanation for why we believe that's a reasonable distribution to use on those -- on that parameter. It will be in the final report that we provide to the NRC.

CHAIRMAN CORRADINI: So in the final report you used RADTRAD also for the dose?

MR. KALINICH: No, sir.

CHAIRMAN CORRADINI: You used mass --

MR. KALINICH: We're just predicting -- we're just providing the removal coefficients, and then the NRC is going to do their own RADTRAD analysis.

CHAIRMAN CORRADINI: Okay. Thank you.

MEMBER ABDEL-KHALIK: Is the aerosol physics the major source of uncertainty in this problem, or could it be the boundary conditions that you took from GE's calculation?

MR. KALINICH: Could be.

MEMBER ABDEL-KHALIK: So how do you ascertain that?

MR. KALINICH: Jay, do you want to answer that question?

MR. LEE: No, it's not --

MR. KALINICH: No, you don't want to answer it, or no, you --

(Laughter.)

MR. LEE: Doesn't want to answer it.

MR. KALINICH: I'm going to let Jay answer that. Oh, I'm going to defer to my boss on this one.

(Laughter.)

I was -- this was the problem I was asked to analyze.

MR. GAUNTT: I'm trying to process the question. The only variant that is shown in those plots, if you want to call them that, is due to the variance from sampling over aerosol --

MEMBER ABDEL-KHALIK: That we understand.

MR. KALINICH: But they want to know if like, for example, if there were things that would influence the thermal hydraulic, would that be more important than this?

MR. GAUNTT: Oh, I see. I see. Well, I guess in a sense there are three separate scenarios that we have analyzed here, and they all show slightly, you know, different thermal hydraulic transients. And so we've just run all three of those. We have not tried to include thermal hydraulic uncertainty in any given scenario we analyzed here.

MEMBER KRESS: This is primarily played out in the --

MR. GAUNTT: Yes, and it's very --

MEMBER KRESS: How well you calculate those. And probably a lot of it goes into the PCC --

MR. GAUNTT: It's a pretty fascinating system. I think there are some more curves, some more diagrams that Jay is going to show. But unlike, you know, your traditional PWR analysis where things just kind of fall out, or you may spray them out, or things like that, this is a very dynamic system. And the vessel, you know, it is designed to sit there and boil water indefinitely. This steam goes into the drywell, and it finds its way into the PCCS, and eventually back into the vessel. So it's a big reflux system.

CHAIRMAN CORRADINI: So I guess I -- I don't want to cut off this interesting discussion. We have a time check. In half an hour you will -- the whole team will be done.

MR. LEE: I'll try.

CHAIRMAN CORRADINI: You will be done in half an hour, so I want you to decide how you want to get there.

MR. WALLIS: How realistic --

MR. BAVOL: Go fast.

MR. WALLIS: How realistic are the thermal hydraulics that go into this? Is this just a vessel that is boiling off into an environment, and it's something that's pretty well understood?

CHAIRMAN CORRADINI: They use the same thermal hydraulics as the GE folks.

MR. WALLIS: Well, is that something that is contrived, like the way they got to this state, or is it a realistic thing?

MEMBER KRESS: Well, you have non-condensables affecting the condensation rate.

MR. WALLIS: So it's realistic thermal hydraulics now?

MEMBER KRESS: Oh, yes. It's pretty good

thermal hydraulics.

MR. WALLIS: Okay. So it's not contrived, like how we got to the beginning of this.

MEMBER KRESS: And, again, it's assumed well --

CHAIRMAN CORRADINI: The initial conditions that initiate it, of course. The rest is calculated.

MR. WALLIS: So we have some faith in the thermal hydraulics. Okay.

MR. LEE: So the main point to show you, this curve is the -- GE and our numbers is reasonably agreed with, and that's --

MR. WALLIS: Well, you did -- you played the same game and got the same result, so I'm trying to figure out if the game is realistic. That's all.

MEMBER BANERJEE: Hopefully, MELCOR doesn't give random answers. Hopefully, MELCOR doesn't give random answers. We are reassured by that.

MR. LEE: Yes. We did use the same MELCOR code.

MR. WALLIS: We have to believe Tom Kress, I think.

MR. LEE: Okay. This is just the same

curve and the same way we did, and this is for accident scenario 2, as GE described it this morning. There is a slight difference in the GE value and ours from, let's say, five hours to the 10. GE values are slightly higher than our numbers.

The Y-axis in the low scale, so we are really talking about difference between .1 to the .5 removal rate. But when we reach this point, like after six hours, most of the aerosol has been removed. We are talking about the small, fine aerosol at this stage of time.

MR. WALLIS: What matters is the deviations from the values when they are big.

MR. LEE: Right.

MR. WALLIS: We don't really worry about the small values. There are some fairly big deviations at the beginning where it makes a difference.

MR. LEE: We do have some explanation of the way it -- the curve shapes, but we are not going to go into detail. But we will give you an idea.

And the next curve is the accident scenario 3. In this case, GE value is more conservative.

MR. WALLIS: Well the real thing that

matters is not all of these wiggles, or what is the bottom line, how much did you remove?

MR. LEE: Yes. Bottom line is we have to calculate the dose, how the dose --

MR. WALLIS: Right.

MR. LEE: -- is affected, and we have not done that yet, because there are other open issues which I'll describe.

MR. WALLIS: That's what matters, isn't it?

MR. LEE: Yes. Until we get those remaining open items resolved, then we are able to calculate the dose, actually compare the dose instead of removal rate.

MEMBER BANERJEE: So in this specific figure, there seems to be, at least at the longer times, some significant deviation of the black line from this bunch of --

MR. LEE: Why we differ on these two lines, and our -- our lines are not covering GE value for the accident scenario 3.

MEMBER BANERJEE: And yours seem quite a bit higher.

MR. LEE: Yes.

MEMBER BANERJEE: I mean, maybe it's --

MR. KALINICH: I don't think you want me up there if you want to get through this.

CHAIRMAN CORRADINI: No, we don't. And I think we can defer this at this point, since you haven't gotten a dose calculation from this. I think when that occurs, then we can look at it --

MR. WALLIS: Presumably, Sandia predicted the integral of all of this removal?

MR. GAUNTT: Yes, we have. Yes.

MS. CUBBAGE: Right. I guess the --

MR. WALLIS: You're not going to tell us that? Did you -- how much did you remove?

MR. GAUNTT: Out at that point in time, it's -- I don't know how many nines we're talking about, but it's -- it's mainly residual, very fine aerosol that's hanging up in the wet well vapor space.

MR. KALINICH: Yes. If you take a look, what's driving the latter time curves is what is going on with the small amount of material that's hanging out in the wet well. And I don't even need to say this, because you're not going to finish.

MS. CUBBAGE: I know, but for the transcript you have to be at a mic.

MR. LEE: Next slide.

Okay. This fission product removal by

passive containment cooling system is a unique design for ESBWR. This is our first scale of open issues, and we are proceeding with the rate analysis of steady state iodine transport within the containment. Again, we asked this to the Sandia -- to come up with a steady state transport phenomena between these various components -- reactor pressure vessels and drywell, PCCS, and GDCS, and to confirm the GE numbers. Randy is doing this particular study.

MR. WALLIS: I read in your SER that MELCOR was going to be used to estimate fission product removal in the PCCS. Is MELCOR set up to model the PCCS, so that it can predict fission product removal? It is?

CHAIRMAN CORRADINI: Yes.

MR. WALLIS: Is there that much detail in it?

CHAIRMAN CORRADINI: That was the point of the original tool.

MR. WALLIS: Okay.

MEMBER BANERJEE: Is MELCOR the only calculational methodology that you have at the moment?

MR. LEE: That's the only code -- the NRC code we have, yes.

CHAIRMAN CORRADINI: Historically --

MEMBER KRESS: Historically, you could use contain, but --

CHAIRMAN CORRADINI: Historically, contain is inside of MELCOR. Hector is inside of MELCOR. All of those basic physics have been subsumed into MELCOR.

MEMBER BANERJEE: And General Electric uses the NRC code.

MR. LEE: MELCOR, yes. I suppose they could have used MAPCODE, for example.

CHAIRMAN CORRADINI: Then you'd have more questions.

MEMBER KRESS: Yes, you'd have lots of questions then.

CHAIRMAN CORRADINI: I think you should be happy.

(Laughter.)

MR. LEE: Randy, do you want to describe this open item, and then we'll --

MR. GAUNTT: Yes. Some work that is ongoing right now for Jay is tied in with the dynamics of iodine behavior in this reactor. And, in particular, the chemistry leading to partitioning of iodine, either in forms that are retained in the pools or else that can be evolved out as an elemental form.

And this diagram here kind of shows the --

illustrates the cycle that is in place. In the ESBWR, there is always water in the primary system, and it is continually boiling. That is how the heat is ultimately taken out of the core. That steam goes into the drywell, ultimately through the PCCS system, condenses in the PCCS and drains into the GDCS and ultimately back to the vessel. So there is a continuous cycle there refluxing through the system.

Now, in the regulatory model here that we have, we toss in -- fission products into the drywell. That is what the NUREG-1465 is, and those fission products include cesium iodide, some amount of elemental iodine. And in the chemistry model, what happens ultimately is the cesium iodide begins its life in the drywell as particulate. The PCCS -- they are swept into the PCCS by the steam, pretty effectively deposited on the water film in the PCCS.

Now, the cesium hydride -- the cesium iodide is aqueous. And it makes its way back into the vessel, and the chemistry model now assumes you have CS plus and I minus. So you have this collection, this sweeping, this scavenging of the cesium iodide. It's gathered into the vessel, becomes aqueous.

MEMBER KRESS: It's in the vessel water.

MR. GAUNTT: It's in the vessel water.

MEMBER KRESS: Where there's a lot of radiation.

MR. GAUNTT: Where there's a lot of radiation.

MR. WALLIS: So, then, it's released again when it comes out of the vessel? Is it steam?

MR. GAUNTT: Yes, it's a cycle here, and we -- and we are out to characterize what is that partitioning.

Now, in the vessel --

MEMBER KRESS: This is a lot different than normal.

MR. GAUNTT: A lot different than your normal sump kind of situation in --

MEMBER KRESS: Seems like you're just moving iodine around.

MR. GAUNTT: You're moving it around, and what we are attempting to do in our analysis is understand the dominant rate processes here. Within the vessel, there is iodine chemistry going on. It is pH-dependent, and so our model considers the presence of buffers, sodium pentaborate, it considers the radiolysis of water, it considers the --

MEMBER KRESS: It won't have any nitrogen in there, will it?

MR. GAUNTT: I'll get to the nitrogen. A little bit of a research uncertainty is how much cesium comes in as cesium hydroxide. And emerging evidence from Febus experiments suggests a lot less than we thought. And that has an impact on the pH of the vessel water.

And the pH is really the principal thing that determines how much iodine stays in that water and how much gets evolved out in gaseous form. That's the whole point of the water chemistry model is to determine what that pH is, and then determine the transport of gaseous iodine out of the water into the air space in the upper vessel.

From there, it is swept out into the drywell, and, again, back into the PCCS where gaseous iodine can, once again, return into the water film and be taken back to the vessel. So there are these rates going on within the atmosphere of the drywell. There is -- then, it gets worse. There is radiolysis in the air, creating nitric acid.

In the lower drywell, there is radiolysis and thermal attack on cable insulation that's releasing hydrochloric. And both of these sources of acid are also swept through the PCCS system, and they find their way into the vessel as well. And this is all tied into a calculation of the -- an analysis of the pH.

Ultimately, long term these acids can overpower the presence of any buffers, and possibly take this pH from, you know, initially it might be as high as eight, owing to the presence of the buffers, but in time, as this acid content grows, it could take the pH below seven.

MEMBER BANERJEE: What is the limiting -- is it the chemical kinetics that limits things, or is it the rate processes like mass transfer, and things like that?

MR. GAUNTT: You know, that is what we're trying to determine from this, because it's a dynamic problem. It's not like the -- as Tom mentioned, it's not the PWR sump thing that we are used to thinking about. We have got this flux of materials, and we want to know, does the uptake in the PCCS remove gaseous iodine faster than it can evolve out of the vessel?

MEMBER BANERJEE: Yes, I suppose -- I mean, at one extreme you could use a lump parameter model with the right chemistry and get more or less the same answers, right?

MEMBER KRESS: It seems like you're going to get a -- some sort of steady state thing in those rate --

MR. GAUNTT: That's ultimately what we're looking for is, what is quasi-steady I2 concentration in the drywell?

MEMBER KRESS: And even if you have a leak rate, it is going to -- it is going to try to hold it at that steady state anyway. It's going to set there and leak iodine out.

MEMBER BANERJEE: I guess the thing is: what is really important here? What is the really important series of steps here? What's the important physics of chemistry?

MEMBER KRESS: Well, that's what they're trying to find out.

CHAIRMAN CORRADINI: My guess is --

MEMBER KRESS: What is this going to have to do with this determination of the pH? That's not an easy task.

CHAIRMAN CORRADINI: If I might just interject, the complete presentation has got to be finished in 15 minutes. How are you doing?

MR. LEE: Probably five. Next slide, please.

(Laughter.)

CHAIRMAN CORRADINI: Including your colleagues next door there?

MS. CUBBAGE: Yes.

CHAIRMAN CORRADINI: What I guess I'm trying to say is --

MR. LEE: One colleague has just one slide.

CHAIRMAN CORRADINI: Let me characterize -- let me just characterize it a bit differently. So there is a lot of details in the physics that we'd like to know. But if you don't have a dose calculation to compare to what we have from the applicant at this point, perhaps we can delay this until we have something to compare and investigate the details of why it is the same or different.

I mean, it's interesting, but we're going to ask you for a bottom line, and I can see you don't have one on this part. So I don't think I want to discuss this and rediscuss it later.

MS. CUBBAGE: Right. But I do think at this stage, since we are several years into the review, we definitely would like the nod that we are headed in the right direction, asking the right questions.

CHAIRMAN CORRADINI: Go ahead.

MR. LEE: Okay. Now, this is the -- GE also depend on the low containment leakage in the case of ESBWR. They are proposing .4 percent, but they -- I just listed three more numbers. It's for comparison purpose. And by the way, ESBWR do have a secondary contained reactor building, so it was surrounding a containment. So that may be a little bit higher, for example, compared to the 81,000, which they do not have a secondary containment.

And the ABWR, we certified with .5, and the EPR is currently proposing .25, which is just for the comparison. So every applicant, they pick their own number --

CHAIRMAN CORRADINI: Right.

MR. LEE: -- and whether they can meet the dose at the site boundary.

Okay. This is a second open item, open issue. This has to do with fission type of hold up in a reactor building. Now, GE is not asking any errors of deposition or played out in this reactor building, but they do assume 40 percent mixing efficiency, which means they have a perfect mixing in a 40 percent value over reactor building. The reactor building is big, like more than two million cubic feet.

And so they are just using the usual and hold up in the decay purpose, and they are assuming 50 percent per day leak rate from the reactor building. We are discussing with GE right now as what is the basis for -- technical basis for assuming 40 percent mixing efficiency.

MEMBER BANERJEE: Doesn't this come out of your MELCOR calculation?

CHAIRMAN CORRADINI: This is outside of the drywell. This is the reactor building on the other side.

MEMBER BANERJEE: Okay. Oh, I see.

MEMBER KRESS: MELCOR can do that, too.

CHAIRMAN CORRADINI: Once they do the analysis.

MR. LEE: Yes, but they are not requesting an aerosol removal.

CHAIRMAN CORRADINI: We're at the point now where you're asking for justification for their number.

MR. LEE: Yes.

CHAIRMAN CORRADINI: Okay.

MR. LEE: We are still negotiating. This is open.

MR. UPTON: And GE would like to comment on that when there is an appropriate time and tell you what we're doing.

CHAIRMAN CORRADINI: Hold it for a moment.

MR. UPTON: Okay.

MR. LEE: The third open issue is control of pH in the water over containment pools to prevent iodine evolution. And there is -- like Randy mentioned, there is acid formation of -- due to the radiolysis of the cable insulation material producing the hydrochloric acid, and also the nitric acid is the --

MS. CUBBAGE: Yes, I think we've --

MR. LEE: -- reaction with the --

MS. CUBBAGE: I think we've covered this issue already.

MR. LEE: Yes, okay.

MS. CUBBAGE: Right?

MR. LEE: So the base formation I think Randy covered, cesium hydroxide. We are injecting sodium pentaborate --

MR. WALLIS: I missed that. Is there actually a plan to inject sodium pentaborate?

MR. LEE: Yes, that is the buffer.

MR. WALLIS: I wasn't sure. I missed that when I read it.

MR. LEE: Yes. That goes to the

reactivity control, but certainly this will buffer the water pH.

And the fourth and the last significant open issue is aerosol deposition in the main steam line and the main condenser. The GE ESBWR main steam line, main steam drain line, and the main condenser are all designed for the SSE criteria, and the main steam isolation valve, like we discussed, is 200 cfh. And GE is assuming that leak rate to continue for entire duration of the LOCA accident, which is 30 days.

CHAIRMAN CORRADINI: So let me just make sure I understand the point here. This is not that I have failed to isolate. This is once I isolate, what is leaked through the isolation.

MR. LEE: Right.

CHAIRMAN CORRADINI: Okay.

MR. LEE: It's leaking from --

CHAIRMAN CORRADINI: Within the --

MR. LEE: Right.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. LEE: Yes. And we are performing independent confirmatory calculations to verify that removal rate GE proposed.

Now, these -- next to all of these

figures, we just received from Sandia last week.

CHAIRMAN CORRADINI: So let's move past them.

MR. LEE: Okay. Significant open items, we discussed all of these four items. Those are significant. There are other open items, open issues, but they are less significant and we are not going to discuss them.

Okay. We have one COL action item. This has to do with any COL applicant. What we have referenced is ESBWR design has to demonstrate that onsite chi over Q value is indeed less than what GE hypothetically assumed chi over Q value.

CHAIRMAN CORRADINI: So this one is -- at least I want to make sure I understand it -- so the point is is that the applicant, relative to how I have the fission product source diffuse and then create dose, the applicant in any one particular site is going to have to show it fits within this envelope.

MR. LEE: Yes.

CHAIRMAN CORRADINI: For the chi over Q.

MR. LEE: Right.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. LEE: The next slide shows the values of chi over Q, and the ESBWR proposed the chi over Q values are --

MR. WALLIS: Aren't these attributes of the weather? Meteorological attributes?

MR. LEE: Yes. Right.

MR. WALLIS: How can the ESBWR control meteorological attributes?

MR. LEE: They use hypothetical several chi over Q values.

MR. WALLIS: It's trying to be a bounding value or something, is that what it's trying to --

MR. LEE: Well, they believe they can meet the dose criteria with this set of chi over Q values.

MEMBER KRESS: They choose values that most sites would be okay.

CHAIRMAN CORRADINI: The sort of 80th percentile weather site.

MR. WALLIS: Right.

CHAIRMAN CORRADINI: But I think the key point is that --

MR. WALLIS: It's not a design feature, it's a weather --

CHAIRMAN CORRADINI: Right. But the key point I think you are after is that if you pick -- if an applicant is in on a site that doesn't fit this, they will have to do a different -- an additional set of calculations --

MR. WALLIS: Yes, right.

CHAIRMAN CORRADINI: -- to show they are okay.

MR. WALLIS: I can understand North Anna, because it is a certain place.

CHAIRMAN CORRADINI: I think they may have picked North Anna as one of their starting points.

MR. MARQUINO: This is Wayne Marquino. This information is published in the plant FSARs. We looked at a large number of sites which are potential customers, and that was the basis for what we picked.

CHAIRMAN CORRADINI: Doesn't the utility requirements document give you a site characteristic?

MR. MARQUINO: I don't think so. At least that's not what we used.

MR. LEE: For example, in North Anna, in the ESP, the chi over Q values are lower than the current ESBWR proposed chi over Q values. But those are the typical -- the numbers for the ABWR and AP1000 and USEPR.

MR. WALLIS: Any pictures here of -- I don't see any pictures.

MEMBER BANERJEE: He has the last slide, a color slide.

CHAIRMAN CORRADINI: Thank you very much.

MR. LEE: Thank you.

CHAIRMAN CORRADINI: Appreciate it.

Do we have the next part of the team?

MR. LEE: I'd like to introduce Ben Parks and Chris Boyd. They are going to be discussing the ATWS and the boron mixing.

MR. PARKS: These are the topics that we are covering in this presentation. Let's move to the next slide, please.

The staff's anticipated transient without scram review, we observed that GE analyzed typically limiting ATWS scenarios. The question comes up: how do you know that an MSIV closure is limiting? There is an evaluation of I think nine different types of scenarios that include a failure to scram, and GE's evaluation shows that the MSIV closure remains the limiting one.

We looked at traditional acceptance criteria. We're looking for a coolable geometry, acceptable peak vessel pressure, containment integrity. GE presented you with those values, those parameters. And our open items right now are boron mixing, and we are seeking to confirm that with the CFD analysis and the TRACG applicability. The TRACG applicability is under review currently.

Can we go to the next slide, please?

I noted an open item when I presented on the standby liquid control system. There was a question about the injection shutoff valves, but I heard that this was discussed yesterday. Do we need to address this now?

CHAIRMAN CORRADINI: Is this about potential failure of the shutoff valves and continued nitrogen injection?

MR. PARKS: Yes.

CHAIRMAN CORRADINI: Is that what you're asking?

MR. PARKS: That's correct. We -- I did another review after the meeting, and I discovered that -- well, in terms of the ATWS analysis, three out of four isolation condensers are available, so they assume a degraded performance. But the valves are installed in series, and they have a diverse power supply. And the initiation -- or the shutoff logic is a two out of four redundant level sensor system.

So I think that a failure is quite unlikely, and they are also subject to the in-service inspection program. So, I mean, they are safety-related. So that is where we stand on that, basically.

