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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.

1 UNITED STATES OF AMERICA

2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

5 MEETING

6 + + + + +

7 ESBWR SUBCOMMITTEE

8 + + + + +

9 THURSDAY,

10 JANUARY 17, 2008

11 + + + + +

12 ROCKVILLE, MARYLAND

13 + + + + +

14 The Subcommittee met at the Nuclear

15 Regulatory Commission, Two White Flint North,

16 Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Michael

17 Corradini, Chairman, presiding.

18 MEMBERS PRESENT:

19	MICHAEL CORRADINI	Chairman
20	SAID ABDEL-KHALIK	Member
21	WILLIAM J. SHACK	Member
22	J. SAM ARMIJO	Member
23	SANJOY BANERJEE	Member
24	DENNIS C. BLEY	Member
25	THOMAS S. KRESS	Member

1 MEMBERS PRESENT: (cont'd)

2 JOHN D. SIEBER Member

3 ROBERT E. UHRIG Member

4 GRAHAM B. WALLIS, Consultant

5 GARY HAMMER, Designated Federal Official

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

2 (8:29 a.m.)

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

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

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

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

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

1 The rules for participation -- again, let
2 me review -- have been announced as part of the notice
3 of the meeting, previously published in the Federal
4 Register. Portions of this meeting may be closed for
5 discussion of unclassified safeguards and propriety
6 information. I will just say that if this is the
7 case, I'd like GE or the staff to remind us, so we
8 don't accidentally stray down that path before we have
9 to back up, so we can check that.
10 We have received no written comments or
11 requests for time to make oral statements from members
12 of the public regarding today's meeting. A transcript
13 of the meeting is being kept and will be made
14 available as stated in the Federal Register notice.
15 Therefore, we request that participants in the meeting
16 use the microphones located throughout the meeting
17 room when addressing the Committee. The participants
18 should first identify themselves and speak with
19 sufficient clarity and volume so that they may be
20 heard.
21 So we will proceed with the meeting, and
22 I guess, Dr. White, you'll start us off?
23 DR. WHITE: Yes. Good morning.
24 CHAIRMAN CORRADINI: Good morning.
25 DR. WHITE: Thank you for having us.

1 Today we are going to begin a presentation on
2 Chapter 15, the safety analysis. We will be
3 discussing the event classification development, the
4 criteria used, the types of events that we have
5 classified.
6 We're going to go into AOOs, of course,
7 design-based accidents. We'll talk about radiological
8 consequences of design-based accidents, and my
9 colleagues contributing today -- Wayne Marquino, Craig
10 Goodson, Dr. Pradip Saha, Dr. M.D. Alamgir, and Mr.
11 Erik Kirstein. And I'm going to turn the floor over
12 to Mr. Marquino.
13 MR. MARQUINO: Now, I think we had a
14 request to go over one of Dr. Saha's slides.
15 MEMBER ABDEL-KHALIK: Right. Because
16 reading the staff's slide, they indicated that the
17 Chapter 15 review significantly -- was significantly
18 affected by GEH's new proposed reactor power control
19 by varying the feedwater temperature. So I have a
20 couple of questions on the feedwater temperature
21 operating domain map that was presented yesterday --
22 this particular figure, right.
23 Now, the line going from point C to
24 point A; at which burnup is that line?
25 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

1 change with burnup in this particular reactor?

2 DR. SAHA: Wayne?

3 MR. MARQUINO: Yes.

4 DR. SAHA: May I interject? May I

5 clarify? This is Pradip Saha from GE-Hitachi Nuclear

6 Energy. Okay. Just for clarification, this is a

7 generalized operating domain that we are proposing for

8 ESBWR. So it really is not tied with any particular

9 exposure level. It is applicable -- this map is

10 basically applicable throughout a cycle.

11 Now, particular values of, say, DELCPR by

12 ICPR, which is kind of fractional change in the CPR,

13 may vary slightly with the cycle. But operation-wise,

14 the reactor may be operated, depending on the need, on

15 this line any time there is a need for.