CHAIRMAN CORRADINI: I think that will help us relative to the reliability. I feel some of us are still thinking about, even if, what occurs. So we can -- we can deal with that at a later time.

MR. PARKS: Sure. Then, finally, we looked at boron mixing. Where we started with this review was the fact that we have studies of scale models from previous vintages of BWRs, and we think because the injection geometry here is different, it warrants a little bit further -- of course, a scale model would be nice, but we don't have one, and that is a very complicated and expensive task.

So our approach here is to -- first, we asked GE to renodalize their TRACG model to provide a more sort of limiting picture of boron transport. And, second, for our own assurances, we pursued a CFD calculation to get a better picture of how the boron transports to compare it to the TRACG predictions.

MEMBER BANERJEE: Using a different code?

MR. PARKS: We used FLUENT .

MEMBER BANERJEE: Which is now owned by the same company.

CHAIRMAN CORRADINI: They don't know that. Don't burst their bubble.

MEMBER BANERJEE: Never mind.

MR. PARKS: Was that the case when we started?

(Laughter.)

Our CFD analysis is a 45 million cell model. It is of the bypass. We did not model the fuel assemblies. We did model --

MR. WALLIS: Does it have two-phase flow in it, or is it -- dual or single phase?

MR. PARKS: We modeled the lower portion of the --

MR. WALLIS: All single phase.

MR. PARKS: -- course with all single phase.

MEMBER BANERJEE: And you're only modeling the bypass frequency.

MR. PARKS: That is correct.

MEMBER BANERJEE: And that is assumed not to be boiling.

MR. PARKS: That is correct.

MEMBER BANERJEE: Right.

MR. WALLIS: Only in the core as well.

MEMBER BANERJEE: They are not analyzing the core.

CHAIRMAN CORRADINI: They are looking at

the bypass, similar to a --

MR. PARKS: The interstitial is between the assemblies we did model. But it bears mention that most of the mixing behavior we observed were on the bottom portions of the core, and our model only covers a certain height of the core.

We got our geometry data to build this model from audit activities. GE also provided us a significant amount of data, and we also surveyed the TRACG input data to get additional conditions, boundary conditions.

We based it on the performance requirements, things that we observed in the ITAAC about the performance of the model.

MR. WALLIS: So how does your CFD model the turbulent mixing, or whatever kind of mixing process is going on here? Because it is mixing the canvases isn't it?

MR. BOYD: It is just the standard -- they used a standard turbulence model to model those jets.

MR. WALLIS: It applies to this kind of a geometry, or --

MR. BOYD: The jets are high-speed jets, and they jet out into that outer opening. And we used a model that was most applicable for jets, although it has not been validated for these specific jets.

I don't think that is really the issue. What we have is a lot of entrainment. There is a lot of flow coming down. Those jets are almost like pressure washers. They have about the same velocity as a pressure washer you'd get at Home Depot. There is 32 of them. They are basically stirring everything up out in that outer region and putting basically a borated solution, which is then drawn in.

The path of least resistance to get into the core is low, because the fuel supports have less blockage than the channel boxes themselves. And what you -- the jets put in something equivalent to about 500 gpm all in together. The flow coming down from the top is an order of magnitude higher, so --

MEMBER BANERJEE: How is it coming?

MR. BOYD: The flow -- GE would have to answer that. I used it as a boundary condition from TRAC, but there is some flow in the channels --

MR. WALLIS: Circulation --

MR. BOYD: -- and it is going out in these leakage paths, and it comes back down through.

So you've got an order of magnitude more flow coming down. That flow has two choices. It can come down through those little interstitial areas, the lattice, and have to pass the blades, which are inserted, or it can make its way out to the side, which is what we found that it does. And then, it's going to go down, get close to the bottom, and then sweep in. Each channel is pulling.

So what you've got is this big flow pattern that comes in and goes down, and then 10 percent of that are these jets that are 32 of them at 120-degree angles and 90-degree spread. They kind of flood that area and mix it up pretty well.

I don't think the turbulence model is too critical there, because it is pretty well mixed before it starts in. And what you see is it swept in.

MR. WALLIS: It's convected in, really.

MR. BOYD: It is convected in, so the TRACG model, not only when it puts that wall up and holds flow out from going in, what it is really doing is it is holding the flow that is coming down from going out and sweeping it in. That's the real conservativism of that wall.

So the channels in the middle that are pulling flow in, they can pull flow straight down, because there is a wall, where in the CFD calculations they are really pulling more from the side, the flow coming down goes out to the side and then sweeps in, carrying the boron in.

So that is basically what is going on. And we did a bunch of sensitivity studies. The main concern I had was what -- well, what if I could feed those bundles in the middle with some flow from up top? So what I did is I took all of the flow and I concentrated it into ring 1, and tried to shove flow down through the middle, just to see if I could break GE's calculation. It's still --

MR. WALLIS: And off to the side --

MR. KALINICH: It's off to the side. That's the path of least resistance.

MR. WALLIS: So the bottom line is that you get about as much boron in the core as they did?

MR. BOYD: Yes. If you look at our boron versus time, we get the same traces that they do. The only thing that is going to change the -- we did a bunch of sensitivity studies, just to see what would change it. And the only thing that changed it were the obvious things. If you inject less into the jets, you get less boron. And if you pool more out through each channel, then you'll have less built up in the core.

MEMBER BANERJEE: So these are your predictions?

MR. BOYD: Those are -- I didn't put -- that Region A is the inner ring that they showed earlier. And what you'll see is the black curve are the NRC predictions, the red curve are the GE predictions.

MR. WALLIS: It's the same.

MR. BOYD: I'm sorry. That's ring 3, that's the outer peripheral region, and you'll see the TRAC -- what that's showing is that TRACG is storing boron out at that outer region. It's not letting it in.

And then, you go into the inner region, and you'll see the NRC predictions and the GE predictions showing boron making it to the inner core, TRACG showing none. Ours are a little higher because of the way we did the lower -- they took their blades and they made them as thick as the -- they blocked off everything in there and cut out volume with their blades, made a conservative approach that way.

I used an infinitely thin wall-thick blade. I have a little more volume. I had upped the resistance to make it flow the same, but I had more volume. They did a complete blockage. They had less volume. And then, my fuel supports are a little bit smaller than theirs, so I have a little bit more volume. That's why you'll see a little bit more boron building up.

MEMBER BANERJEE: It's just a volumetric effect.

MR. BOYD: That's a volumetric effect.

MEMBER BANERJEE: Yes.

MR. BOYD: But the penetration times look very similar. The height of the boron layer I compared, and it looks very similar.

MR. WALLIS: It's really the convection pattern that does that, and it sweeps it in.

MR. BOYD: That's a convection issue. I don't think the turbulence model matters at all. I think we could dump the boron in there in different ways and get the same answer.

MR. WALLIS: This is very reassuring. I mean, it seems to me that we shouldn't -- we shouldn't have these extraordinarily conservative TRAC models which really mislead us about how dangerous it might be when it isn't.

MR. PARKS: Well, they still comply with the acceptance criteria.

MR. WALLIS: It's better to have a realistic model like this.

MEMBER BANERJEE: Well, this is basically a density-driven flow event?

MEMBER BANERJEE: There is actual convection.

MR. BOYD: It is like a chimney-driven flow.

MEMBER BANERJEE: I see. With a buoyancy effect.

MR. BOYD: But there's cooling flow.

MEMBER BANERJEE: Yes.

MR. BOYD: Now, our CFD models were drastically different, too. There were different approaches we focused on different things.

MR. WALLIS: But it's the heating and the vents he changed that's causing this motion, this --

MR. BOYD: In the channels, though, are really driving it. And we're not modeling -- we're modeling those boundary conditions, pulling in through these little holes. So it --

MR. WALLIS: So the chimney effect, you mean, is due to the heating effects.

MR. BOYD: Right.

MEMBER KRESS: What happens to the sodium pentaborate over the long term? Does it stay in solution, or do you boil off and take it with the steam, or does it concentrate? And is there a possibility of recriticality in the long term? You still can't put the rods in, I suppose.

MR. PARKS: I don't believe so. I'm going to defer to Wayne. I think we asked for a 72-hour analysis, but that might have been SVO. Wayne?

MR. MARQUINO: Yes. The boron stays in the liquid phase.

MEMBER KRESS: When the steam goes out?

MR. MARQUINO: Yes. There is a free surface in the upper plenum here, so you have steam coming up. The liquid stays in the vessel.

MEMBER BANERJEE: Not in the chimney? It doesn't go up into the chimney, the boron?

MR. MARQUINO: No. The other -- what was your other question?

MEMBER KRESS: Well, I was concerned about recriticality in the long term.

MR. MARQUINO: Right. Right. Another thing that we looked at was if you depressurized the reactor, that actually causes voiding and a better response. And then, at low pressure, we didn't see the reactor go critical at the end of the depressurization. So we do not see a recriticality during the ATWS, even if you hit the depressurization curve in the EPG.

MEMBER SHACK: Wasn't there some pentaborate carryover in the MELCOR calculations?

MR. MARQUINO: In the MELCOR calculation, there is transport of the sodium pentaborate through the liquid phase, out the break, and into the lower drywell.

MEMBER SHACK: So you're losing it that way, then.

MR. MARQUINO: Yes.

MEMBER KRESS: In the liquid.

CHAIRMAN CORRADINI: Do you want to go back to your original slides?

MR. BAVOL: That was our final slide.

CHAIRMAN CORRADINI: Oh, okay.

MEMBER BANERJEE: Could we have copies of your backup slides?

CHAIRMAN CORRADINI: You will be able to get copies. I think as we have had in the past with the subcommittees, Gary will assemble it and send us -- on a CD.

MEMBER BANERJEE: Including the backup slides.

CHAIRMAN CORRADINI: Sure, yes, as part of it.

MS. CUBBAGE: Those that were presented.

MEMBER BANERJEE: Sorry?

MR. WALLIS: I mean, Chris has presented a nice picture. What is the conclusion of the management?

MR. SHUAIBI: The reason that we asked the Office of Research to do this was to confirm that whatever TRACG was doing was something that was conservative, and that we could accept. So I think what you've -- what we've done is the Office of Research has done some CFD analyses. They have confirmed that the analyses that were performed using TRACG were in fact conservative. That is --

MEMBER BANERJEE: But there is still some --

MR. SHUAIBI: And I'm looking at -- I'm looking at Chris I guess to nod for me.

MR. PARKS: Yes, this is our draft report at this point.

MEMBER BANERJEE: But there are still some further studies with TRACG nodalization or something going on, or not? Am I misreading --

MR. PARKS: The TRACG nodalization, that would be a part of the Chapter 21 review.

MEMBER BANERJEE: Okay. But I had noted -- maybe I just misread what you wrote there.

MR. PARKS: We had -- that was the separation, because we were concerned that there was I guess a bit of smearing of the boron --

MEMBER BANERJEE: Right.

MR. PARKS: -- that would non-conservatively I guess overstate the boron mixing, and so they separated the peripheral bypass, since we're --

MEMBER BANERJEE: Oh, that was the blocking thing they did.

MR. PARKS: Right. And you saw that on our slide, where their prediction in ring 3 or ring 4 was higher.

MEMBER BANERJEE: Yes. Okay.

MR. WALLIS: So you would -- if you believe this, you would be able to accept the use of much less boron.

CHAIRMAN CORRADINI: They don't believe it that much.

MEMBER BANERJEE: Let's not go there.

(Laughter.)

CHAIRMAN CORRADINI: They don't believe it that much.

MR. PARKS: That hasn't been proposed.

CHAIRMAN CORRADINI: Other member

comments?

(No response.)

Okay. We'll recess for lunch. Back at 1:20.

(Whereupon, at 12:21 p.m., the proceedings in the foregoing matter recessed for lunch.)

CHAIRMAN CORRADINI: All right. Why don't we get started.

Wayne, you wanted to -- Mr. Marquino wanted to begin with a couple of comments to help us from the morning session. And you're going to show us a video.

MR. MARQUINO: Okay. I just want to follow up on one of the open items that Jay Lee of the NRC staff mentioned, and then go over the Chapter 21 material, and then we'll have a LOCA movie that may help explain our design better.

Going back to I think it was the previous ACRS meeting, which included control room habitability, one of the comments from the staff was that we do not have a secondary containment in ESBWR. That's an observation. What we have is a reactor building that surrounds the primary containment. I think that is related to the open item that Jay Lee had, one of his five on reactor building mixing.

And before I talk to what we're doing to address that, I want to summarize some of the conservatisms that we have in analysis of doses. We have the fuel failures that are assumed, even though we don't actually fail the fuel in the LOCA. We don't take credit for fission product removal mechanisms after 12 hours.

We align the timing of the release to the worst meteorological conditions, so we apply a bad chi over Q at exactly the worst time in the event. We assume the containment leakage is at the maximum value at the containment design pressure throughout the event for 30 days. We assume a high wind velocity when determining the differential pressure for testing the reactor building, which is inconsistent with the worst chi over Q conditions, which correspond to stable atmospheric conditions and low wind velocity.

And then, finally, we assume bounding site characteristics. The actual at least first two sites' characteristics produce a dose of about half of the bounding chi over Q. So there's a number of conservatisms in our dose calculation.

One thing that we did very simply in analyzing the reactor building mixing is we simply determined where the penetrations are. Those are the main leak sources, and we determined the building volume around those sources. We're asked for some additional justification of that, and we'll be using the GOTHIC computer code to develop a fairly detailed 3-D model of the reactor building to look at the transport of radioactivity from the primary containment source through rooms and HVAC ducts, and then finally out of the building.

That will probably combine with the reactor building differential pressure evaluation, so that we look at the tradeoffs between high wind, favorable chi over Q, low wind, low differential pressure, lower leakage, but worse chi over Q.

So that's our plan, and I'd like to hear any comments that the ACRS has on that approach.

CHAIRMAN CORRADINI: Let me ask one thing about GOTHIC. Are you going to use the distributed parameter model, or are you going to use the lumped model, such as in MELCOR?

MR. MARQUINO: I don't know. I don't know much about GOTHIC, but I'll take that.

CHAIRMAN CORRADINI: I mean, GOTHIC is basically COBRA NC gone wild. And so it -- there is essentially a 3-D -- three-dimensional version, a CFD approach, and there is the essentially what I'll call a lumped parameter approach like MELCOR, where you essentially have volumes and an orifice between volumes. I'm curious which one you intend to use for your analysis.

MR. MARQUINO: Well, we may -- we think it's important in some of the initial volumes to have more detail of possible stratification, that that would produce unfavorable mixing. As you get downstream, that's probably less critical, and we might use the lumped parameter option.

CHAIRMAN CORRADINI: Okay.

MR. WALLIS: All of these conservative analysis -- assumptions, you're going to end up with a prediction which meets the regulations.

MR. MARQUINO: Yes.

MR. WALLIS: So we don't need to worry.

MR. MARQUINO: That's right. So that -- I think that should give you some assurance. We're asking when seeing the MELCOR evaluations by GE and the staff and the uncertainties, those uncertainties are covered by the overall conservatism of the --

MR. WALLIS: So we don't know it until we see the bottom line that the staff comes up with.

MR. MARQUINO: Right.

CHAIRMAN CORRADINI: But we have seen your

-- I have to go back and check on the DCD, but that will be the comparison point at the end, yes. The staff will do these separate calculations.

MR. MARQUINO: Yes. Another reason I bring this up is because see you in the DCD that we're at 4.9 rem on the control room dose, and the acceptance criteria is 5, and the -- offsite we're 20 something, and 25 acceptance criteria. We've artificially -- we used the most conservative chi over Q to push that dose up, basically to the maximum, to give us maximum flexibility for siting the ESBWR.

MR. WALLIS: So this is on the worst day of the year sort of thing?

MR. MARQUINO: Yes. That's another conservatism I forgot to mention.

CHAIRMAN CORRADINI: Okay.

MR. MARQUINO: Okay.

CHAIRMAN CORRADINI: Do you think it would be more -- I mean, just -- you can do it however you want. Do you think it might be more beneficial to show the video first, or after you talk about the TRACG?

MR. MARQUINO: I think you'll have more questions about the video, so I'd like to go through the --

CHAIRMAN CORRADINI: Okay.

MR. MARQUINO: We have a very brief Chapter 21 presentation, go through that, and then show the video.

CHAIRMAN CORRADINI: Okay. That's fine.

MR. WALLIS: Is that because we'll understand the video better than the -- we'll have more questions?

(Laughter.)

CHAIRMAN CORRADINI: We'll go with your decision. Go ahead.

MR. MARQUINO: Chapter 21 covers the application methodology for various uses of TRACG, AOO infrequent events, special events, and ATWS.

Next slide, please.

To give you some background, in the early '90s, ESBWR project started with a test and analysis program description to evaluate what testing would be needed to license SBWR, and we knew we would be applying the TRACG code. We were looking at what was needed to qualify the TRACG code. We applied code scaling applicability and uncertainty methodology to developing that, including the phenomena importance and ranking tables.

We then conducted the tests that were

identified as necessary, but in the mid '90s the SBWR program ended and our licensing interactions with the NRC were pretty much suspended at that time. But GE continued internally with a larger output version of SBWR/ESBWR.

And, internally, at GE the interest in TRACG continued. We leveraged the work we had done for SBWR, and in the late '90s we submitted for NRC review and approval a TRACG for BWR 2 through 6 AOO analysis.

And then, in 2002, we submitted the TRACG 04 code for application to ESBWR, and a lot of you were involved in that review.

Next slide, please.

So here we are. We have submitted applications of TRACG that have been approved by the staff. They are AOO analysis for BWR 2 through 6, ATWS pressure analysis for BWR 2 through 6, which is very similar to AOOs, ESBWR LOCA analysis, and ESBWR stability analysis.

And then, we have two LTRs that are still under review by the staff -- the ESBWR ATWS pressure, clad temperature, and suppression pool temperature application. And we talked about the boron mixing related to that, incidentally, this morning.

And then, a recent submittal for ESBWR AOO, infrequent event, special event -- this is kind of a funny situation, because we had submitted a lot of material to the staff in referencing different LTRs, referencing the test analysis program description and PIRTs. And there was a lot of information that was disbursed, and this LTR basically brings it all together. And it also provides details on the results that are in the DCD and the uncertainty analysis we did to support the operating limit.

Next slide, please.

So we covered the boron mixing in ATWS this morning. Another significant RAI or set of RAIs that we have is related to stability during ATWS, and we are taking back some of your questions about stability related to the chimney that we'll work through.

CHAIRMAN CORRADINI: Let's just be clear. So I think the thing that I heard from the other members was that their concern was behavior within the chimney, and also the coupling between the chimney and how you had the bundle arrangement -- I think it's 16 -- 16 assemblies feeding one chimney and that interplay.

MR. MARQUINO: Yes.

CHAIRMAN CORRADINI: Okay.

MR. MARQUINO: And we have this recent LTR, which is very similar to the approved NED 32906 application of TRACG. In the transient analysis area, Chapter 21, some of the RAI questions had to do with hydraulic control unit failures during select control rod insert. As I said, that's a local phenomena, individual blades inserting.

The NRC asked us what would happen if a blade or two blades paired to an HCU failed, and we've provided a response to that, and we've made revisions in the DCD to address it.

Next slide.

Okay. So I'd like to show you an animation of the LOCA response, and Dr. Chester Cheung is here to talk you through it. It's very short. I think it's three minutes.

(Whereupon, the video began.)

MALE VOICE: The piping in any nuclear powerplant is rigorously designed to stringent codes and is routinely inspected for optimal safety and performance. In the unlikely event of a pipe leak or break, ESBWR passive safety features are designed to prevent the nuclear reactor's core from overheating. In fact, these safety features would keep the fuel at or below its normal operating temperature for a period of time established by the regulatory authorities.

If a pipe leaks or breaks, control rod blades are automatically inserted into the reactor core, stopping the nuclear reaction. The feedwater system maintains a sufficient water level in the vessel to avoid activating the passive core cooling system. In the event that plant power is lost at the same time that a pipe leaks or breaks, the ESBWR passive safety systems activate to replace the power operated systems.

With no electricity to pump water into the reactor pressure vessel, the passive safety systems utilize natural forces to flood and cool the core. Triggered by the loss of power, heat exchanger tubes drain water into the reactor pressure vessel. As the tubes empty, steam from the reactor is drawn in and condensed. This removes heat from the reactor and transfers it to the IC pool in the upper part of the building.

If the water level drops to a level below that expected for common plant events, a time sequence of depressurization and passive cooling begins. Depressurization begins when the safety relief valves open and transfer steam from the reactor into the suppression pool where it is condensed back into water.

This relieves pressure in the reactor pressure vessel. The depressurization valves open next, transferring steam from the reactor directly into the containment. At the same time, high pressure tank valves open, forcing liquid through piping directly into the core.

Near the end of depressurization, valves open and allow water to drain from the GDCS pool into the reactor pressure vessel, raising the water level and completing the process of cooling the nuclear core. A passive natural circulation cooling cycle then begins as steam bubbles from the core drift to the surface.

The steam then flows from the containment to low pressure heat exchangers in the PCC pool that condense the steam into water. The core's heat is transferred to the PCC pool through this steam. As the steam condenses in the low pressure heat exchanger, it drains first to the GDCS pool, then returns to the reactor pressure vessel, completing the closed loop cooling system.

Because the core has remained cooled through the sequence, the nuclear fuel does not heat up, and the fuel tubes remain intact. If any radioactivity is released from the core, the containment building prevents the release into the environment. The ESBWR passive safety systems automatically keep the reactor core consistently cooled for 72 hours, unlike any operating nuclear plant. The pools are sized to remove heat from the core for three days. After that time, the upper pool will be refilled.

In summary, accident events like pipe breaks can be accommodated by the ESBWR passive safety systems without any reliance on the AC power grid or even emergency generators for three days with no core heat up, unlike any operating nuclear plant today.

(Whereupon, the video ended.)

MR. WALLIS: It doesn't say anything about the suppression pool.

MR. MARQUINO: It does.

MR. WALLIS: It doesn't, really. It doesn't show anything bubbling into it.

MR. MARQUINO: It showed like steam --

MEMBER BANERJEE: From the SRV.

CHAIRMAN CORRADINI: But the equalization line under current calculation isn't --

MR. WALLIS: No. But the event clearing

would happen as you pressurize the drywell.

CHAIRMAN CORRADINI: Well, I saw that. I saw those --

MR. WALLIS: Did I miss that?

MEMBER ARMIJO: Well, it showed the level in the downcomer.

MR. WALLIS: Oh, it did.

PARTICIPANT: It has these steam jets.

MR. WALLIS: That's an SRV line. That doesn't show bubbling. There's bubbling around --

MR. MARQUINO: It falls around --

MR. WALLIS: There's a big bubbling, an eruption --

MR. MARQUINO: It doesn't show pool swells. All right.

MR. WALLIS: It doesn't show pool swell. It's a very gentle --

MR. MARQUINO: These are very gentle, little tiny bubbles.

MR. WALLIS: You show the non-condensables coming in and --

DR. CHEUNG: It's a sanitized version.

(Laughter.)

It's a sanitized version.

MR. MARQUINO: Let me try to -- at least

the time sequence lines up with our TRAC results. We informed it based on that. Yes, there's simplifications, and we can't get into a lot of the detail. We tried to put something together that shows the systems functioning, so that people could have an overall understanding.

MR. WALLIS: The SLC system operates as an accumulator, even if you don't need the boron.

MR. MARQUINO: Yes.

MR. WALLIS: Always?

MR. MARQUINO: Yes. Triggers on low water level.

MEMBER BANERJEE: I guess the last four words "unlike any other reactors" or whatever, that's sort of redundant.

MEMBER BLEY: It's a sales tool.

MR. MARQUINO: And this is available on the GE website.

MEMBER BLEY: It's on the website.

MR. MARQUINO: Any other questions?

MEMBER KRESS: What makes the steam go up that pipe?

MR. MARQUINO: What makes the steam go up the pipe to the PCC?

MEMBER KRESS: Yes, instead of condensing on the other surfaces.

DR. CHEUNG: The steam flow is much higher than on the surface can condense. The surface contains only a small amount.

CHAIRMAN CORRADINI: But the answer I guess is it will condense everywhere, and that will be your cold point to draw it there, right? I mean, Dr. Kress' point I think is fair, is it?

MEMBER KRESS: I think --

CHAIRMAN CORRADINI: It will condense everywhere to begin with.

MEMBER KRESS: Eventually, you may end up with all the water on the floor, instead of feeding it back to the core.

DR. CHEUNG: It depends on the break.

CHAIRMAN CORRADINI: Can we ask the question a little bit differently? Have you -- in your containment analysis which we are going to have you come back and tell us about in detail, you have considered the cold wall heat sinks and the proportion of how much water condenses there versus on the PCCS, right?

MEMBER KRESS: Supposedly MELCOR will do that.

MR. WALLIS: Event clearing there.

DR. CHEUNG: We have models, the heat sink structure in this, but we purposely ignore a lot of structural heat pipings to maximize the energy that will go into the containment system. But in the long term, we --

MR. MARQUINO: The presentation you gave yesterday included the results out to 30 days, which considered the condensation on the structures that we were asked about, right?

DR. CHEUNG: Yes. We estimate that all the way up to 30 days. Does that answer your question?

CHAIRMAN CORRADINI: But then, let's just push the point one further, what Dr. Kress is asking. So he might be asking, ideally, you'd like all the water to go up to the PCCS, condense, the non-condensables will be pushed back based on submergence into the suppression, into the wet well. The water will go into the GDCS, but there will be some losses to the cold walls, and you've calculated how much you lose that will be ending up in little dribbles and drabbles inside the drywell, right?

DR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay. We can look at that in the detailed analysis. We'll want to look at

that.

MEMBER KRESS: May be a long-term cooling problem.

CHAIRMAN CORRADINI: I think that's actually probably early in time as we're going to get the most condensation, because as soon as they build up the temperature on the wall, it will shut itself down just by --

MEMBER KRESS: Well, there's a lot of heat capacity on those walls.

MR. MARQUINO: And another thing we should tell them is the equalizing valve is there for specifically that scenario. So if we lose too much from the system, and it's on the floor of the drywell, the water level in the core would drop, and then the equalizing valve opens, floods it from the suppression pool --

MEMBER KRESS: Ah, that's the thing I was looking for.

DR. CHEUNG: And, actually, for the current evaluation, all of the way up to 30 days, we don't need the equalization line to open.

CHAIRMAN CORRADINI: Well, that's what I want to get back to. I mean, it could open, but in all your analysis you showed us yesterday under

Chapter 6, no eventuality of your limiting condition, the main steam line break accident, which was your limiting accident, did you need to have the equalization line open.

DR. CHEUNG: No. We didn't --

CHAIRMAN CORRADINI: You were continuing to have inventory, so you never got to the magical switchpoint, which would have wanted that valve to open. Is that not correct?

DR. CHEUNG: That's correct. Different elevation. Up to 30 days, we don't need that. But if we have N minus 2 problem, or N minus 2 failure, that's like one of the pools, one of the three pools, the water stayed behind. Then, we will have a defense in depth system. The equalization line will come in, and in that situation that suppression pool is about 10 meters from the RPV bottom. The top altitude is 7.5, so we have a head of 2.5 meter. So there is plenty of water to make sure that the coil is covered.

MR. WALLIS: Can I ask you about the vacuum breakers now? I mean, in order for the PCCS to work, you have to have a positive pressure difference from the drywell to the wet well, right? And I guess the idea of the vacuum breaker is that, you know, you pressurize the wet well, you've driven all of the non-condensables in there.

So you want to relieve that pressure by letting it breath it back into the drywell. But that doesn't give you a positive pressure difference between the drywell and the wet well to drive the PCCS. So you must have a hydrostatic head somewhere or something that makes it work. I don't understand where that is.

DR. CHEUNG: Let me answer that. The vacuum breaker opens if, and only if, the wet well pressure is higher than the drywell pressure.

MR. WALLIS: Yes, it's higher than the drywell pressure. It's got to be significantly lower for the PCCS to work, though.

CHAIRMAN CORRADINI: Right. But it's a timing issue, as I understand it, Graham. Early in any of their accidents, all of the flow is down in through the vents, and then they have a positive pressure. The pop-it valve will open and --

MR. WALLIS: As long as the pressure is rising in the containment, everything is fine. But when you want to try to turn it around, that's when you get into trouble. That's why you put the fans in or someone put the fans in.

CHAIRMAN CORRADINI: The vacuum breaker is not -- is designed to be leak-tight at that point.

MR. WALLIS: But then, you can't get the PCCS to work.

CHAIRMAN CORRADINI: Well, it slowly, slowly builds pressure.

MR. WALLIS: Oh.

CHAIRMAN CORRADINI: Because, as they said, everything is being driven by the non-condensables and --

MR. WALLIS: Well, then, it has to keep building pressure in the drywell. But that's what you want to turn around, though.

MR. MARQUINO: The PCC --

MR. WALLIS: How does it ever turn around the pressure in the drywell?

MR. MARQUINO: The PCC will work without a differential pressure, if it's full of steam. But when it doesn't --

MR. WALLIS: But it soon gets filled -- eventually, it gets non-condensables if it's not breathing out the non-condensables.

MR. MARQUINO: Right, right. When it needs a differential pressure is to purge itself of non-condensables.

MR. WALLIS: Right.

MR. MARQUINO: And we talked yesterday about how it comes to equilibrium with the core steam generation.

MR. WALLIS: But it doesn't if it can't breathe out the non-condensables. It works as long as the pressure keeps going up in the drywell, because that breathes out the non-condensables. But it can't turn it around and make it come down.

CHAIRMAN CORRADINI: Just one thing, Graham. I think -- I mean, I agree with you from a timing standpoint. If you look at one of their plots in Chapter 6, even though the pressure is going up, the drywell is still at a higher pressure than the wet well.

MR. WALLIS: Because the pressure is going up. But if the pressure -- if you want to get the pressure down in the drywell, below the pressure in the suppression pool, you have to do something.

CHAIRMAN CORRADINI: Right.

MR. WALLIS: And I don't know how you do that without having a fan or something that -- to --

MR. MARQUINO: That's why we put the fan in.

MR. WALLIS: But it's desirable not to have this.

MR. MARQUINO: There's other ways.

DR. CHEUNG: Let me answer it the other way. The PCC works not because of the -- the heat is created by not enough steam condensed or the -- you have --

MR. WALLIS: As long as the pressure is going up in the drywell, it's okay.

DR. CHEUNG: Yes. But once you turn on a fan, then the PCC becomes an active heat exchanger. It does not depend on what's going on in the wet well, because you have a forced flow circulation.

MR. WALLIS: You have a forced flow, but you have to have that forced flow. Otherwise, you'll never turn the pressure around. Isn't that right?

DR. CHEUNG: That's the idea of using the fan is to force it.

MR. WALLIS: But the fan wasn't there until recently.

CHAIRMAN CORRADINI: They would come to an equilibrium that was below design pressure, but would not necessarily decrease.

MR. WALLIS: It would never come down.

CHAIRMAN CORRADINI: It would come down very, very slowly.

MR. WALLIS: Very slowly, yes. Okay.

Just -- why can't you make some kind of passive arrangement that makes it turn itself around? That would be very desirable.

CHAIRMAN CORRADINI: They could vent the wet well.

MR. WALLIS: Yes.

CHAIRMAN CORRADINI: I mean, that's what ABWR has as their final --

MR. WALLIS: You can vent the wet well.

CHAIRMAN CORRADINI: Yes.

MR. WALLIS: Yes.

CHAIRMAN CORRADINI: And get rid of the non-condensable gas and bring down the overall level.

MR. WALLIS: Yes. But they won't do that.

CHAIRMAN CORRADINI: Well, they chose not to.

MR. WALLIS: Okay. So I guess it's clarified. Isn't it a bit artificial, because you're trying to make it last for three days and then something else has to happen.

DR. CHEUNG: After three days, we are supposed to have simple systems bring it up.

MR. WALLIS: I was trying to tell my wife that you have such a wonderful design that you could just walk away from it. But you can't.

MS. CUBBAGE: For three days.

MR. WALLIS: You have to do something after three days.

MR. MARQUINO: Well, we have to refill the pool at three days. That has always been part of the design, and now we've had --

MR. WALLIS: That's understandable, but you're actually introducing a new -- a fan or something.

MR. MARQUINO: Yes.

MR. WALLIS: When did the fan get introduced?

MR. MARQUINO: Well, the fan was investigated in the '90s during the PANDA testing. It wasn't part of our original submittal. We --

MR. WALLIS: Because I've never seen it until this time.

MR. MARQUINO: It was put back in in -- well, started telling the staff about it in the March timeframe.

CHAIRMAN CORRADINI: So let me ask a question about the venting. So did you consider this in comparison to what ABWR has as a possibility? Unless I misunderstand, does not ABWR have a venting capability in the wet well as a final way to bring down pressure?

MR. MARQUINO: Not in the design basis accident analysis. In ABWR, like the BWR 6s, you get a very significant drop in pressure from cold water spilling out of the break and condensing the steam in the drywell.

CHAIRMAN CORRADINI: Okay.

MR. MARQUINO: So that wet well, then, is not needed in the design basis LOCA analysis.

CHAIRMAN CORRADINI: Beyond design basis. Okay. That was my mistake. I'm sorry. Thank you.

MR. MARQUINO: Well, thank you very much for your questions.

CHAIRMAN CORRADINI: Are we turning to the staff?

PARTICIPANT: Unless you want to take a long break.

CHAIRMAN CORRADINI: No.

(Laughter.)

MR. WILLIAMS: Good afternoon. My name is Shawn Williams. I'm the Project Manager for Chapter 21 of the safety evaluation report. As many of you are aware, there is not a Chapter 21 of the DCD. Chapter 21 covers testing and computer code evaluation. The safety evaluation report speaks to the information that was provided in topical reports regarding the TRACG code and its qualification.

This is a list of the lead and supporting reviewers. We wanted to have a special note for Veronica Wilson, because she was the actual author for nearly six of the SERs you saw, four of the topical reports, Chapter 21.6, and Chapter 6.3. Of course, she doesn't have the pleasure of presenting them, but --

CHAIRMAN CORRADINI: Is she in the audience, so we can get her?

(Laughter.)

PARTICIPANT: She's hiding.

MR. WILLIAMS: RAI status, 111 original RAIs, 77 are resolved. Currently it says 34, but I wanted to note there are about 10 to 15 Chapter 4 and Chapter 6 RAIs that will also need to be resolved to close out all of the Chapter 21 issues. Even though there are 34 open items, GE has responded to about 12 of them that are still on staff's plate.

I'm going to hand it over to Ralph Landry, who is going to give you an introduction of Chapter 21.

MR. LANDRY: Good afternoon. I'm Ralph Landry from the staff of NRO. The introductory remarks I'm going to make are pretty short, and I want to introduce the different staff members who are responsible for the individual sections of the review.

You've already heard about the stability, and you've heard about ATWS, and you've heard about the AOOs. This afternoon we're going to talk about the LOCA open items. We are going to talk about some of the transient open items, and then a discussion with the Committee.

So far, we have been to the Committee for the testing and scaling of the TRACG support. That was in 2004, as part of the acceptance review of TRACG for LOCA. In 2004, we want to the Thermal Hydraulics Subcommittee and the full Committee to approve use of TRACG for LOCA analysis on ESBWR.

In 2006, we came to the Thermal Hydraulics Subcommittee and the full Committee with a review of the acceptability of TRACG for stability analysis for ESBWR. We have been reviewing TRACG applicability for ATWS and for transients, and those reviews will be incorporated as part of the overall SER on the design certification review.

As Wayne Marquino mentioned in his presentation, we went to the Subcommittee and to the full Committee on the review of TRACG for applicability to the AOOs for the operating fleet. What we are looking at for the applicability to ESBWR is an extension of that applicability to incorporate the ESBWR design features that are not part of the operating fleet designs.

So we have been reviewing TRACG, and we have been back and forth to the Thermal Hydraulics Subcommittee, and to the full Committee, on three occasions already for TRACG, for the AOOs for the operating fleet, for applicability to LOCA for the operating fleet, and for applicability -- or to the ESBWR, and applicability to the stability for ESBWR.

MR. WALLIS: Are there any phenomena in these transients which we haven't already reviewed on the LOCA and stability that we have to worry about? I can see that ATWS has some new features, but are there other transients that have new features?

MR. LANDRY: This is looking at the passive features of the design for the transients. We wanted to do a separate review of the applicability to make sure that the code was still applicable to the features of this design.

MR. WALLIS: Did you look at the range of variables on the phenomena or something? Are there any new phenomena in these --

MR. LANDRY: No, I didn't. Jim Gilmer will be --

MR. WALLIS: He is going to say that.

MR. LANDRY: -- covering some of this.

MR. WALLIS: I would just be surprised if there are many new phenomena that you have to worry about in the transients that you haven't already looked at for LOCA and stability.

MR. LANDRY: Well, that's why I said, Graham, that this is really extending that approval from the operating fleet. Now, you have to recall, when we reviewed it for the operating fleet, that was applicable to BWRs 2 through 6. It was not applied for applicability to BWR 1 or ABWR. So we are reviewing it to make sure that it's applicable for the ESBWR.

MR. WALLIS: But I was thinking about the -- you've already reviewed for LOCA and stability for the ESBWR. So you've looked at the kind of phenomena that happen during transient.

MR. LANDRY: This is another check on that.

MR. WALLIS: Okay. So it just seems to me it shouldn't be that big a job, right?

MR. LANDRY: Right.

MEMBER BANERJEE: You don't want to put words in his mouth.

MR. LANDRY: We always have additional --

MR. WALLIS: Yes, I know. I know.

MR. LANDRY: -- things we want to look at.

MR. WALLIS: I was wondering about what we have to worry about. We have to worry about much --

MR. LANDRY: You just have to believe us.

MR. WALLIS: Okay.

(Laughter.)

CHAIRMAN CORRADINI: You look very believable today.

MR. LANDRY: Thank you.

MEMBER BANERJEE: Especially since you have moved to NRO, right?

MR. LANDRY: Moving right along, I'd like to briefly summarize the regulations that apply to the reviews that we have for presentation this afternoon.

Overriding for the LOCA, 10 CFRs 50.34 and 50.46, of course, and standard review plan Section 6.3, emergency core cooling, 15.65, and 15.02.

With that, I'd like to turn the discussion over to Dr. Wang to discuss LOCA and LOCA applicability with you.

DR. WANG: Good afternoon. My name is

Weidong Wang, and I am going to talk about the applicability for LOCA, which Ralph has already discussed -- I mean, mentioned that we had received a topical report in the past, and we have approved in the preapplication stage for LOCA application. And at that time, we had an SER and we listed 20 confirmatory items which basically these items should be addressed during this DCD application.

And my presentation here is try to give a few points of interest for these confirmatory items, which later GE submitted to us.

Next slide, please.

The first item is phenomenon identification ranking table for long-term cooling, and GE has submitted through the II report -- report letter basically for -- they divided this phenomena into catalogs for the LOCA. One is --

MR. WALLIS: I thought you were reviewing TRACG, not PIRT.

DR. WANG: That's right.

MR. WALLIS: Is PIRT also part of the review, then?

DR. WANG: Well, PIRT, basically for the TRACG code, we needed to simulate for the --

MR. WALLIS: That's what you put into

TRACG?

DR. WANG: Okay. The purpose of PIRT here is we want to identify the phenomena. And that phenomena, the TRACG has the capability to model this phenomena. That's the purpose of being mentioned here.

And these confirmatory items was listed in the past ISE, and basically for this evaluation we tried to go through all of these confirmatory items, even though today I only selected a few to discuss here.

CHAIRMAN CORRADINI: May I ask -- I think I see where you're going with this.

MR. LANDRY: Let me see if I can help Weidong out on that. This might help you, too, Mike. When we did the TRACG applicability for LOCA review, before the DCD was submitted, that material did not take TRACG for LOCA into the long term. The part that was submitted was only a short-term PIRT. It was not a PIRT into the long-term applicability or long-term phenomenon applicability.

That's why when we did the TRACG SER we listed as one of the confirmatory items that when you come in with a DCD you have to provide a PIRT for long-term. And that's what Weidong is talking about.

MEMBER BANERJEE: Right. And a lot of your evaluation, then, related to the integral test for the PCCS and how they agreed with that.

MR. LANDRY: Did that help you, Mike?

CHAIRMAN CORRADINI: Yes. I had a different question, though. In the long term, the ratio of the machine to what you put the machine in the building matters. So what is the effect of the 12.5 percent uprate from 4,000 megawatts thermal to 4,500, when all of the other pieces of the building stay the same size? Is that reflected in the concern over -- because in the long term, time scales don't matter. It's a matter of energy balances of what I have and what I heat up. Has that been considered, or is that part of the --

DR. WANG: There is another open item later I will discuss. Basically, we would like to verify or check any new -- especially in the core for this, say, void fraction generation, the TRACG code capability. Basically, we have an II on that I think I will cover in the later slides.

For the long-term core cooling -- and we basically checked GEH supplement for the phenomena for the high break locations, like a main steam line break and feedwater line break. And the interesting phenomena here is the capacity relative to RPV volume, and also PCCS capacity relative to decay heat. The PCCS is basically for heat removal for this whole system in the long-term cooling.

And for low elevation breaks, the lower drywell volume with this elevation, basically since the break is low you needed to have something -- volume to hold the water. And also, break flow pressure drop -- break flows and the pressure drops through the DPVs, because for the lower -- lower part of this break, the break is more considered a small break for the bottom drain line break. So pressurization is slow, and this ADS system, like DPV, is -- for break flow is important.

And the staff will evaluate this long-term core cooling, and we found it acceptable.

MEMBER BANERJEE: You also reviewed the scaling analysis and everything that --

DR. WANG: We do and --

MEMBER BANERJEE: -- top down?

DR. WANG: Do you have any specific questions which Mohammed --

MEMBER BANERJEE: No. I'm just asking the scope of the review.

DR. WANG: Yes.

MEMBER BANERJEE: What --

MR. LANDRY: Sanjoy, we did review the scaling analysis and reviewed the testing program when we reviewed TRACG for LOCA applicability before the DCD. After the DCD came in, because, as Mike pointed out, it was at a higher power level, we went back and looked at what we had reviewed for the testing and for the scaling to see that there was nothing in this power uprate that -- or the changes that we saw that would negate our calling to question any of the positions that we had taken in acceptance of the testing and scaling program.

So, yes, we did review it, and we went back and checked it and looked at it again after the DCD came in.

VICE CHAIRMAN ABDEL-KHALIK: Let me just ask a slightly different question. The implication, of course, when you're talking about long-term cooling is that you understand everything about short-term cooling. And we hear a great deal about non-condensable gas accumulation in ECCS systems for current reactors. Is there any mechanism by which a non-condensable gas can accumulate in the gravity-driven system that would prevent them from operating in the short term?

MR. LANDRY: We did not see in the short term anything that would -- any way that you would have sufficient non-condensable accumulation to prevent this system from operating. But we --

VICE CHAIRMAN ABDEL-KHALIK: Do you have any idea about the detailed piping arrangement of the gravity-driven system?

MR. LANDRY: We reviewed --

VICE CHAIRMAN ABDEL-KHALIK: Whereby pockets of gas may actually accumulate during startup?

MR. LANDRY: We have to -- I guess we would have to see the real details. If the piping arrangement was different than our understanding of it when we did the LOCA TRACG report, or if it was different than our understanding of the system today -- let me call on Andre Drozd from the staff, who did part of the containment review.

MR. DROZD: This is Andre Drozd from Containment Issue -- Containment Branch. There is a chance of collecting non-condensables in the PCCS. However, it helps to resolve the issue if you remember that PCCS can work in two modes. One mode is a condensing mode, where you condense in the tube, you suck in -- suck in steam from the drywell. the second mode is delta P mode. That is, if by any chance you degrade your heat transfer in the PCCS, drywell pressure goes up, and delta P between drywell and wet well increases in such a way that it flushes through.

So it works kind of in a forced flow. The delta P that potentially can be created forces flow through PCCS, and, therefore, reestablishing the condensing mode of operation.

CHAIRMAN CORRADINI: But that -- if I just might make sure I understand. That leads to Graham's point, which is after you get through the initial transient, then you're back to whatever that delta P set, and that will set -- that delta P will slowly rise, rise, rise, as you --

MEMBER BANERJEE: I don't think that was Said's point.

VICE CHAIRMAN ABDEL-KHALIK: Perhaps GE should answer my question.

MEMBER BANERJEE: Yes.

MR. UPTON: This is Hugh Upton with GEH. We have a reference routing for the GDCS lines injecting into the RPV. It's sloped back to the pools, so if there's any accumulation of nitrogen in the line it will bubble up to the pools and up to the drywell air space.

VICE CHAIRMAN ABDEL-KHALIK: Has that been verified?

MR. UPTON: In what way, the routing?

VICE CHAIRMAN ABDEL-KHALIK: Do we have a detailed --

MR. UPTON: Yes. We have isometrics. Yes, we have isometrics on that routing. And I think it has been provided -- has it been provided in this one? We can provide the detailed isometrics on request.

VICE CHAIRMAN ABDEL-KHALIK: Now, if there is gas accumulation in the gravity-driven system lines, would TRACG be able to model the effect, the presence, of a fairly large non-condensable gas bubble in a gravity-supplied line?

DR. WANG: TRACG should have this capability, because that is basically the gas and the liquid flow and -- which is -- and also up to the regular pressure. So I don't see anything will prevent the TRACG's capability to model this phenomena.

You are talking about is -- you have a large non-condensable bubble trapped in the GDCS line, is that what you are trying to --

VICE CHAIRMAN ABDEL-KHALIK: Correct.

DR. WANG: And I don't think TRACG has any problem to simulate this phenomena.

VICE CHAIRMAN ABDEL-KHALIK: And you say that based on what, your own personal experience? You've done calculations of this type?

DR. WANG: Not really personally used the TRACG. But I was -- developed it by FIRE code and TRACE code, and I was involved in this kind of calculation. In my personal experience, I don't think TRACG should have this problem, even though I never really learned TRACG myself.

VICE CHAIRMAN ABDEL-KHALIK: Okay. Now, back to the isometrics that will be provided by GE, will the staff review that to make sure that this problem is indeed impossible?

MS. CUBBAGE: We have received PNIDs. You know, I think if they set a design criteria that there is going to be a certain sloping, then when they build the plant they are required to build it the way they said they would.

MR. UPTON: That's correct. We have a requirement that we slope the lines away from the RPV at I think one inch -- 1 to 100. I think that's the average slope.

MR. WALLIS: I think the problem would come about if you put the check valve in the wrong place, so that there was air trapped below the check valve. You wouldn't get enough delta P to open it. You would put the check valve in the right place in this line, so that you don't trap -- possibly trap non-condensables below the check valve, and then they won't open because there isn't enough delta P to open it. So I assume that you put the check valve in the right place.

MR. UPTON: Again, we have looked at that.

MR. WALLIS: The long pipe with the check valve in it, and there's air underneath it. It won't open if it doesn't have enough pressure to push it open. But you're not going to put the check valve at the top of the pipe, presumably.

MR. UPTON: That's correct.

MR. WALLIS: I hope not.

MEMBER BANERJEE: Well, these non-condensables in EEC lines is an issue that we've had to deal with in the past. So --

PARTICIPANT: We still are.

MEMBER BANERJEE: We still are. So it has to be -- make sure that we know something about it.

MR. WALLIS: Be sure that some architect-engineer doesn't go and route the pipe up and over a wall or something.

DR. WANG: I just wanted to clarify what my statement I said for this TRACG have the capability to -- you know, this I assume, okay, because TRACG is too free to model, which is similar to the TRACE code, and also RELAP 5 is too free to model.

What I tried to say is for this you have liquid and you have non-condensable gas for this flow to be able to simulate. However, for condensation in the PCCS, that's a different issue. I tried to make a point -- you know, if you have some trapped in it, if you have liquid, you should be able to simulate. That's my point.

CHAIRMAN CORRADINI: thank you.

DR. WANG: And next preliminary item I would like to bring up is, since TRACG, up to that time for the preapplication, that was version TRACG 02, and later for the DCD phase --

MR. SHUAIBI: Let me just go back to the question that was raised. Let us take that back as a lookup and come back maybe between now and the Subcommittee, maybe at -- between now and the full Committee, and maybe at the full Committee we'll have an answer for you as to how we're considering that or what we need to do to consider it.

I think I understand the question is your concern is like looped seals and things like that in the system that could maybe prevent or cause some problems. We understand the question, so let us take that back and we'll get back to you.

VICE CHAIRMAN ABDEL-KHALIK: Thank you.

DR. WANG: So staff would like to -- GE basically provided a confirmatory -- confirms the new models, and if they are applicable to the ES design -- ESBWR design, and I have listed a few model improvements here, which will impact the ESBWR calculation. But we think these models will include ESBWR calculations.

First is entrainment model and --

PARTICIPANT: What's that?

DR. WANG: Entrainment model. Basically --

PARTICIPANT: You're not going to add another field.

DR. WANG: No, we didn't do that.

MR. WALLIS: Which kind of entrainment are you talking about? Are you talking about entrainment in something like annular flow, or are you talking about entrainment from a pool when you're above --

DR. WANG: Annular flow. That's what --

MR. WALLIS: Annular flow. So it's a --

CHAIRMAN CORRADINI: So you mean to improve the model.

DR. WANG: Right, you improve the model, yes.

MR. WALLIS: There's not entrainment from a pool where you've got bubbles coming out of it. It's not that kind of entrainment.

DR. WANG: Not for that one. And here is basically -- we have increased the power, and we are basically -- GEH made this improvement, and staff made the judgment evaluation what they have done. And entrainment model they use the ECM/ECC model, and the improvement is basically they consider that as when it's dried out -- they consider a partial dryout and partial -- but just kind of -- basically, they improved the prediction for the low pressure data.

At the time, in the preapplication, the model is mainly for high pressure.

MR. WALLIS: Can I ask you something, though, to follow up on Said's question? This GDCS pool draining into the reactor, is the opening that goes into the vessel always below the water level? Or is there a possibility that it's opening and then spilling out like an open drain? Does it pour out like -- if it pours out like an open drain, you have to ask: do the non-condensables go back up the pipe or not? And does that change the hydrostatic head in the pipe?

DR. WANG: Even if it vortexes --

MR. WALLIS: Yes. But, I mean, the simplest thing: does it run full or not? Because that changes the hydrostatic head. It's like when you empty the sink in your hotel room or something, you know, if there's a bubble in the pipe, if often doesn't drain very fast until that bubble is gone. The bubble comes up the pipe into the sink. It doesn't go the other way. So there's a bubble coming back up the GDCS line, is that what you mean?

DR. WANG: Yes, I understand your question, but I --

MR. WALLIS: Does that ever happen or not?

CHAIRMAN CORRADINI: GE is going to have to answer that one, yes?

MR. MARQUINO: Okay. I want to be clear. Are you asking about the GDCS line going into the vessel?

MR. WALLIS: Going into the vessel from the GDCS line. Does the end of that pipe ever -- is it ever not submerged? Because if it's not submerged, then you have to ask: does the gas go back up the pipe countercurrent flow or not?

MR. MARQUINO: I think that's like nine meters. Do you remember the --

MS. CUBBAGE: Graham, just to make sure, are you talking about if the GDCS has been actuated or during normal operation?

MR. WALLIS: At any time.

MS. CUBBAGE: At any time.

MR. MARQUINO: When it's actuating.

DR. CHEUNG: This is Chester Cheung from GEH.

MR. WALLIS: After it has been activated, but, you know, after it has been activated there's less flow in --

MS. CUBBAGE: Yes. That's what I -- yes.

DR. CHEUNG: This is Chester Cheung from GEH. The GDCS pool surface level is somewhere around 22 meters or 20-some meters. The elevation for the connection to an RPV is 10.5 meters. So you are talking about 13 meters of water head.

MR. WALLIS: I know. But that is not always available if the pipe has got gas in it.

CHAIRMAN CORRADINI: I think what they are asking you is: where is the inlet line compared to where the level is where you initiate injection?

MR. WALLIS: And during injection, does that level ever come down and expose the end of the injection line, so that gas could go back up the pipe? That's what I'm asking.

MR. MARQUINO: Dr. Wallis --

MEMBER BANERJEE: Where it meets the RPV.

DR. CHEUNG: Meet the RPV at 10.5 meters.

MR. WALLIS: I think that the level in the vessel sometimes is below, because your minimum collapsed level is sometimes eight or nine meters.

DR. CHEUNG: The level may be dropped below the connection point, but --

MR. WALLIS: When that happens, does gas go back up the GDCS line?

DR. CHEUNG: No. The --

MR. WALLIS: Do you have a high enough --

DR. CHEUNG: No, let me finish. There is trouble in the line. If the pressure in RPV on the other side of it is lower --

MR. WALLIS: No, it's not a question of pressure. It's a question of having enough flow to prevent gas going back up.

DR. CHEUNG: It has something to do with the pressure. If the pressure is lower --

MR. WALLIS: That's not --

DR. CHEUNG: The pressure is higher --

MR. WALLIS: That's not the issue.

MEMBER SIEBER: It could be stagnant.

CHAIRMAN CORRADINI: Let's try it this way. You said it's 10.5 meters to the pipe from the core?

DR. CHEUNG: From the bottom of the RPV.

CHAIRMAN CORRADINI: From the bottom of the RPV. Where is the setpoint where you initiate GDCS injection? What is that setpoint in terms of level?

DR. CHEUNG: In terms of level, it is 11.5.

PARTICIPANT: A little bit above --

DR. CHEUNG: A little bit above --

PARTICIPANT: -- the collapsed level.

DR. CHEUNG: -- the collapsed level.

PARTICIPANT: Okay.

VICE CHAIRMAN ABDEL-KHALIK: During transient, it is possible that after you have actuated this gravity-driven system, the water level in the vessel would drop below the point --

DR. CHEUNG: Yes.

VICE CHAIRMAN ABDEL-KHALIK: -- where the line connects with the vessel.

DR. CHEUNG: Yes.

VICE CHAIRMAN ABDEL-KHALIK: So there may be countercurrent flow of gas up that pipe.

CHAIRMAN CORRADINI: Where would the gas come from, though? That would be --

DR. CHEUNG: Well, that is what the --

MEMBER BANERJEE: I think what he was saying is that TRACG should be capable of modeling that countercurrent flow if it occurs. Now, that's a capability --

MR. WALLIS: Does it model concurrent flow in horizontal pipes?

DR. CHEUNG: Yes, we model -- let me try again. The RPV pressure, if higher, it won't stop any flow from it going back.

MR. WALLIS: No, it doesn't stop gas going the other way. You can have liquid running one way and gas going the other way.

DR. CHEUNG: It doesn't.

MEMBER BANERJEE: It really doesn't, so don't argue that...

DR. CHEUNG: No. The --

CHAIRMAN CORRADINI: I think he's starting higher up. He's just trying to talk you through that initially pressure in the RPV is high, pressure on the other side of the check valve is low, the check valve is isolated.

MR. WALLIS: You've got water going through the line. Is that water flow big enough to prevent bubbles going back up the line?

CHAIRMAN CORRADINI: But where would the bubbles come from? It's all steam.

MR. WALLIS: Well, the steam will go in and condense, presumably, in that line and cause --

CHAIRMAN CORRADINI: It would rather go up the line than up the chimney?

MR. WALLIS: It could go up the line.

DR. CHEUNG: The steam with cold water countercurrent flow.

MR. WALLIS: A pipe will only run forward, stop gas going back up the pipe, if you have a high enough velocity in it.

DR. CHEUNG: The RPV pressure at that point in time is larger, higher than the drywell pressure. non-condensable gas is almost impossible to get in the RFP in the first place.

MR. WALLIS: High pressure is irrelevant. It's the flow rate in the pipe that --

MEMBER MAYNARD: Isn't the GDCS pool at the top, isn't that open to the drywell environment?

So if you do have gas, it's going to go back up there into the pool and bubble --

MR. WALLIS: The thing is, if there is that, it will change the hydrostatic head. It will change the flow rate. That's the whole thing. It will affect the flow rate of GDCS flow.

MEMBER BANERJEE: I guess the issue here is if TRACG is above the capture this type of phenomena --

MR. WALLIS: Then it's okay.

MEMBER BANERJEE: -- then it's okay, because it will be automatically captured. On the other hand, the point that Graham is making is that one has to be sure that TRACG can count -- capture countercurrent flow in a horizontal pipe. If it can do that, then it should be part of -- automatically part of the calculation.

DR. CHEUNG: Do you want to make a comment?

CHAIRMAN CORRADINI: Can I just make sure I understand your question? Where Said started was he was concerned about having non-condensables. Okay. Now you are talking about steam flow going back up the pipe that rather -- going up all that area this way. I don't think steam wants to go the hard way. Why doesn't it want to just go straight back up?

MEMBER BANERJEE: That's the calculation of --

MR. WALLIS: That's the whole continuum. It sees the gravitational head in the pipe, and it sees a crude number, and it will go back up the pipe.

MEMBER BANERJEE: Well, whichever, but that should be calculatable. That should come out of your --

MR. WALLIS: I'm not sure that TRAC can handle it. It's not that easy a problem to --

MEMBER BANERJEE: Yes. The issue that has been raised I think is whether you can handle countercurrent horizontal flow, which is not all that straightforward, because you get waves, you get flooding. It's a different behavior -- horizontal countercurrent flow. So maybe you could just answer that question. Did you look at that specific issue?

MR. WALLIS: I don't think they did. I think it's an open item for me. And even if you got steam, the steam will run in to condense on the cold water, and it will then pile up whatever non-condensables are in the pipe.

And then, the question is: are they going to go up the pipe, or are they going to come back out into the vessel?

DR. CHEUNG: Let me answer the other way. Okay. TRACG has the option to turn on the countercurrent flow, since it's happening in any --

MR. WALLIS: Well, I guess what I'd have to do is look at the velocities you're calculating in the pipe and figure out if I think that gas would go up the pipe or not.

DR. CHEUNG: I think it's a hand --

MR. WALLIS: Rather than asking what TRAC does, I want to see the numbers and --

MEMBER BANERJEE: If the pipe doesn't fill, it you don't have the velocity to fill it --

MR. WALLIS: Then it would change the draining rate.

MEMBER BANERJEE: Yes.

CHAIRMAN CORRADINI: So I'm still back at the beginning. You initiated 11-1/2 meters, and the pipe is coming into the downcomer at 10 meters. And in one of your limiting sequences you uncover that pipe?

DR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay. And that's the main steam line break?

MR. WALLIS: And gas could go up the pipe.

Now, if you think about your hotel room drain, you know, if there's gas in the pipe, the drain pipe from your sink, then the only head that is draining the water in is the little head near the plug, the hole. When that gas comes out, if you get enough water to fill that pipe, you get, you know, six feet of water sucking water out and it goes zipping down there. It makes a big difference what's in that pipe. It takes a certain amount of velocity to clear the pipe.

CHAIRMAN CORRADINI: Yes. But you're talking a non-condensable versus steam in cold water. So I'm not sure that's exactly the analogy.

MR. WALLIS: Yes. But if they're non-condensable, if the steam --

MEMBER BANERJEE: Over a period of time, the steam will condense and --

MR. WALLIS: So I think it is a viable question, an issue. That's the kind of thing I think we ought to be focusing on. And we go through all this stuff here. We think, well, what could possibly not be properly modeled by this kind of analysis? That's what we should be focusing on.

MEMBER BANERJEE: TRACG has a non-condensable field in the steam, right?

PARTICIPANT: Yes.

MEMBER BANERJEE: So if there was non-condensables going in, they would accumulate in this line and you --

MR. WALLIS: How does it figure out which way they go once they're in there? That's the question.

MEMBER BANERJEE: That's the issue, yes. Because probably if you don't get the interfacial drag quite right, you might just sweep this out, whereas in fact this might sort of migrate, as Graham says, up against -- if the flow rate is not high enough. So that has to be probably looked at.

VICE CHAIRMAN ABDEL-KHALIK: So as far as we know, there is no calculation that the staff knows of that shows that this issue is a non-issue. Is that correct?

MEMBER BANERJEE: That's correct. But basically --

VICE CHAIRMAN ABDEL-KHALIK: So rather than sort of relying on intuition, and so on, is it reasonable to expect that the applicant would do a mechanistic calculation to show that this is indeed a non-issue, or it is calculable by the existing code? And this question was directed at both GE and the NRC.

MR. DONOGHUE: I think the answer is, yes, we should think about this -- first of all, the phenomenon, and get some understanding of it somehow, but then exercise the code, our confirmatory calculations to see what happens.

MR. WALLIS: And if it doesn't predict what looks physically reasonable, then you have to question it.

MR. DONOGHUE: Yes.

CHAIRMAN CORRADINI: What is the current calculation assuming in this regard? Do you guys know?

MR. MARQUINO: The current calculation -- number one, the vessel is not filled with non-condensables during operation. It's full of steam.

CHAIRMAN CORRADINI: That's Graham's point. Graham's point or concern is is that -- is that you've got this competing effect. So I guess a question to ask is: are you allowing this to occur, or are you essentially assuming it's just water flow in?

MR. MARQUINO: No. We're allowing it to occur, and the code has the capability to model countercurrent flow in the --

CHAIRMAN CORRADINI: What NEDO do we look at to make ourselves feel better?

VICE CHAIRMAN ABDEL-KHALIK: I'm sorry. Does your calculation have enough resolution to answer this question?

MEMBER BANERJEE: Yes. In the line between the GDCS and the RPV, do you have enough --

MR. WALLIS: I think it assumes single-phase flow probably.

MR. MARQUINO: No. There is no switch in the code that will cause it to say it's only single-phase flow.

VICE CHAIRMAN ABDEL-KHALIK: But would it have enough resolution to predict a free surface inside that pipe?

MR. MARQUINO: The nodalization will have some impact on where it tracks free surfaces.

MR. WALLIS: Does it have a criterion that lets or does not let steam go back into the pipe? I don't show that --

MR. MARQUINO: So I think what would be appropriate is you asked if -- isn't it reasonable that the applicant -- we should get back to you and describe the capabilities of the code, our nodalization, the piping slopes, so that we can justify to you that this countercurrent flow phenomena is not significant in the LOCA.

MR. WALLIS: Does it show that there's a big enough crude number that it will sweep out anything that goes in there, and so --

MR. MARQUINO: And agree that it might be -- the hand calculation could validate the code in this regard.

MEMBER BANERJEE: There are regimes, I imagine, where the flow is fairly small, right, through that line?

MR. WALLIS: We just don't know. I just don't know how --

MEMBER BANERJEE: So one way around this would be if you have the capability in the code, and if you nodalize that finely enough, and just make -- yes, just show that you are capable of capturing that phenomena, then it should be automatically --

MR. WALLIS: Well, it depends how much pressure there is from the vessel. It may be that the flow into this GDCS line is simply driven by gravity, and there is really essentially no pressure difference from the outside world. You can go around through the core and all the way back to the pool. There is still very little pressure there.

CHAIRMAN CORRADINI: Dr. Wallis?

MR. WALLIS: There will be -- you've got

so much header water that the velocity is so big it shoots everything out. But if there's a back pressure from the core, then you could reduce the flow rate to the point where you get steam going back up the line. I just don't know.

CHAIRMAN CORRADINI: Dr. Wallis?

I guess the one thing I'd ask GEH, as you thinking about all of this, at least point us to the right topical, so we can look to see what you've done to date.

MR. MARQUINO: Okay.

PARTICIPANT: That would be helpful, a good starting point.

MR. WALLIS: Well, don't make me search in somewhere to find it.

(Laughter.)

MR. MARQUINO: You want a page number and like a three-digit section number.

MEMBER BANERJEE: Yes. Does it handle condensation in horizontal --

MR. WALLIS: I think you are all right, but I think we ought to be asking if, from a safety point of view, what kind of things could happen which might somehow change the scenario in a way which isn't predicted.

MEMBER BANERJEE: Right.

MR. SHUAIBI: And I guess today we're not going to be able to satisfy you, and, you know, we'll take this one back and we'll take a look at it, and we'll come back. And if additional analyses need to be done, that's -- that's part of the reason why we're here is to get your input.

MR. WALLIS: the staff didn't ask this question before?

MR. SHUAIBI: If we had, I think we would have been up answering your question. It appears to me like this is something that you've identified that we need to go back and look at. So we appreciate that.

MR. WALLIS: And I think we ought to look at the PCCS arrangement. We've got some sort of sketches about how the condensate and the non-condensables get vented this way and that way, and there's a fan. But until you see the piping, you can't really tell what's happening there.

So we can't tell, is the fan going to ingest water, or is the water going to get -- prevent the non-condensables? Until you see the details of the design you can't really tell whether some of these things will work, and that's what bothers me about this kind of rather superficial review --

MS. CUBBAGE: Right. Well, I --

MR. WALLIS: -- if TRACs predict something and you accept it, you know.

MS. CUBBAGE: Well, I think we already decided yesterday we'd be coming back with more details on containment, and we have not yet seen the details of this fan arrangement.

MR. WALLIS: Right. Okay.

MR. SHUAIBI: I just want to make sure -- I don't think it's fair that we're doing a superficial review. I think we've done a lot of work.

MR. WALLIS: I'm sorry. I mean, the TRAC, when you just look at TRAC, without looking at the details of the fittings, and so on, I mean, maybe "superficial" is the wrong word, but, I mean, just a code type analysis, where you don't look at the details of what happens at some of those nodes. That could be called "superficial." I'm not saying it in the derogatory sense. I mean, it's at a high level, surface.

MR. SHUAIBI: Just let me add one comment to that is that even if you have detailed design drawings and you build everything, as you are well aware, you will find that in operating plants there could be still be a problem. So plants are going to have to have programs to still make sure there is no gas buildup in there, in the GDCS system.

MEMBER BANERJEE: But it's very hard to find that, as we know.

MR. SHUAIBI: Yes.

MEMBER BANERJEE: Because we have faced this, as you know, before. It is very hard to find out if there is gas or not, and we are facing this with the operating reactors right now.

MR. SHUAIBI: Right.

DR. WANG: Okay.

MEMBER BANERJEE: Before you jump from the entrainment model, I wanted to ask you about the flow regime.

DR. WANG: Basically, what -- GE have improved the flow regime to annular flow, and I only can give you, you know, high-level summary on that for here.

Basically, they look at that -- the mechanism for the change to annular, and they said that was the philosophy for the change regime and annular regime is equal, and then try to solve the void fraction and use that void fraction as the base for flow regime transition.

MEMBER BANERJEE: So now, because of this somewhat increasing power, you are probably close to the transition between turbulent and annular flows.

DR. WANG: Right.

MEMBER BANERJEE: And in these rather large pipes, and like the chimneys, what sort of database is there for that? I mean, I'm sure there is some in the oil-gas industry, but there isn't a huge amount that I know of in any other.

DR. WANG: I believe we went through an audit, and they look at data like at Toshiba they have done some low pressure data, and basically I believe GE has validated this model against those data. So the point here is improvement is -- in the past is mainly focused on the high pressure, and here is focusing on the low pressure system.

MR. WALLIS: The real question isn't, what is -- isn't really, what is the flow regime, but does the correlating scheme predict the data? Because you can have the wrong flow regime in terms of looking at it, but the fudge factors in the model will predict the data very well. And that's okay.

MEMBER BANERJEE: That's not okay.

MR. WALLIS: So Dick Finlay doesn't necessarily have to model the right flow regime in order to get the right answer.

MEMBER BANERJEE: If you have enough correlating parameters, you can fit anything.

DR. WANG: First of all, I let you know I really haven't looked at these things very closely, because in the past for this TRACG code review I think we have a staff comment go --

MEMBER BANERJEE: I'll tell you where our -- where we are -- at least I am coming from. Yesterday, Professor Abdel-Khalik raised a question where what is happening is when the flows are issuing from the channels into the chimneys, there is going to be very strong, three-dimensional effects, obviously, until things settle down. But this length can be quite long, the development length. Okay.

And it could be quite important, particularly if you have, you know, a liquid level somewhere like halfway up the chimney or a quarter way up the chimney. So you really don't have a flow regime in the sense of a static flow regime. All you have is a developing region there, which would have very different characteristics.

And how does that get captured? You know, if you have static flow regime maps, sort of the question was: shouldn't you be doing some analysis of this region to find out important it could be?

MR. WALLIS: Did Ontario Hydro try different distribution methods?

MEMBER BANERJEE: No, did not. As far as I -- there is another issue which is even more important, which is whether you really get static head fluctuations which are large. And we asked this question about the chimney about two years ago, and it was answered by doing some fine nodalization runs with TRACG.

But, again, there was the issue of: how well does the fine nodalization runs capture the real effects if you are using a static flow regime map anyway, you know?

DR. WANG: That's why GE is proposing for the interfacial --

MEMBER BANERJEE: Right, right. So that's not there yet.

DR. WANG: Right.

MEMBER BANERJEE: Okay.

DR. WANG: But I think for the question you raised, as far as I think for -- it's too difficult a question basically to address here.

MEMBER BANERJEE: But there are -- there could be some experiments which would clarify the issues. If you get large static head fluctuations in these chimneys with a certain frequency, then we are worried about how it couples, you know, to the core. So we are looking at -- even though we are not addressing stability with TRACG here, nonetheless, that has been a concern.

MR. WALLIS: You're thinking of an experiment where you take a chimney element and you take your 16 different channels, and you put in different regimes in the channels, and you see what happens and measure with real conditions, that sort of thing?

MEMBER BANERJEE: Well, if not real conditions, perhaps with freon or something, you know. I don't know.

MR. WALLIS: Well, ideally, with full scale and full pressure.

DR. WANG: I don't have an answer for you on this.

MR. WALLIS: GE traditionally has a very good philosophy of doing, when they can, full scale, full condition experiments. That's what they do with the fuel. Very good job. Test the fuels, real conditions. The chimney -- that doesn't seem to have happened, so we're relying on TRAC or something else to predict what happens in the chimney.

So these sorts of questions can always be raised, and I just don't know how you answer them, except by some kind of engineering judgment, unless you've got some evidence.

MR. MARQUINO: We've heard your concern, and we will work to address it.

MEMBER BANERJEE: Somebody mentioned that the Dodewaard experience might be looked at in relation to this problem. And that might be helpful to bring it in and --

MR. WALLIS: Did they have chimneys like this?

MR. MARQUINO: They had chimneys. Yes, they had four by four super channels.

MEMBER BANERJEE: And --

MR. MARQUINO: Or, excuse me, two by two super channels. It was somewhat shorter than ours.

MEMBER BANERJEE: And you've used TRACG, of course, against that.

MR. MARQUINO: Yes.

MEMBER BANERJEE: Okay.

CHAIRMAN CORRADINI: Did we miss that? Is that analysis in another NEDO that I don't -- I can't remember where it went?

MR. MARQUINO: I think it's in the 32177 report, the TRACG qualification report.

CHAIRMAN CORRADINI: And then, just for the sake of -- and then, you will also give us some advice on that one as well as the one where you said there is already a calculation for us to look at as you consider the countercurrent in the piping. Thank you.

MEMBER BANERJEE: Perhaps some scaling analysis or something to indicate the applicability of that data, has that already been done, or have I missed that?

MR. MARQUINO: We did submit a scaling analysis for --

MEMBER BANERJEE: I know that. But the applicability of this Dodewaard data, I mean, in terms of the range of parameters and the other non-dimensional groups, is it within the range of what we are looking at TRACG here for?

MR. MARQUINO: Do you want to comment on the Dodewaard scaling or --

MEMBER BANERJEE: No. I mean, does it actually have the same range of, let's say, these pie groups or whatever we talk about?

DR. SAHA: Okay. This is Pradip Saha from

GEH. The scaling analysis that we did, and then it was upgraded for 4,500 megawatts, I think was geared towards the LOCA.

So basically we looked into GIST and GIRAFFE SIET experiments. And then, we showed that even though the power has been raised by 12.5 percent, so decay heat goes up, but primarily dominant phenomena during LOCA was that ADS or the enthalpy -- mass and enthalpy going out predominantly in the most dominant term was ADS. And the decay heat portion was much smaller. So that is why we concluded -- and I think staff has agreed with that -- that the earlier experiments are applicable to 4,500 megawatt also.

Now, for Dodewaard, I don't think there was anything related to --

MEMBER BANERJEE: No. That would be more towards normal operation.

DR. SAHA: Right. No, it was not part of that study.

MEMBER BANERJEE: I know it's a separate issue --

DR. SAHA: Yes.

MEMBER BANERJEE: -- but let me ask this for information, then. For the applicability of TRACG to other things, say even anticipated transients, and so on, which are more at elevated pressures, and so on, has there been some scaling analysis done?

DR. SAHA: Not that I know of. As you know, I kind of joined GE only two years ago, so that maybe may have been done -- a lot of other things -- before that. So I'm not aware of it. So maybe Mr. Marquino can say or we can get back to you on that.

MEMBER BANERJEE: Well, let's say that we are going to come to anticipated transients, and so on, the applicability of TRACG to that.

DR. SAHA: Yes.

MEMBER BANERJEE: So it would be useful for that to know something about how Dodewaard data was compared, whether it was in the same range of pie groups or whatever, and how it compared with that. I don't know who is the right person to ask this question, but --

DR. SAHA: Yes. Let me say that when I was given the assignment to respond to RAI 6.3-1, and that was the RAI from the staff to justify or show that the RES scaling analysis that was done for 4,000 megawatt, that's invalid. So that is what I took up, and, as I said, that we responded to it and staff has accepted that. And that was based on, as I again said, LOCA. And Dodewaard test was not included in

that.

MEMBER BANERJEE: Obviously, because there is no LOCA test done.

DR. SAHA: Right. I know that what Mr. Marquino mentioned in the TRACG qualification report and Rev 3, I think 32177 probably, the number, I think there is a simulation of Dodewaard with TRACG. But I do not recall whether there is any scaling analysis.

MEMBER BANERJEE: Yes, because that would show whether the conditions which are important were similar or not or within the range of interest. I think that's the real issue.

DR. SAHA: We understand.

MEMBER BANERJEE: Okay.

DR. SAHA: And I'm sure Wayne is taking notes of that.

MEMBER BANERJEE: Great. Thank you.

DR. WANG: Continue?

CHAIRMAN CORRADINI: Yes.

DR. WANG: Okay.

CHAIRMAN CORRADINI: Please.

DR. WANG: For the thermal conductivity, actually yesterday we talked about it for the LOCA part. And there is other models. TRACG has updated the models, and these models are actually for the LOCA

-- it is not important. I just basically list it here for -- to illustrate what kind of models TRACG has went through from version 2 and through version 4.

MR. WALLIS: So you don't use the quench run model for this --

DR. WANG: Because no dryout for the LOCA.

MR. WALLIS: -- for this source term? You just take some sort of source term, you don't try to figure out core damage or anything like that?

DR. WANG: Because for the LOCA there is no -- I mean --

MR. WALLIS: But, I mean, when you're doing the Chapter 15 analysis, you don't try to be realistic in any way about if it does dry out and then you construct this artificial scenario, how does it rewet?

MR. LANDRY: Are you talking about for the radiological assessment?

MR. WALLIS: Yes.

MR. LANDRY: We're talking about strictly for the design basis.

MR. WALLIS: Yes, but you don't try to make any bridge whatsoever between reality and the regulations.

MR. LANDRY: For the design basis analysis for LOCA, the core does not dry out. So none of these models apply.

MEMBER KRESS: They just have to show that the temperature in the hot leg --

MR. WALLIS: When you get into Chapter 15, you just make a leap into the source term without asking how it got formed, right?

CHAIRMAN CORRADINI: For 15.4, that's what they have to do.

MR. WALLIS: All right. So --

MEMBER BANERJEE: But for some of the anticipated transient, there is dryout. But then, you don't worry about rewet I guess.

MR. MARQUINO: Not for anticipated transients.

MEMBER BANERJEE: Sorry. Special -- what did you call --

MR. MARQUINO: For ATWS -- for ATWS, there is a dryout-type phenomena.

DR. WANG: Okay. Go to the next one?

CHAIRMAN CORRADINI: Please.

DR. WANG: Okay. This confirmatory item is about -- addresses the power and the results from main steam isolation valve closure. Basically, at the preapplication stage, staff asked GE to confirm about

-- say if for the main steam isolation valve closed, what about the power transient, is it going to increase or not? And GE has the response that basically the rod -- I mean, the scrams way earlier occur before this main steam isolation valve closure during the LOCA. So this problem has been closed.

And the next one, basically GE is aware from the earlier submission to the later design change being made, and the staff asked GE to confirm the TRACG applicability, say, for the core power since it has changed from 4,000 megawatts to 4,500 megawatts.

And staff asked us to confirm the applicability of the TRACG interfacial shield model. This is an open item.

And for ICS was for the -- LOCA analysis was not a part of the ECCS, and the latest design is considered as a part of the ECCS, and the staff have a question basically -- ask GE to make a clarification about nodalization, and also justify that the modeling of the IC heat removal capacity in the LOCA is conservative.

And other changes -- other design changes, we believe TRACG has the capability to model, so these will not affect TRACG applicability. Many of them are listed here. For example, core shroud size and core lattice. These are not really modeled for this -- well, the core lattice is not really modeled.

And another example is the number of bundles and the control rod drives. These are also another model for this LOCA analysis.

If you have no questions, I'll go to the next one.

Other confirmatory item is basically for the containment analysis the TRACG assumed there's a loss of feedwater flow, and staff raised the question is -- if you have additional feedwater goes to the reactor vessel. If you don't, basically assume it's lost, and the additional inventory and energy, and that can eventually go through the containment. And staff raised this question, basically wanted GE to address for this containment system.

And next confirmatory item, 11, is similar to this item 10. Basically, staff asked GE to add a detailed modeling of this feedwater system. And I believe GE has submitted this II back, and currently staff is reviewing it.

MR. WALLIS: You are talking about some sort of model for these heaters, the actual feedwater heaters, this -- taking bleed steam from the turbine and how they work?

DR. WANG: I believe --

MR. WALLIS: Do you want to --

DR. WANG: I believe it is not really what you have just mentioned. I believe that in the beginning when -- people at NRR at times raised this question, is it related to the item 10, and they wanted to have more realistic modeling of this inventory amount goes to the reactor vessel and also go through containment.

It's not anything, you know, for the current feedwater operation domain. But GE did answer -- they have added some model for the feedwater, so we are looking at it.

Any clarification here?

DR. CHEUNG: This is Chester Cheung. Three years ago when we modeled the feedwater line, only modeled the -- half of it. And at that point in time, the GDCS volume compared with the lower drywell volume and then the feedwater line volume is kind of mixed. And there was a concern that you have the whole line of feedwater volume was water inventory going into the drywell, and then what happened.

And now we model exactly all of this volume into it, and in case of feedwater line break all of the volume in the feedwater line, it did go into the lower drywell and pressurize the drywell that way. So at that point in time, it was a volume concern, the volume between the different locations.

DR. WANG: Does that answer your question, Dr. Wallis?

MR. WALLIS: I'm not sure. Why do you say feedwater heater modeling?

DR. WANG: Because the heater modeling will affect the amount of their -- this whole system in the -- for the feedwater drain, there is many stages of the heaters.

MR. WALLIS: Right.

DR. WANG: And if you model the system --

MR. WALLIS: Well, the vessel actually has quite a bit of water in it before the heat -- water heaters, doesn't it?

DR. WANG: Yes, there's quite a bit of water.

MR. WALLIS: So you want to know where the water goes, is that what you're modeling, then?

DR. WANG: We model it, and then the water eventually will go in the lower drywell.

MR. WALLIS: I see.

DR. WANG: Until the isolation valve or the feedwater line actually closes.

And there is an uncertainty analysis we discussed yesterday about, you know, basically this is not a technical issue but a laboratory issue, and you needed to answer -- address how --

MR. WALLIS: How uncertain they are about 2,200 degrees?

DR. WANG: Right. And they claim this coil is always covered, so there is no issue. But we needed to ask GE to address this.

CHAIRMAN CORRADINI: I'm not sure what you're asking them. You're asking them to come up with some sort of uncertainty analysis?

DR. WANG: Basically, have to address this laboratory guide, but what --

MEMBER BANERJEE: You are looking at what the level above the core or something.

CHAIRMAN CORRADINI: No, that's what they're suggesting. I'm trying to understand your question. Are you saying that you haven't evaluated their response based on level? Is that --

MR. LANDRY: The regulation, 50.46, says you can do either a realistic analysis with a determination of uncertainty, or you can do an Appendix K analysis. What General Electric-Hitachi has submitted is a realistic analysis.

MR. WALLIS: Well, you can't do an Appendix K analysis of this --

MR. LANDRY: They have not done any form of an uncertainty analysis, and what we are simply saying is they don't uncover the core. This is not a safety issue, it's not a technical issue, it is a compliance issue. The regulation doesn't say a realistic analysis, and if you don't uncover, okay. It says you do this or you do this, and they have not done --

MR. WALLIS: I think they have. They have essentially said it doesn't uncover, so their uncertainty is zero.

MR. LANDRY: Yes. But they have to do some sort of -- we discussed this over and over with them.

MEMBER BANERJEE: I guess it's uncertainty of uncovery that -- by the --

MR. LANDRY: They have to do some sort of uncertainty analysis.

MR. WALLIS: Of uncovery.

MS. CUBBAGE: And we have asked this to GEH in an RAI. We're waiting for their response.

MR. WALLIS: Okay. Well, I'm sure they'll respond.

MR. LANDRY: This is not a safety issue. It is a compliance issue with the exact statement of the regulation.

CHAIRMAN CORRADINI: Got it. Thank you.

MR. WALLIS: But they asked for uncertainty analysis of these 2,200 degrees and things like that.

MR. LANDRY: No. No, it says with a determination of uncertainty.

MR. WALLIS: So a blanket uncertainty.

MR. LANDRY: It just says a determination of uncertainty.

MR. WALLIS: Okay.

MEMBER BANERJEE: So you can define that uncertainty the way you like. It can be done -- certainty involved in that core uncovery calculation.

MR. LANDRY: And that's what we've said. Do some sort of uncertainty determination.

MEMBER BANERJEE: I think that's fair.

MR. LANDRY: Yes.

MR. WALLIS: And you might find there's a certain probability of uncovery. You might. You might. Okay.

MR. WILLIAMS: Jim Gilmer got turned over from Veronica the transient portion of the 33083P, and he is going to discuss his -- discuss the review of that.

CHAIRMAN CORRADINI: Okay.

MR. GILMER: We made a decision early on to take out ATWS to allow Ben Parks more time to discuss the key issues of core injection, which he talked about this morning.

MEMBER SIEBER: Take a break.

MR. GILMER: Some of the things that we are going to talk about in the AOO and infrequent events also apply to the ATWS.

CHAIRMAN CORRADINI: Would you be hurt if we took a break now? I'm starting to look at members that are looking at bit weary. So can we take a 15-minute break and come back to you? Would that be okay?

MR. GILMER: Sure.

(Whereupon, the proceedings in the foregoing matter went off the record at 3:02 p.m. and went back on the record at 3:17 p.m.)

CHAIRMAN CORRADINI: All right. Let's get started. Let's go.

MR. GILMER: I wanted to say that the key ATWS concern was the ability of TRACG to model the boron injection which Ben Parks talked about this morning. There are a few items that I'll mention here also, if there's time.

CHAIRMAN CORRADINI: That's fine.

MR. GILMER: We do have a couple of key open items that I want to summarize.

Next slide.

The SRP 1502, Shawn had an earlier slide, so that's all I'll say there. But there are some additional key references on transient and background analysis methods. And NUREG/CR-5229, which is the CSAU method for LOCA was also used for the --

MEMBER BANERJEE: But in these anticipated transients, TRACG presumably is coupled to some sort of neutronic field, right?

MR. GILMER: That's correct.

MEMBER BANERJEE: And they were separately approved I guess, right?

MR. GILMER: Well, that's still ongoing. I'll let Dr. Yarsky --

MEMBER BANERJEE: Okay.

MR. GILMER: -- address the neutronics. He's our expert on that.

DR. YARSKY: This is Peter Yarsky speaking. What is in TRACG is a kinetics model that is basically like a mirror image of the steady state neutronics code. The steady state neutronics code is still under review, but information is taken from that and fed into basically a similar engine which is in TRACG.

MEMBER BANERJEE: And what is this engine? Is it multi-node or just one-dimensional? What sort of --

DR. YARSKY: It's a three-dimensional --

MEMBER BANERJEE: It's a three-dimensional --

DR. YARSKY: -- nodal diffusion.

MEMBER BANERJEE: Okay. And that is fed into TRACG here.

DR. YARSKY: Yes. So information comes from the steady state model, but the same engine is mirrored in TRACG.

MEMBER BANERJEE: But this is a transient calculation which is done now, right?

DR. YARSKY: Yes.

MEMBER BANERJEE: And show how does that get -- transient nature of this get transmitted back and forth to TRACG, in terms of, let's say, your void fraction is changing, or whatever, so you --

PARTICIPANT: Moderated temperature.

MEMBER BANERJEE: Yes, temperatures are changing. Does that change various things in the code, the cross-sections or how you collapse them and feed back?

DR. YARSKY: I'm not sure if I --

MEMBER BANERJEE: The interaction between the two.

DR. YARSKY: Yes. I'm not sure if I can answer that in sufficient detail in open session.

MEMBER BANERJEE: Oh, okay. But there is an answer to that, right?

DR. YARSKY: Yes.

MEMBER BANERJEE: Okay.

CHAIRMAN CORRADINI: But just to be clear, so you're in the midst of the review as of now. So we'll probably hear back from staff when you guys are at a point.

MR. SHUAIBI: Let me make sure what Peter said I guess clear. He can't answer it in an open session, because we're in open session. I guess if we go to a closed session, he may be able to get into more detail, a little bit more detail.

CHAIRMAN CORRADINI: But before we go to that effort, I just want to make sure I understand. You still are in the middle of the review? Because you have not issued the SER yet on this part of this.

DR. YARSKY: This is being reviewed as part of Chapter 4, but the actual review is for the topical report, the nuclear design topical report, which is the -- which in it contains the qualification of the methods.

CHAIRMAN CORRADINI: Right.

DR. YARSKY: So that's going to be an SER that is issued for the proprietary topical report.

CHAIRMAN CORRADINI: Which we eventually will get to look at.

MS. CUBBAGE: Yes.

DR. YARSKY: Yes.

CHAIRMAN CORRADINI: Okay.

MEMBER BANERJEE: He wants to move on, so -- he doesn't want to --

(Laughter.)

CHAIRMAN CORRADINI: I don't want to go into closed session right now for that one question.

MEMBER BANERJEE: So all we're saying is we will address this issue in a -- later on.

CHAIRMAN CORRADINI: I guess there is one thing -- and maybe I missed it -- we got some of the topicals in a CD that we have. There's others that people are mentioning that are still either in transit or have arrived and staff is looking at them. Is there like a master list that I've missed?

MS. CUBBAGE: A master list. There is a list of topical reports in DCD Chapter 1, I believe. There is a list of all of the references, some of which are old and long since been approved, some of which are supporting the DCD and the SER we're writing for the certification. Some of them we're going to have separate SERs we're writing -- for example, in the fuel, we've written a separate SER on TRACG for stability. We have given you a number of those on the CD.

CHAIRMAN CORRADINI: But the DCD Version 3 has at that time what that list is in Chapter 1. Are there additions to that?

MS. CUBBAGE: Yes. There have been some recently submitted topical reports, two of which I gave to Gary at lunch time. That's the feedwater topical, and I think he has already given you CDs. Feedwater topical and initial core transients, you have in your hand. And maybe I can get with Gary at some point offline, and we can kind of do an inventory of what you have and maybe what you need.

CHAIRMAN CORRADINI: Okay. That would be very helpful.

MEMBER BANERJEE: I think it would be helpful if Gary circulated what you called a master list, at least the current status of --

CHAIRMAN CORRADINI: Yes. The current status of what GE has as coming or has come and what you guys have reviewed, and so that we can -- because in some sense I'm becoming a bit lost.

MS. CUBBAGE: Right. We have received -- with the exception of perhaps one topical, we have received at least the Rev 0 version of every topical we are expecting to get ---

CHAIRMAN CORRADINI: Okay.

MS. CUBBAGE: -- at this point. As the review continues, there will be revs of various ones that are -- that you have already received.

CHAIRMAN CORRADINI: Sure. Okay. Thank you very much.

MR. GILMER: Okay?

CHAIRMAN CORRADINI: Sorry. Thank you.

MR. GILMER: The staff's recent review is based on the preapplication -- the approval topical 33083. The transient revision was Section 4, which is the subject of this transient safety evaluation.

Like the LOCA, GEH's method was the CSAU 14 stuff, and our evaluation concludes that the product appropriately -- is appropriate for this.

MEMBER BANERJEE: So are you going to tell us sometime about these independent calculations done with TRACE and PARCS to --

MR. GILMER: Yes.

CHAIRMAN CORRADINI: But I don't have a feeling you're going to do it today, though.

MR. GILMER: That's correct.

MEMBER BANERJEE: When is this time going to be? I mean --

MR. GILMER: Well, we have -- Tony Ulses from our Office of Research has done TRACE/PARCS calculations. They're ongoing, not yet completed.

MEMBER BANERJEE: Oh, I see. Okay.

MR. GILMER: Maybe Tony can at least answer when he expects to --

MR. DONOGHUE: Oh, I don't want to put Research on the spot for their schedule here in the ACRS meeting. What I will say is that they have to -- they have to run their code, they have to evaluate it before they even release it to us, and then we have to evaluate the results and make sure --

CHAIRMAN CORRADINI: Is there an RAI to do for --

(Laughter.)

Just out of curiosity.

MR. DONOGHUE: There is a formal process to ask for work. We are bureaucrats, after all.

MEMBER BANERJEE: Work is underway right now. Is that -- the work is underway?

MR. DONOGHUE: Yes. Yes.

MR. LANDRY: The analyses are underway. Tony has run a number of cases. He has some cases to run yet. But those calculations have not gone through the full checkout procedure here, and sign-out, concurrence, and transfer to the other office.

We do a lot of checking, the vendors do checking and QAing before they send material in. We do checking of our material before we send it to others and before we present it in public, because we want to make sure that what we're doing is -- that our calculations are right also.

MEMBER BANERJEE: So how many months have been spent up to now on this, Ralph?

MR. LANDRY: Bits and pieces of time. I don't know if we could estimate the exact amount of time, because Tony has had other work he has had to do. He has been working on this since last spring in pieces, and then he had other work, and then he'd come back and do some more. So I don't think I can put a handle on exactly how much time, if you put it in a continuous stream of time.

We have work going on on AOO calculations. We have work going on on LOCA calculations. We have the ATWS work that we're doing, which you've heard about. So we have a number of areas where we're doing confirmatory calculations using TRACE and using FLUENT and these -- all these tools that are available to us.

MEMBER BANERJEE: TRACE and PARCS have been coupled now, right, to the ATWS, so --

CHAIRMAN CORRADINI: What does that mean in this regard? Are they communicating online simultaneously? Are they feeding input decks to each other?

MR. LANDRY: Let's let Tony explain it. But TRACE has been coupled with PARCS and with TRITON.

CHAIRMAN CORRADINI: What is TRITON?

MR. LANDRY: It is a cross-section code.

CHAIRMAN CORRADINI: Oh. Thank you.

MR. ULSES: Hi. This is Tony Ulses, the Office of Research. We basically have the PARCS code is now actually compiled right in with TRACE directly, so there is no -- you know, we're not actually handing information between two separate codes. In other words, you know, I use PARCS to calculate power, and then it's inserted into the TRACE, the fuel structures.

It calculates -- then, it calculates a fuel temperature and a moderator density. It hands it back to PARCS. So that's all handled online, and then we feed it a set of cross-sections, which is derived to cover the entire expected space of the analysis in terms of fuel temperature, void conditions within the core, and that is essentially how the code works.

MEMBER BANERJEE: Is there a table you fill in or what?

MR. ULSES: Well, actually, it works with -- it actually works based on partial derivatives within the model itself. And we've actually used the HELIOS code to generate the cross-sections, although we do have our own internal TRITON code that we're -- we actually have cross-sections. I just haven't had time to actually plug them in and run them and see how they work yet so far.

CHAIRMAN CORRADINI: Because I was going to say I was under the impression that RELAP and PARCS and HELIOS were coupled, and so when you used another cross-section -- so HELIOS is not used here, it's this other tool that you mentioned.

MR. ULSES: We actually have HELIOS cross-sections. And that's what we've used to date.

MR. LANDRY: That's what we've used in this case. Another task that Tony wants to do is to use TRITON to generate the cross-sections instead of HELIOS, so that it would be a completely coupled TRACE, PARCS, TRITON.

CHAIRMAN CORRADINI: Okay.

MR. ULSES: Exactly. Exactly.

CHAIRMAN CORRADINI: Thank you.

MR. GILMER: Okay. One thing I did not have on the slide is ISL has done their own independent technical evaluation for both ATWS and AOO, and those are attached to the safety evaluations that the members should have, the SERs also.

MEMBER BANERJEE: Attached to the --

CHAIRMAN CORRADINI: It's attached to -- where is it attached? I'm sorry.

MR. GILMER: It should be --

MEMBER BANERJEE: On 21? Is this an addendum or --

CHAIRMAN CORRADINI: No. They're attached to the specific SERs that say SER for ATWS and SER for transients. There was two addendums. They're not attached to the addendums, and they're not attached to Chapter 21.

MR. ULSES: They're in the attachments to the particular --

MEMBER BANERJEE: Yes. SER for TRACG is applied to ATWS clean, you call it.

CHAIRMAN CORRADINI: Okay. All right.

MR. GILMER: Okay. The significant open items -- there are a couple on the isolation condenser modeling. One we discussed earlier on the ability of the TRACG to model condensers, so we'll have to resolve that with the -- whatever we've done on the benchmark, other ways, and get back with you on that.

The other one was just regarding the test that was done, the range --

CHAIRMAN CORRADINI: I think you need to speak louder.

MR. GILMER: Okay. The range that GEH looked at did not cover the high pressure that could result from an SRV opening, so there is an open item on that. And some slight disagreement between us and staff and GEH on the ranking of the few PIRT parameters and the high and medium ranked, and the way they are combined to get the uncertainties.

CHAIRMAN CORRADINI: The isolation condenser modeling, can you remind me what -- the issue there is just how it's modeled? I don't remember the --

MR. GILMER: Veronica would like to chip it on that one.

MS. WILSON: Just for a second. This is Veronica Wilson. We had several issues with the isolation condenser modeling that GE had. Now, you've got to remember that GE uses it for LOCA and AOOs. And for LOCA specifically, we had questions about the non-condensable gas, because they don't have non-condensable gases in AOOs. So that was specifically the LOCA. The treatment of that, the data, was a little non-representative, and so we just asked GE to justify --

MR. WALLIS: Where do those gases go in the isolation condenser?

MS. WILSON: There is a vent line to the suppression pool.

MR. WALLIS: There's a vent line to the suppression pool.

MS. WILSON: Yes. And so --

CHAIRMAN CORRADINI: So the treatment there is different than in the PCCS? It's the same model as far as I thought, as far as I understood. And they're using the Berkeley and the MIT test as their basis to at least show they -- so what's the issue?

MS. WILSON: I think it was the PANTHERS data that actually did full-scale isolation condensers.

CHAIRMAN CORRADINI: Yes.

MS. WILSON: Now, these are not representative -- that was what we were told, that they're not representative of ESBWR. But when they had injected some non-condensable gases and then they modeled that with TRACG, they completely missed like a lot of the timing and some of the pressures.

I think it was a pressurization -- timing was missed, and so it kind of showed that in the presence of non-condensables the model that they were using with TRACG, not exactly working out. And so when we asked GE some questions. It's an open item. We're discussing it right now with GE. It just kind of is not clear that with the presence of non-condensables that the TRACG model is working out so well.

CHAIRMAN CORRADINI: Well, I mean, this concerns me more for the PCCS, since it really -- it really needs to work well there. So is it -- so let me just ask one more time. Is it at high steam mass fracture that there seems to be a problem, or at any steam mass fracture?

Because there tends to be an ability to err on condensation and heat transfer coefficient very easily at small amounts of non-condensable gas. At high amounts of non-condensable gas, everything tends to be relatively insensitive once I'm out there. So is it a function of the proportion, or is it they missed it over a wide range of regimes? That's what -- I'm looking back.

MS. WILSON: I can't answer your question completely. We were told by GE was that the tests that they showed us that showed this mistiming was not actually representative of any way -- in the way that the ECCP valve would be operated. And so I'm not really sure that there was ever a range done.

The description says that they merely did the test to show that the vents would work. When they were testing the PANTHERS, they were testing the IC, and that the isolation -- I mean, the non-condensables would certainly go to the suppression pool. And that, they said, was the purpose of the test. They weren't really trying to set up realistic conditions to model that, and so --

CHAIRMAN CORRADINI: Can I ask GE to kind of illuminate us?

MR. MARQUINO: Yes, thank you. The test didn't simulate a transient, a specific transient event, or a LOCA event. It was -- the heat exchanger is the same headers as ESBWR, so in that sense it's completely representative of ESBWR. But in that PANTHERS test of non-condensable gas, they fed the heat exchanger non-condensable gas. We watched its performance degrade, and then they opened the vent valve and they saw it purge itself and pick up heat capacity again. So --

CHAIRMAN CORRADINI: So it's a LOCA TRAC analysis of the test.

MR. MARQUINO: I think we did do a TRAC analysis of the test, and I think the statement that it wasn't representative of ESBWR must be it's not exactly ATWS boundary conditions applied during the test. Does that -- Veronica, do you want to clarify?

MS. WILSON: We weren't really concerned about ATWS to begin with, because like the time scales, as you had pointed out -- which we agree with -- were not really long enough to create the radiolytic gas decomposition. So it was more for the LOCA, because we knew that you guys actually modeled that.

And I think some of the details might be proprietary, but we know that the non-condensables are modeled in the LOCA due to the long-term nature of the vent, and so --

CHAIRMAN CORRADINI: Can I ask GEH to give me a -- you don't -- any one of your numbers?

MR. UPTON: Yes, I found the open item. I was trying to get back to what the staff said in the SER, but I guess I don't remember the test. I'm sorry.

CHAIRMAN CORRADINI: The PANTHERS, is that 32177, or is that one in the ESBWR?

DR. CHEUNG: I cannot get it off my head.

CHAIRMAN CORRADINI: We have that one. Or no --

MS. WILSON: 32725?

CHAIRMAN CORRADINI: Is there a 76 --

PARTICIPANT: 377.

MR. MARQUINO: 32177 is the TRACG qualification --

CHAIRMAN CORRADINI: Okay, thank you.

MR. MARQUINO: -- LTR.

CHAIRMAN CORRADINI: Thank you.

MR. WALLIS: Now, this isolation condenser, is it the vessel pressure, isn't it? So there's a tremendous pressure difference between it and the suppression pool.

MR. MARQUINO: Yes.

MR. WALLIS: So what controls the flow rate to the suppression pool?

MR. MARQUINO: The vent. It's got a little vent line, and if it --

MR. WALLIS: Is the race to be -- condense the steam enough so that it doesn't all get sucked to to the suppression pool down the vent line?

MR. MARQUINO: No, it's -- if there is radiolytic acid, the vent line would be --

MR. WALLIS: But even if there's no non-condensables, there's going to be tremendous suction in that vent line, isn't there?

MR. MARQUINO: No, but the vent line is closed.

MR. WALLIS: It's closed.

MR. MARQUINO: So if there's no non-condensables in it, the vent line is closed.

MR. WALLIS: When does it open?

MR. MARQUINO: It opens automatically on high pressure.

MR. WALLIS: On pressure. On pressure.

CHAIRMAN CORRADINI: And how would the pressure be any different than the RCS? What do you mean by high pressure? A differential pressure from the vessel?

MR. WALLIS: In the RCS, or what?

MR. MARQUINO: No. Absolute gauge pressure. So if the -- it's an orifice vent line. If the pressure is higher than the setpoint for some duration, the vent line opens, it purges itself, pressure comes back down again.

MR. WALLIS: But that setpoint must depend on the pressure in the vessel, or it is determined by the pressure in the vessel.

MR. MARQUINO: It's --

CHAIRMAN CORRADINI: So let me just make sure -- and then, we'll have to go look and do our homework. But what you're saying, if I understand it correctly, is is that with the isolation condenser as the ultimate heat sink in this mode, pressure would rise within the system to some setpoint, you would have a vent clearing orifice, and that would supposedly clear it and then bring the pressure back down? Am I understanding correctly?

MR. MARQUINO: Yes. The symptom is the pressure -- the pressure is too high. If the IC is functioning, it will depressurize the reactor. So if the pressure is high for a long duration, the ICs become radiolytic gas built up and --

MR. WALLIS: The microscopic thing, it says the thing isn't working, because the pressure is staying up. So we'd better open a vent film.

MR. MARQUINO: Yes. Vent line, yes.

CHAIRMAN CORRADINI: With a small amount of leakage, which that supposedly vents --

MR. WALLIS: With a small amount of leakage.

CHAIRMAN CORRADINI: It will vent both steam and gas and should clear it and start the process.

MR. WALLIS: And then it closes again, is that right?

MR. MARQUINO: Yes.

DR. CHEUNG: This is Chester Cheung from GEH. I want to add one more comment. In the LOCA analysis, the IC heat transfer credit was not taken into consideration. So the only criteria is the IC drain line water volume.

CHAIRMAN CORRADINI: Well, we should go to 332 or 32177 to check this out further.

DR. CHEUNG: That is describing the DCD revision.

CHAIRMAN CORRADINI: Okay. Thank you for

the reference.

Go ahead.

MR. GILMER: Okay. One final item we --

MS. WILSON: Wait. I'm sorry, I was going to clarify. We have the reference for you for the IC -- if you want the exact like accession number, and what information would be useful? The NEDC number?

CHAIRMAN CORRADINI: Ye.

MS. WILSON: Okay. It's NEDC -- well, it's -- okay. Here's the title of the document. Update of ESBWR TRACG Qualification for NEDC 32725P and NEDC 33083P.

CHAIRMAN CORRADINI: Can you go slower, please?

(Laughter.)

You're way too fast for --

MS. CUBBAGE: We are going to get it to Gary, because --

CHAIRMAN CORRADINI: Good. Thank you.

MS. CUBBAGE: -- it's not really an LTR, right?

CHAIRMAN CORRADINI: Oh, it is not.

MS. CUBBAGE: It's a submittal.

CHAIRMAN CORRADINI: Okay. Thank you.

MS. WILSON: Yes. And so --

CHAIRMAN CORRADINI: If you get it to Gary, then we can do our homework.

MS. CUBBAGE: It's reference 27 in the Chapter 21 SER.

MS. WILSON: Yes. And we had separate issues with the IC for the AOO modeling, and that had to do with nodalization and heat transfer correlations, without going into any proprietary detail. They were just kind of inconsistent with what GE chose to demonstrate in the qualification, so we asked them to justify what they used in the actual TRACG model.

CHAIRMAN CORRADINI: Thank you. Thank you very much.

MEMBER BANERJEE: Yo you mean they didn't measure any heat transfer coefficients and couldn't in the IC test, right? Or am I getting confused about something?

MS. WILSON: I'm sorry. Will you repeat that?

MEMBER BANERJEE: They could not measure any heat transfer coefficients, could they?

CHAIRMAN CORRADINI: They just measured total heat removed, I thought, essentially heat exchanger performance.

MS. WILSON: Right. But they used a heat transfer correlation in TRACG --

MEMBER BANERJEE: Based on single --

MS. WILSON: Yes. From what he was saying from the Berkeley and the -- I think the name of it is actually proprietary -- that other model that they had, and that is what they used --

CHAIRMAN CORRADINI: It's published in the open literature. I think we can say it.

MS. WILSON: Okay. Yes, the Kuhn-Schrock-Peterson one, and that was what they had used to try to match the data. They didn't actually measure like a heat transfer correlation, but then they didn't proceed to use some of the same -- but it wasn't for the internal condensation. I think it was the external -- not insights, because that is what they use inside the tubes. It was the heat transfer correlation on the outside of the tubes.

MR. WALLIS: Governed by the outside. I mean, the condensation coefficient is so high it's governed by the convection coefficient on the outside? No?

MS. WILSON: The point is they use something different than what they used to validate the TRACG in ESBWR, and so we just asked to justify

that.

MEMBER BANERJEE: I haven't looked in this.

CHAIRMAN CORRADINI: Okay. Thank you very much.

MR. GILMER: Okay. The last item is the capability to model lower plenum cold water mixing. There's an open item on that.

CHAIRMAN CORRADINI: Can you -- since this is one of the three final ones, can you remind me about that one again? I'm sorry. In terms of just the plenum mixing.

MR. GILMER: Yes.

CHAIRMAN CORRADINI: Distribution of temperatures?

MR. GILMER: Well, the main concern was, what is the effect on the minimum CPR? They presented a three-region model, and the RAI response only gave the inner and central rings. We don't have the periphery.

CHAIRMAN CORRADINI: Oh, okay. Okay.

MR. GILMER: So that's the issue.

CHAIRMAN CORRADINI: Informational.

MR. WILLIAMS: That's it for our presentation for Chapter 21.6, unless there are any further questions.

MR. WALLIS: Does the cold water mixing -- you don't know how they're going to resolve that. So we don't know either.

CHAIRMAN CORRADINI: I guess I took it the way you explained it is informational. You had some of the information, but not all of the information.

MR. GILMER: That's correct.

MR. WALLIS: The concern is that different temperatures go into different regions of the core, and this changes the CPR?

MS. WILSON: Well, we didn't have enough information from what GE gave to -- since it's a very coarse, nodalized -- you know, TRACG is these big, large cells -- that there would -- if there was actual stratification in the lower plenum, that that would be adequately represented by TRACG.

So we asked GE to kind of investigate this and show us, because we're worried that you could get maybe some concentration of cold water and, like you said, might have more significant MCPR.

MR. WALLIS: Even the nodalization for TRACG?

MS. WILSON: We have, but it's very coarse in comparison to like a real live plant.

MR. WALLIS: It doesn't really represent stratification, does it?

MS. WILSON: Exactly. And so that's why we wanted to make sure that if there was, that that would either be adequately representative or maybe that there just is not.

CHAIRMAN CORRADINI: So let's go around this way this time and get the members' comments.

MR. WALLIS: I was going to take the overview and say I think the staff is doing the right thing. They've asked a lot of questions. They've asked the kind of questions that we would ask in many ways. And we really need to see how they're answered.

I think our role is to make this list of things that we're concerned about, which may not have been raised enough by the staff, or, if they have, we don't know that. And to try to sort of supplement in some intelligent way these questions, which I say are very comprehensive already, but there may be some which haven't been asked.

I think that's our job, and I'll give this to the Chairman, which he can then present to the staff. And, otherwise, I think we're doing the right thing here. I think both the staff and the applicant have been responsive to any questions we have raised.

I really want to go into the details of what these technical questions are, but I'll send you a list.

CHAIRMAN CORRADINI: That's fine.

MEMBER BANERJEE: Yes. I think in many ways I have the same sense of things as Graham that there are many technical issues which we'd like to see a lot more of. And I'll send you a list of these as well. I've been compiling them, and they are actually --

MR. WALLIS: How many pages are there?

MEMBER BANERJEE: Several pages. But I am going to actually boil it down to one page --

CHAIRMAN CORRADINI: That would be wonderful. Thank you.

MEMBER BANERJEE: -- for you. But otherwise, I think it's going all right.

MEMBER BLEY: It seems like it's going right. The questioning seems good. One issue came up today that isn't strictly a thermal hydraulic one that I thought I'd mention. You were talking about the control rod withdrawal, and I know you're pursuing that during -- based on the events that happened during refueling in Japan.

I just looked at -- sneaked ahead and

peeked at the PRA, because some of these kinds of issues I thought would be fine if they are dealt with in the PRA. That one specifically blocked out of the PRA, and that the whole shutdown PRA assumes the rods are in place the whole time. So there are no reactivity issues. So that will come up with the PRA as well as here.

MEMBER ARMIJO: I don't have anything to add. I agree with Graham's and Sanjoy's comments.

CHAIRMAN CORRADINI: Dr. Shack?

MEMBER SHACK: I just had a question for GE. I'm very interested in this Dodewaard data, because it seems to me that it's the only thing around that is going to address Said's question. I don't think you are going to go off and run a full-scale test at this point.

And it's not 32177, as far as I can find. Can you tell me where it really is?

MR. MARQUINO: I will have to get the -- there is these two qualification reports, one for TRACG in general and one for ESBWR. If it's in 32177, it must be in the other one. We'll research and get back to you.

CHAIRMAN CORRADINI: If you could pass it to Amy, they can just bundle it and send it to us.

That would be good. I'd appreciate it.

MR. MARQUINO: Okay.

VICE CHAIRMAN ABDEL-KHALIK: I mean, like everyone else, I mean, we have a list of issues that have been raised. We'll provide that list to you, so that the staff and GE can come back and provide answers to those. I must say I was somewhat dismayed when I saw the statement about the -- that the Chapter 15 review was significantly affected by that, the new proposed reactor power controlled by varying the feedwater temperature.

But we appreciate getting the topical. We'll review it, and we'll do our homework, and hopefully we'll see more details on that.

Thank you.

CHAIRMAN CORRADINI: Thank you.

MEMBER MAYNARD: Well, I think that -- I agree the staff is asking a lot of good questions, and I think that we're getting in a lot -- overall, I think this seems to be a good design. I think these issues are going to get resolved. I do think that the questions are good and need to be dug into thoroughly.

A couple of things we forget sometimes. We're dealing primarily with what they're taking credit for. There are still other mechanisms. There is still a lot of defense in depth of active systems and other things that are available to get water moved around and stuff. So there is some defense in depth, although we're not allowed to take credit for that for the design basis stuff and for 72 hours.

I think that probably the biggest -- the key thing to me in the questions is the treatment of the non-condensable gases and, you know, what are the real flows through these systems. I think there is probably plenty of conservativism in the analyses, as long as the non-condensable gases do what is assumed in the analysis. And that's where I think probably the key effort needs to be is in really taking a hard look at that, because that is so important to the success of the passive cooling systems and stuff there.

So I think we're on the right track, but there are still a lot of unanswered questions to deal with there.

One other thing -- I think we do need to be careful that -- you know, our job is to review the adequacy of their design rather than us try to tell them how to design things. And we may all have different ways that we would like to see things handled, and our job is really to take a look at what they are proposing as to the adequacy of that.

That's all I've got. Designed by Committee doesn't always end up with a better design, so --

CHAIRMAN CORRADINI: Tom?

MEMBER KRESS: I guess I'm going to be the outlier here. I think the design is very good. It's a good reactor, and the staff is doing a good job.

I'm very, very concerned about the iodine issue. It looks to me like it's closer to be a showstopper than anything. I don't know how they're going to deal with it. There may be ways to deal with.

CHAIRMAN CORRADINI: In terms of a change in the pH, or in terms of just that there will continually be the recycle and transport?

MEMBER KRESS: You've got to -- I've got to see this analysis by the Sandia people, but it's an extremely difficult thing to determine pH. In most of the cases I've seen where the pH has been determined, not for this reactor but for other reactors, it tends -- unless you've got a highly buffered system, it tends to go negative. I mean, it tends to go acid.

CHAIRMAN CORRADINI: It goes acidic.

MEMBER KRESS: Yes. And I don't know what it will do in this reactor, but, if it does, you have an iodine pump there that is pumping iodine continuously into the containment. And over the long term it's just going to leak out. It's going to go into -- it's going to establish a steady state. I don't know what that level will be, but it's one that has to be dealt with.

If you did -- you know, you're not going to get that iodine. It's one of these things where you have to specify a source term, and a design basis accident. So it's a compliance issue. It's not going to happen. You won't -- I don't think you'll see it in the PRA, but it has to be dealt with because it --

MR. WALLIS: That concerned me right from the start. I mean, they've got this wonderful design which cools the core, it's designed to do that. And then, when you look at it from the point of view of --

MEMBER KRESS: If you close this off --

MR. WALLIS: -- this other thing, it's the iodine pump. So the very fact that it cools the core so well makes it do this other job so badly.

MEMBER KRESS: So I'm anxious to see how that one gets resolved, frankly.

MEMBER BANERJEE: But with the sodium pentaborate, do you still think it will become acidic?

MEMBER KRESS: There's a lot of water in this thing. And, you know, and if you impose this source term, and you've got all of these nitric acid producers and they've got the hydrochloric acid from other things, the cases I've seen in other reactors -- not like -- not this reactor, it tends to go acidic.

I don't know what will happen. I'm anxious to see what Sandia comes up with.

MEMBER SHACK: I mean, that's one of the things that's bad about pure water is it doesn't take much to move a pH around.

MEMBER SIEBER: To make it unpure.

MEMBER KRESS: That's right. So, you know, I don't know how GE will deal with this. I don't -- I guess we'll wait until we see the results of the calculations and see if it's bad or not.

MEMBER BANERJEE: There's a buffer in the --

CHAIRMAN CORRADINI: I want to make sure I understand relative to the bad. So the bad is the dose or the -- how it's changing the water chemistry for long-term corrosion?

MEMBER KRESS: You have to change the water chemistry to get the dose.

CHAIRMAN CORRADINI: right.

MEMBER KRESS: But the dose is what's going to be bad, because it's -- an iodine pump pumps it right out of the containment.

CHAIRMAN CORRADINI: Jack?

MEMBER SIEBER: Well, I agree with Dr. Wallis that we've covered a lot of material. There are some open items. I think the staff is on track, and it seems to me there is more open items today than there was yesterday. And maybe it's because I've struggled with the reassignment in advance of coming here.

I don't know if there is a showstopper or not. I think Dr. Kress' point is well made, and I also believe there are solutions to it. But they may not be pretty solutions. We've had this issue before in other plants, and I think it's something that needs to be addressed.

I am also particularly impressed with Dr. Abdel-Khalik's comments about non-condensables, which several others have followed up on. And I suspect you can analyze your way out of it, but I think you'd be better off getting isometric drawings and looking at them and having an experienced engineer or two look for the traps to see where they would occur, then that's the time to apply the codes and the mathematics to determine what it takes to overcome those or what impact it has on the ability of gravity-driven cooling systems to operate.

So, to me, I think the issues that come out of here is the issue of non-condensables and the iodine, which I think require followup by all of us -- General Electric, the staff, and the ACRS. That would be it for me.

CHAIRMAN CORRADINI: Well, I've written down -- I think I've written down most of what I've heard. I'm going to get from the members a list, and I'll compile it and send to everybody. I've developed already a summary, but I'll keep on adding to it and just circulating it.

MEMBER BANERJEE: How detailed a list do you want? Just some topics, or do you want a --

CHAIRMAN CORRADINI: I think major -- I guess I'd break it down into two categories. One category would be major things -- and I'll term it the way Graham said it, which is major things that are gnawing at you about something relative to the design that appears to have been overlooked that could be significant. And take an accident, take how the design may go somewhere that staff may have seen, may have not seen, GEH is kind of addressing, but basically taking it somewhere -- that's your concern.

And then, a lot of other things which may be issues, may not be issues. And what I will plan to do is take all of it, hopefully organize it properly send it to Amy, and then the next time we get together, since -- and I guess I'll leave it with you, Amy, on this regard -- my interpretation is we have another batch of chapters which we will look at. That probably won't be for a couple months at least.

So in those couple months or more, let her look with her colleagues at the list and say what things fit together. One natural to me is containment response. We could address some of the questions that Tom has relative to DBA calculations that are both source term related as well as containment systems related, and accumulate some of these things and go through a detailed analysis, pick a few accidents and walk through them, so we can understand.

MEMBER BANERJEE: So the containment response is going to be very coupled through the --

CHAIRMAN CORRADINI: It will be a very coupled -- for example, I mean, if there is information that finally comes out, depending when it comes out, in terms of the STERN lab test data for the GE 14E, get a subcommittee -- or get the Subcommittee together, and then again look at that relative to the CPR. So arrange it so that we can address these issues as the staff is ready to address them with GEH in support.

MS. CUBBAGE: Yes, I think that's a good plan.

CHAIRMAN CORRADINI: And then, I will just bring it up as it comes out.

MR. WALLIS: Don't have too many issues. If we are really going to delve into an issue, it takes time. We've got to look at, you know, proper evidence and reach conclusions. You can't have 50 issues on the table when we meet as a Subcommittee.

CHAIRMAN CORRADINI: No. My thought is we are going to come down to a handful.

MR. WALLIS: Handful of good ones.

CHAIRMAN CORRADINI: Yes.

MR. WALLIS: Okay.

MS. CUBBAGE: Right.

CHAIRMAN CORRADINI: So on that note, I wanted to thank GEH and all of the folks that were here, and are still here, that are not rushing to the snow-covered airport.

(Laughter.)

All right. Thank you for all your help.

Thanks to the staff. Amy?

MS. CUBBAGE: We did have one -- we wanted to offer just to go to closed just for a couple minutes, because I think Dr. Yarsky would like to maybe try to address one of the remaining issues.

CHAIRMAN CORRADINI: Was this the issue relative to the neutronics that Sanjoy asked?

MS. CUBBAGE: Yes.

CHAIRMAN CORRADINI: Okay.

MEMBER BANERJEE: We can get that off the table.

MS. CUBBAGE: Yes, we'd like to do that.

CHAIRMAN CORRADINI: So I'm supposed to ask anybody that is not supposed to be here to please leave.

MS. CUBBAGE: Right.

CHAIRMAN CORRADINI: And how will we know that?

(Whereupon, at 4:00 p.m., the proceedings in the foregoing matter went into closed session and then subsequently returned to open session.)

CHAIRMAN CORRADINI: Okay. Thanks to the staff, and then we'll take a bit -- minute afterwards. Gary reminded me, but I'll remind the members, we have to have -- not have to -- we are expected to provide another interim letter to the staff, but given that we've gone through four chapters in November, and we've gone through these four chapters, there are a number of open items, I think we have to decide what -- I wasn't planning to ask for -- do a letter in February, but to do it in March. But we have to decide what chapters we want to write about.

If there's a lot of open items with a very long list, we might want to wait and simply only deal with the information we saw back in November, which was a bit more straightforward and very few open items. Right?

MS. CUBBAGE: Right. There are eight chapters on the table.

CHAIRMAN CORRADINI: Eight chapters on the table, some of which are a bit unwieldy.

DR. YARSKY: Yes.

CHAIRMAN CORRADINI: All right? So that is something we have to come to decide. In February, we'll go through a progress report to the full Committee and probably make a decision on what sort of letter we'd write in March.

Everybody understand what I just said?

MS. CUBBAGE: I didn't. We're coming back in March, right?

CHAIRMAN CORRADINI: Right.

MS. CUBBAGE: Okay. I just wanted to make sure.

CHAIRMAN CORRADINI: For a letter. For a letter. Everything else is internal discussions with us.

MEMBER BANERJEE: You may want to be there in February as well.

CHAIRMAN CORRADINI: You're welcome to come in February.

MS. CUBBAGE: Well, I absolutely can. It's whether we have, you know --

CHAIRMAN CORRADINI: No. The answer is we plan to do it in March.

MS. CUBBAGE: Thank you.

MR. KINSEY: A point of clarification.

CHAIRMAN CORRADINI: All right. Thank you so much.

MR. KINSEY: So what you are saying is that we will decide between now and --

CHAIRMAN CORRADINI: The Committee is going to have to decide what the letter is -- what the scope will be.

MR. KINSEY: What the scope of the March

meeting will be.

CHAIRMAN CORRADINI: What the scope of the March meeting will be and the letter.

MR. KINSEY: Eight chapters or something less than that.

CHAIRMAN CORRADINI: That's right. And I'll communicate that earlier, much earlier, to everyone. Okay?

(Whereupon, at 4:14 p.m., the proceedings in the foregoing matter went off the record.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Eric Hendrixson
Official Reporter
Neal R. Gross & Co., Inc.

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter **15**

January 17, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

Outline of Presentation

- Brief the Subcommittee on the staff's ongoing review of the ESBWR DCD application:
  - 15.1 "Introduction"
  - 15A "Event Frequency Determination"
  - 15.2 "Anticipated Operational Occurrences"
  - 15.3 "Infrequent Events"
  - 15.4 "Accident Analyses
  - ATWS/ESBWR Boron Mixing
- Answer the Committee's questions

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

Review Team for Chapter 15

- Lead PM
  - Bruce Bavol
  - Amy Cubbage
- Lead Technical Reviewers
  - George Thomas
  - Dr. John Lai
  - Dr. Lambros Lois
  - Jay Lee
  - Benjamin Parks
  - Christopher Boyd (RES)

1/16/2008 3

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

Summary of Regulations and other Review Guidance

- GDC's-10, 13, 14, 15, 16, 17, 19, 20, 25, 26, 28, 35, 38, 50, 55, 60
- 10 CFR 50 Appendix A

Guidance From:

- SRP Section 15

1/16/2008 4

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

RAI Status Summary

- Original number of RAI's - 119
- Number of RAI's resolved - 94
- Number of Open Items - 25

1/16/2008 5

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 15.1

Presented by
George Thomas
NRO/DSRA/SRSB

January 17, 2007

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

<u>SER Technical Topics of Interest</u>

- Design Features
- Events Categorization
- Acceptance Criteria
- Analysis Method and Requirements

Unique Design Features

- Elimination of active ESF Systems
- 4 redundant I&C channels for safety systems
- Triple redundant processors for control systems
- Event frequency is expected to be less compared with current operating BWRs

DEFINITIONS

- **Anticipated Operational Occurrences (AOOs) mean those conditions of normal operation which are expected to occur one or more times during the life of the nuclear power unit (Appendix A of 10 CFR Part 50)**
- **Infrequent Events are Events that may occur during the life time of the nuclear power unit (SRP 15.0)**
- **Postulated Accidents- Unanticipated conditions of operation i.e not expected to occur (SRP 15.0)**
- **DBA-Postulated accidents that are used to set design criteria and limits for the design and sizing of safety-related systems and components (SRP 15.0)**

ESBWR EVENTS CATEGORIZATION

Event	Frequency	Acceptance Criteria
AOOs	>0.01 Events/Year	RPV Level above TAF, SLMCPR, RPV Pressure≤ 1375 psig
Accidents Infrequent Events	< 0.01 Events/Year	RPV Level above TAF 10% of 10 CFR50.34 (a) (ii) (D) (1)-2.5 rem TEDE, RPV Pressure ≤1500 psig
DBA	10E-4-10E-5	25 rem TEDE, N/A
Special Events (ATWS,SBO etc)	Varies	Case by case

Probability Vs Risk Concept

- High Frequency Events shall have a small consequence (i.e., SLMCPR criteria) and Lower Frequency Events could have more severe consequence (i.e., Radiological release may occur)

1/16/2008 11

Analyses Requirements

- TRACG used for analyses (except for reactivity transients)
- TRACG will be addressed in Chapter 21
- Analyses of all categories of AOOs and Infrequent Events identified in the SRP are required for design certification
- Only Limiting Events need to be reanalyzed for subsequent reloads using GE14E fuel

1/16/2008 12

Review Issues

- Staff had concerns in accepting the ASME Level C Criteria (RPV Pressure 1500 psig) for all accidents
- RPV inspection/analysis (to justify continued operation) will be performed according to ASME Section XI if the RPV pressure exceeds 1375 psig
- Initially GEH included only the acceptance criteria of " Greater than 99.9% of the fuel rods in the core would be expected to avoid boiling transition" instead of the SLMCPR in the TS. The staff found that to be unacceptable. 10CFR50.36c (1) (i) (A) require the SLMCPR to be in the TS. GEH agreed

Review Issues (Cont)

Operation in the FW Temp Operating Domain

- Chapter 15 review significantly affected by GEH's new proposed reactor power control by varying the FW temperature
- LTR NEDO-33338, "ESBWR FW Temp Operating Domain Transient & Accident Analysis, October 2007" is under staff review

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15.1

Discussion/Committee Questions

1/16/2008 15

UNITED STATES NUCLEAR REGULATORY COMMISSION

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 15A

Presented by
Dr. John Lai
NRO/DSRA/SPLB

January 17, 2007

Infrequent Event Frequency Determination

- Methodology
  - If an initiating event is modeled in the ESBWR PRA, the frequency is taken directly from the PRA, e.g., Turbine Trip. Additional analyses not given in the PRA are conducted, e.g., total turbine bypass valve failures.
  - The event frequency is determined from the actual BWR operating experience, modified to reflect the ESBWR improved design, e.g., Stuck Open Safety Relief Valve (SORV).

1/16/2008 17

Infrequent Event Frequency Categorization (Cont)

  - For events involving multiple hardware failures or human errors, the event frequency is based on conservative estimates of the hardware failures (Including CCF) and human errors, e.g., Loss of feedwater heating of selected control rod run-in, inadvertent shutdown cooling function operation.
- Staff Review
  - Staff reviewed 16 infrequent event frequency analyses.
  - Staff issued two RAIs (SORV Frequency and Unavailability of ICS).
  - Staff found that the results are acceptable.

1/16/2008 18

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

Discussion/Committee Questions

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 15.2 & 15.3

Presented by
Dr. Lambros Lois
NRR/ADES/DSS/SRSB

January 17, 2007

Analysis of Anticipated Operational Occurrences (AOOs).

Section 15.2: Analyses of AOOs

- No major issues
- ESBWR is generally more forgiving than existing plants. For example, due to large vessel volume overpressurization transients do not reach the pressure setting of the pressure relief valves,
- ESBWR has demonstrated larger margin to the safety limits compared to existing plants.

1/16/2008 21

Infrequent Events (IEs)

Section 15.3: Infrequent Events

- IEs are reviewed per SRP Chapter 15
- LOCA is reviewed separately
- OLMCPR = 1.30, (assumed)
- Two transients: Generator load rejection, and pressure regulator failure, develop high and narrow power peaks. The DCD did not calculate energy deposition to assure that fuel melt and cladding strain criteria are met.

1/16/2008 22

Reactivity Transients

- Reactivity transients: for example, control rod withdrawal error during refueling. The DCD finds that this event is incredible. However, the SRP requires that it be analyzed and in addition, such an event did take place (Japan 1999 BWR4) the staff requested that GEH submit an analysis.

Overall Observations

- The ESBWR is more resilient than conventional plants

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

Discussion/Committee Questions

1/16/2008 25

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 15.4 "Accident Analysis"
Chapter 6.5 "Fission Product Removal & Control Systems"

Presented by
Jay Lee
NRO/DSER/RSAC
January 17, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, “Accident Analysis”

Key Regulations and Review Guidance

- Part 52.47 (a)(2)(iv)(A)
- Part 100.21, “Non-Seismic Siting Criteria”
- Part 50, Appendix A, GDC 19, “Control Room”
- Primary SRP: SRP 15.0.3, “Design Basis Accident Radiological Consequence Analyses for Advanced Light Water Reactors” (2007)
- Regulatory Guide 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors” (2000)
- NUREG-1465, “Accident Source Terms for Light-Water Nuclear Power Plants” (1995)

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, “Accident Analysis”

10 CFR 52.47 (a)(2)(iv)(A)

“The fission product release assumed for this evaluation should be based upon a major accident, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release into the containment of appreciable quantities of fission products”

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, “Accident Analysis”

“Major Accident” and “Possible Accidental Events”

- listed in SRP 15.0.3 and RG 1.183 for light water reactors such as the ESBWR

1/16/2008 29

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, “Accident Analysis”

“Appreciable Quantities” of Fission Products Released for “Substantial Meltdown of the Core”

- given in NUREG-1465, “Accident Source Terms for Light-Water Nuclear Power Plants”

1/16/2008 30

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Regulatory Issue for Review

- Does the ESBWR design provide adequate mitigation of radiological consequences in the event of a major reactor accident to protect public health and safety, as demonstrated by meeting the siting dose acceptance criteria specified in 10 CFR 100 and 10 CFR Part 52.47 (a)(2)(iv)(A)?
- Prevention vs. Mitigation

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Fission Product Release Points to the Environment Following Design Basis Accident

- Containment Leak at 0.4 weight percent per day
- MSIV Leak (containment bypass) at 200 scfh
- These values are specified in the ESBWR Technical *Specifications as surveillance requirements*

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

SER Technical Topics of Interest

The ESBWR design does not provide active fission product mitigation systems (i.e., safety-related containment spray, filters). Instead, the design provides following passive fission product mitigation:

- Fission product natural deposition in containment
- Fission product removal by passive containment cooling system (Open Item)
- Low containment leakage
- Fission product holdup in reactor building (Open Item)
- Control of pH of water in containment pools to prevent iodine re-evolution (Open Item)
- Fission product natural deposition in main steam lines and main condensers (Open Item)

1/16/2008 33

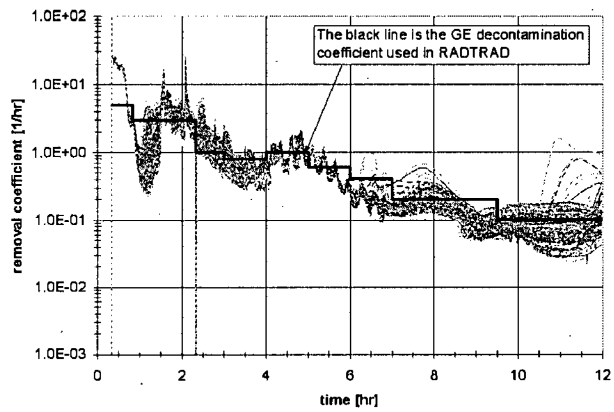
ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Fission Product Natural Deposition Processes in Containment

- Performed independent confirmatory calculation to verify fission product removal rates proposed by GEH
- Deposition processes involve gravitational settling, diffusiophoresis, and thermophoresis
- Used MELCOR code to establish thermal-hydraulic boundary conditions to estimate fission product removal rates
- Performed quantitative analyses of uncertainties in predicting removal rates using a Monte Carlo sampling method (150 realizations)

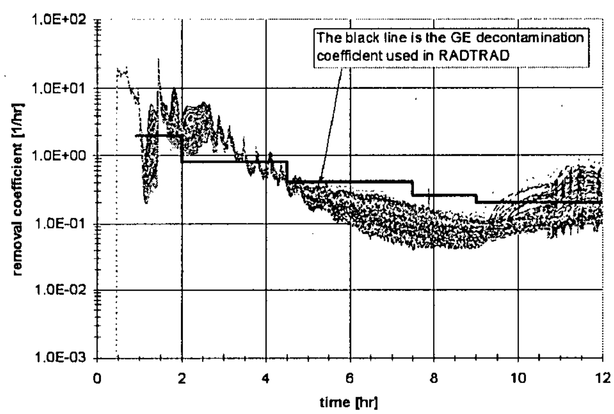
1/16/2008 34

MELCOR Calculated Aerosol Removal Rates for Accident Scenario 1 (RPV Bottom Drain Line Break with Degraded Low Pressure Makeup)



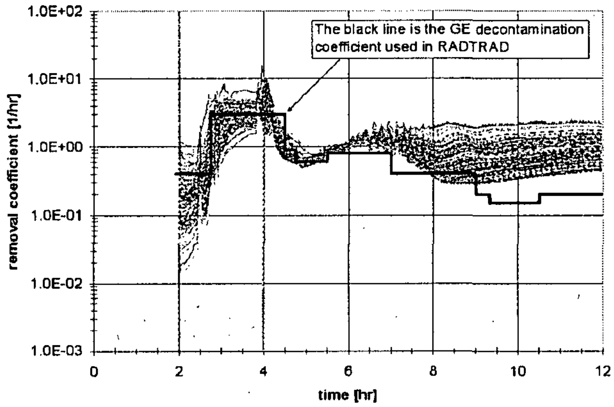
1/16/2008 35

MELCOR Calculated Aerosol Removal Rates for Accident Scenario 2 (RPV Bottom Drain Line Break with Degraded High Pressure Makeup)



1/16/2008 36

MELCOR Calculated Aerosol Removal Rates for Accident Scenario 3 (Loss of Preferred Power)

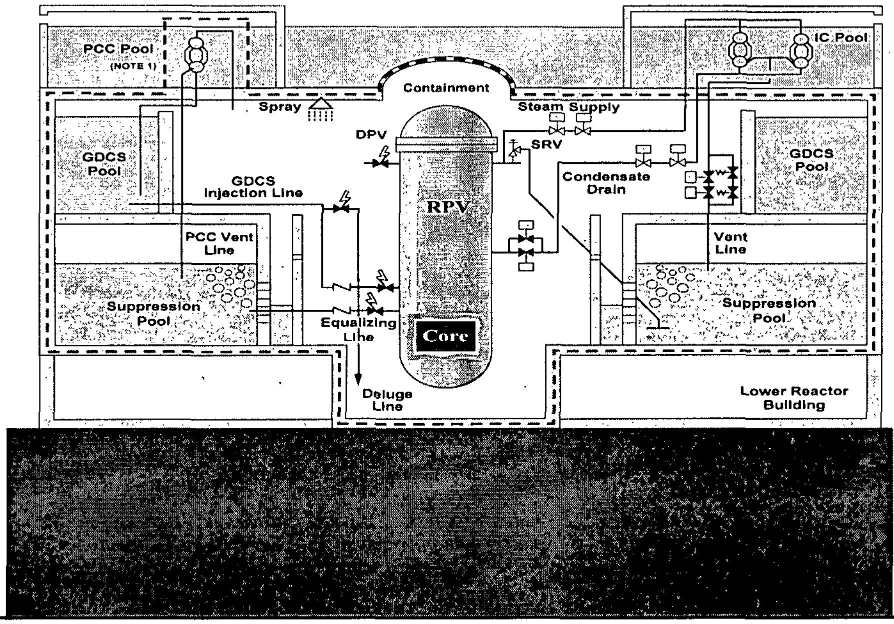


ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Fission Product Removal by Passive Containment Cooling System (Open Item)

- The staff is proceeding with a rate analysis of steady-state iodine transport within containment between RPV, drywell atmosphere, PCCS, and GDCS to confirm GEH analyses.
- Iodine re-evolution (source) and removal by PCCS (sink) will be evaluated.

ESBWR Containment



ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Low Containment Leakage

- ESBWR (proposed): 0.4% per day

- ABWR (certified): 0.5% per day
- AP1000 (certified): 0.1% per day
- EPR (proposed): 0.25% per day

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Fission Product Holdup in Reactor Building (Open Item)

- 40% mixing efficiency (dilution) in reactor building
- 50% per day leak rate from reactor building

1/16/2008 41

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Control of pH of Water in Containment Pools to Prevent Iodine Re-evolution (Open Item)

- **Acid formation**
  - Hydrochloric acid
  - Nitric acid
- **Base formation**
  - Cesium hydroxide
- **Buffer Injection**
  - Sodium Pentaborate

1/16/2008 42

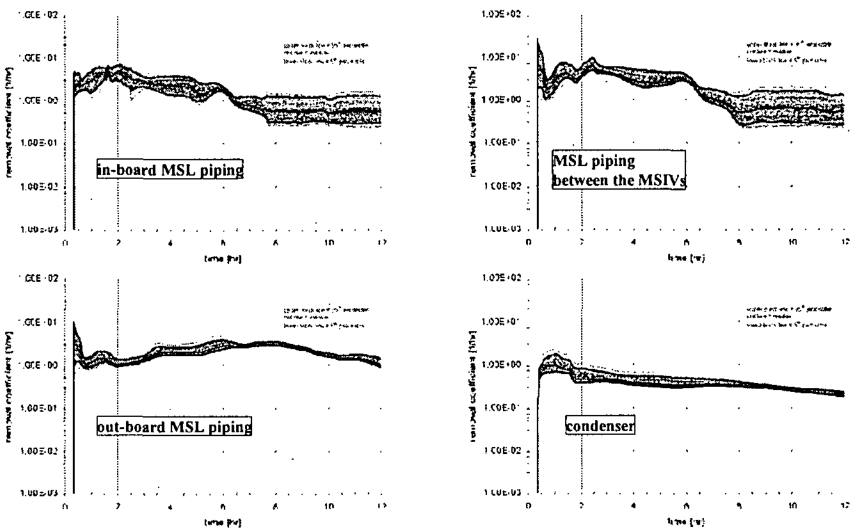
ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Aerosol Deposition in Main Steam Lines and Main Condenser (Open Item)

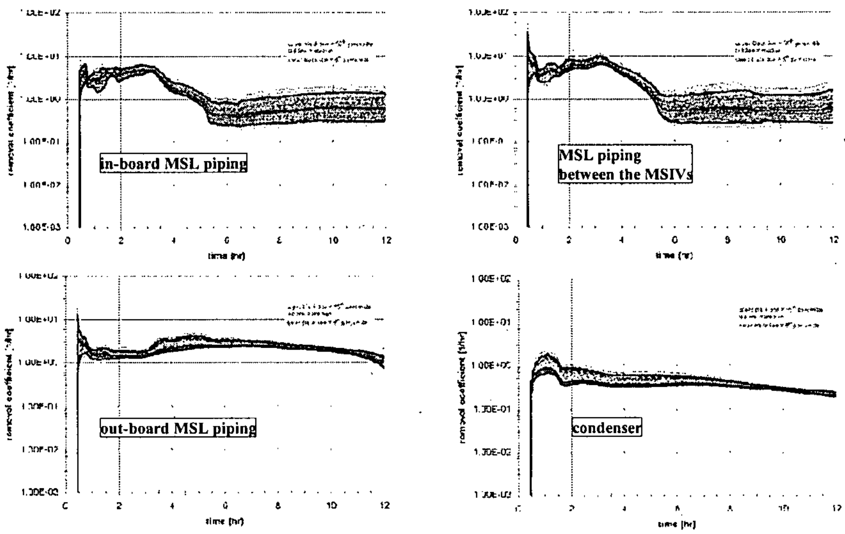
- Main steam lines, main steam line drain lines, and main condensers are designed to meet SSE criteria
- Main steam isolation valve leak rate assumed (200 scfh) is specified in ESBWR technical specification
- 200 scfh leak rate is assumed for the entire duration of accident (30 days)
- Performed an independent confirmatory calculation to verify aerosol deposition rates proposed by GEH

1/16/2008 43

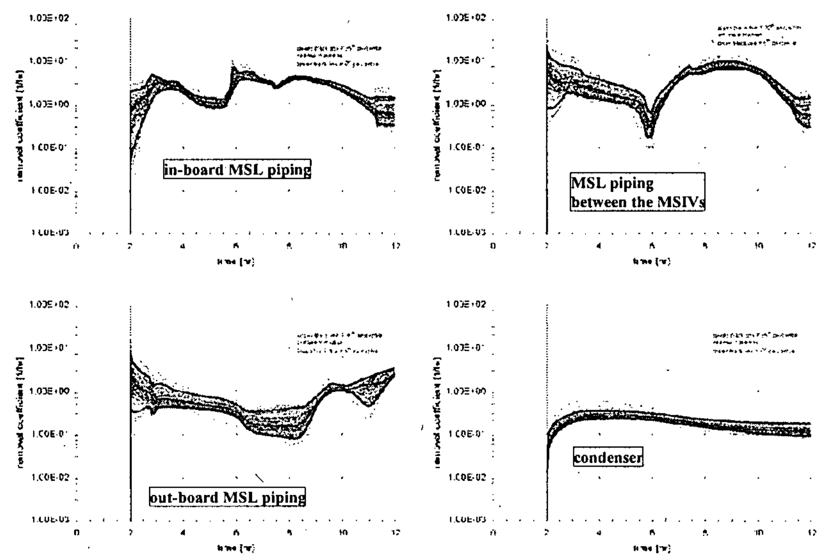
MSL and Condenser Aerosol Removal Rates for Accident Scenario 1



MSL and Condenser Aerosol Removal Rates for Accident Scenario 2



MSL and Condenser Aerosol Removal Rates for Accident Scenario 3



46

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Significant Open Items

- Fission product removal by passive containment cooling system
- Fission product holdup in reactor building
- Control of pH of Water in Containment Pools to Prevent Iodine Re-evolution
- Aerosol Deposition in Main Steam Lines and Main Condenser

1/16/2008 47

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Significant SER Chapter 15 COL Action Item

- Demonstration by COL applicants who reference the ESBWR design that its site-specific X/Q values fall within those values certified in ESBWR standard reactor design

1/16/2008 48

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Example: Short-term (Accident) Atmospheric Dispersion Factors (χ/Q values) at Site Boundary (EAB) (sec/m^3)

- **ESBWR (proposed): 2.00E-3**

- **ABWR (certified): 1.37E-3**
- **AP1000 (certified): 5.10E-4**
- **US-EPR (proposed): 1.00E-3**
- **North Anna (ESP): 2.26E-4**

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

Discussion/Committee Questions

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Anticipated Transients Without Scram
ESBWR Boron Mixing

Presented by
Benjamin T. Parks
NRR/ADES/DSS/SRSB

Christopher Boyd
RES/DSA/RSAB

January 17, 2007

Topics Covered

- Chapter 15: ATWS Review
- SLCS Injection Shutoff Valve Performance
- Boron Mixing

ATWS Review

- GEH analyzed typically limiting ATWS scenarios
- Additional scenarios analyzed for sensitivity study
- Traditional acceptance criteria were used
  - PCT, Vessel Pressure
- OPEN ITEMS
  - Boron Mixing – Staff performing confirmatory analysis
  - TRACG Applicability – Currently under review

1/16/2008 53

SLCS Injection Shutoff Valve Performance

- Shutoff valves are safety related.
- ATWS analysis assumes degraded IC performance (only 3/4 ICs available).
- Shutoff valves are ASME code components subject to inservice inspection program.

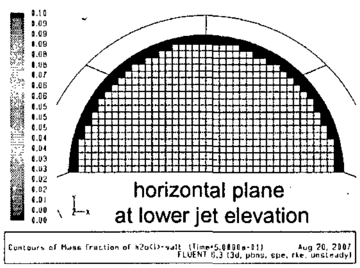
1/16/2008 54

Boron Mixing

- Differences in ESBWR design and analysis approach warranted further evaluation of ATWS Boron Mixing.
- GEH has renodalized their TRACG analysis model to provide a more limiting evaluation of boron transport.
- Staff CFD analysis is underway.

1/16/2008 55

Staff CFD Analysis



- 45 million cell model of ESBWR bypass
- Geometry data obtained from:
  - Audit activities
  - GEH-provided data
  - Surveys of TRACG input
- Input assumptions based on performance requirements and TRACG data.
- Staff analyzed sensitivities in steady-state mode, and general phenomena in transient mode.

1/16/2008 56

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

Discussion/Committee Questions

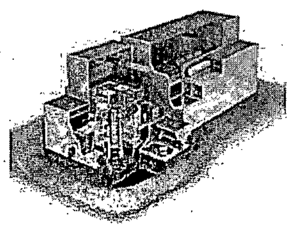
1/16/2008 57

ESBWR DCD Chapter 15 Safety Analyses

Advisory Committee on Reactor Safeguards

Wayne Marquino
Craig Goodson
Pradip Saha, PhD
MD Alamgir, PhD
Erik Kirstein

January 17, 2008



HITACHI

15.0 Classification of Events

- Anticipated Operational Occurrences (AOO) expected during life of the plant, includes normal operations/evolutions, and unplanned occurrences/failures
- Design Basis Accidents – Primarily limiting events for dose consequences show mitigation capability
- Special Events – evaluated to regulatory acceptance criteria
- Infrequent Events - subset of accidents
- Approximately 45 events identified and analyzed
- Appendix 15A event frequency calculation supports event classification

15.0 Improved Reliability of Fault Tolerant Digital Controls

Added Redundant Sensors, Actuators & Controllers

Several Events moved to lower probability category

Specific event frequency determination justifies:

- Fewer initiating events
- Higher plant capacity factor
- Improved fuel economics

15.1 Nuclear Safety Operational Analysis

- Similar to Failure Mode & Effects Analysis (FMEA, Pre-dates PRA, not very detailed)
- Documents primary success path credited in safety analysis
- Relates to Technical Specifications (TS)

15.2 Anticipated Operational Occurrences *<braces indicate Limiting Event>*

Demonstrates ESBWR meets all AOO acceptance criteria

Critical Power Ratio (CPR heat transfer condition ensures clad integrity)

- Operating Limit CPR such that 99.9% of fuel rods do not enter transition boiling
- Steady State Safety Limit CPR retained in TS

Reactor Pressure

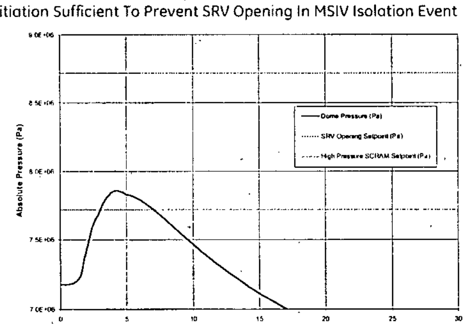
- SRV actuation avoided

Core Water Level

- Core remains covered with no ADS required

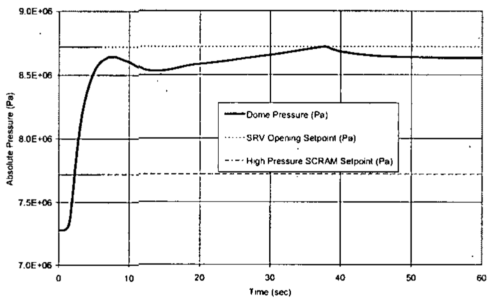
15.2 Increased Steam Volume in RPV Mitigates Pressurization

IC Initiation Sufficient To Prevent SRV Opening In MSIV Isolation Event



15.5 Increased Steam Volume in RPV Mitigates Pressurization

No Pressure Overshot in ASME Over-Pressure Protection Analysis



15.3 Infrequent Events (IE)

- Radiological consequence is less than 2.5 rem total effective dose equivalent (TEDE)
  - Dose evaluated for 1000 fuel rods (bounding for IE)
  - Bounding CPR change *<Cold Water Injection>*
- The plant maintains the reactor water level above the top of active fuel (TAF) *<All Events>*
- The RCPB pressure is less than 1500 pounds per square inch gauge (psig) *<Load Reject, fail all Bypass>*

15.4 Analysis of Accident Dose

Section 15.4 provides description of:

- Radiological consequences of Design Basis Accidents

  -FHA, LOCA, MSLB, CRDA, Feedwater Line Break, Failure of Small Coolant Line Outside Containment, RWCU/SDC System Line Failure Outside Containment, Spent Fuel Cask Drop

- Dose calculations performed in accordance with Regulatory Guide 1.183 (Alternate Source Term, AST)
- Resulting doses meet 10 CFR 50.34(a) and GDC 19 dose criteria
- All accidents (with exception of LOCA) conservatively assume no credit of Control Room emergency charcoal filtration

15.4 Containment System Fission Product Removal

Some Fission Products would be removed on containment structures and in PCC heat exchanger

MELCOR applied to calculate a removal coefficient

Range of scenarios analyzed to determine limiting thermodynamic conditions:

1) Low pressure core failure LOCA
   Bottom drain line LOCA, IC, SLCS, GDCS failures, ADS works
2) High pressure core failure LOCA
   Bottom drain line LOCA, IC, SLCS, ADS failures
3) Non-LOCA high pressure core failure
   Loss of AC & FW, IC, SLCS, ADS failures

Significant core damage in all scenarios; ECCS recovered just before lower head failure (consistent w/ AST)

15.4 pH in Containment Pools

SLCS injection credited for buffering

Cable degradation and Nitric Acid production considered

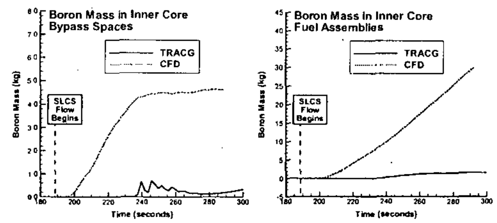
Evaluation of pH in containment pools is being revised for DCD R5 (GEH will consider radioactivity in suppression pool)

15.5 ATWS MSIV Closure – SLCS Bounding

Parameter	Acceptance Criteria	Calculated Value
RPV Integrity: Maximum Vessel Bottom Pressure, MPaG (psig)	10.34 (1500)	9.41 (1364)
Containment Integrity: Maximum Bulk Suppression Pool Temperature, °C (°F)	121 (250)	73.1 (163)
Fuel Integrity: Peak Cladding Temperature, °C (°F)	< 1204.4 (2200)	850.3 (1562.5)
Ratio of Oxide-to-Clad Thickness	< 17%	< 0.3 %

Analyses meet the Acceptance Criteria with large margin.

Comparison of Results: TRACG & CFD



CFD INDICATES:

- Increased Radial Transport of Boron toward the Core Center relative to TRACG
- Greater Amount of Boron Entering the Fuel Bundles relative to TRACG
- TRACG Core Boron Concentration conservative

13

15.5 Special Events
<braces indicate Limiting Event>

- The plant maintains the reactor water level above the top of active fuel (TAF). *<Station Blackout (SBO)>*
- The plant design maintains pressure in the reactor coolant and main steam systems below 110 percent of the design value. *<MSIV Isolation, position scram failed>*
- RCPB pressure is less than 1500 psig (ASME Service Level C, 120% of Design). *<ATWS>*
- The plant maintains containment and suppression pool pressures and temperatures below their design values. *<All Events>*

14

Appendices

15A Event frequency calculations for Infrequent Events

15B Radiation Source Term

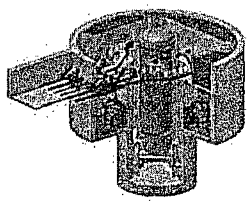
15

Summary

- ESBWR meets all regulatory requirements for AOO's, & Special Events and DBA's
- Considering ESBWR design for lower event frequency, Infrequent Event category included in licensing basis
- ESBWR passive safety features and large vessel produce a slower dynamic relative to previous designs

16

ESBWR APPLICATION Chapter 21.6 METHODOLOGY for TRACG AOO/IE/SE/ATWS



Wayne Marquino
John Sorensen

January 17, 2008

HITACHI

TRACG ESBWR Background

Early 1990s - SBWR Test & Analysis Program Description (inc. CSAU/PIRT)

Early 1990s - SBWR Test Program

Mid 1990s - SBWR DOE program ends, ESBWR (larger output) continued internally at GE

Late 1990s - NRC approves TRACG for BWR2-6 AOO analysis

2002 GE submits TRACG04 application for ESBWR

HITACHI

Submitted Applications of TRACG

BWR2-6 AOO *

BWR2-6 ATWS Pressure *

ESBWR LOCA *

ESBWR Stability *

ESBWR ATWS Pres/PCT/Supp.Pool Temp. NEDE-33083 Supplement 2

ESBWR AOO/IE/SE (SBO) NEDE-33083 Supplement 3

*NRC Issued SER

HITACHI

ESBWR TRACG ATWS Methodology- NEDE-33083P, SUPPLEMENT 2

Extends Application of TRACG to boron shutdown during ATWS and Peak Clad Temperature

RAI's:

Boron Mixing- GE is finalizing a CFD analysis to demonstrate that the blockage of boron flow applied in TRACG is conservative

Stability - GE is executing a more bounding event from stability standpoint

ESBWR TRACG AOO/IE/SE Methodology- NEDE-33083P, SUPPLEMENT 3

Uses the Approved NEDE-32906 AOO CSAU process with ESBWR specific PIRTs.

RAI responses to address HCU failures during SRI in limiting event