16 MEMBER ABDEL-KHALIK: Okay. The question

17 I'm asking is: if I were to start at point A --

18 DR. SAHA: Well, yes. For -- assuming

19 that you have reached point A with proper fuel

20 conditioning.

21 MEMBER ABDEL-KHALIK: Right.

22 DR. SAHA: Yes.

23 MEMBER ABDEL-KHALIK: And you're telling

24 me this is at the end of cycle.

25 DR. SAHA: Not necessarily. That is what

1 I am trying to clarify. This can happen, say, just --
2 you have started up the reactor, and then there is a
3 reason to lower power without moving the control rod.
4 It could be the next exchange -- I mean, control rod
5 sequence exchange after three months.
6 MEMBER ABDEL-KHALIK: My question is
7 really a lot simpler than all of that.
8 DR. SAHA: Oh, okay.
9 MEMBER ABDEL-KHALIK: Okay? You have a
10 66-degree temperature limit on feedwater, and you're
11 saying that that gives you a 15 percent change in
12 power.
13 DR. SAHA: That is correct, yes.
14 MEMBER ABDEL-KHALIK: Okay? Now, are you
15 telling me this is at the end of cycle or --
16 MR. MARQUINO: I don't think they're
17 saying that.
18 DR. SAHA: I'm not saying -- that's what
19 I want to clarify.
20 MR. MARQUINO: Let me -- the original
21 calculations that we ran with TRAC to determine what
22 temperature range we were going to use, I think we're
23 at -- with an end of cycle wrap-up file conditions.
24 DR. SAHA: Maybe we should go back and
25 see, because if I remember most of the calculation was

1 done at MOC, middle of cycle.

2 MR. MARQUINO: Okay. So you think they

3 were MOC?

4 DR. SAHA: I think so, in the -- in the

5 NEDO-33338, I think I remember it MOC.

6 MR. MARQUINO: And we did a range of

7 exposures in the 338 --

8 DR. SAHA: Yes. And also --

9 MR. MARQUINO: -- transient analysis.

10 DR. SAHA: -- from our previous

11 exploration, which is in the DCD, for certain

12 transient we know that MOC is the worst case, or UOC

13 is the worst case. So you use that knowledge also.

14 MEMBER ABDEL-KHALIK: What I'm trying to

15 find out is: what is the range of delta P --

16 MR. MARQUINO: Let us get back to you on

17 exactly what exposure point corresponds to the --

18 MEMBER ABDEL-KHALIK: The 66 --

19 MR. MARQUINO: -- percent power change.

20 But as you point out, the value will be different at

21 different stay points from a 486 --

22 MEMBER ABDEL-KHALIK: Right.

23 MR. MARQUINO: -- temperature change.

24 MEMBER MAYNARD: I would assume at

25 whatever it comes out to be that you would end up with

1 limit on temperature and power that would be a part of
2 your operating and maybe tech specs or whatever, such
3 that your safety analysis takes the worst case points
4 into account.
5 MEMBER SIEBER: That's right.
6 MR. MARQUINO: Yes. And that's the
7 purpose of this diagram is to establish an envelope
8 within which the plant can operate.
9 MEMBER SIEBER: But you can operate any
10 place in that envelope and be in compliance with the
11 regulations and your technical specifications. You're
12 just explaining one technique that allows you to move
13 around in that envelope. Is this information in the
14 DCD?
15 MR. MARQUINO: No.
16 MEMBER SIEBER: No. Okay.
17 MS. CUBBAGE: I have --
18 MEMBER SIEBER: So it's not required.
19 CHAIRMAN CORRADINI: Yes, I think this is
20 the point. Said wanted a clarification. I think
21 we've got the clarification, but staff has just
22 received the report, and it --
23 MS. CUBBAGE: Right. And it is -- I have
24 it with me today. I can transfer it on stick to Gary,
25 so --

1 MEMBER SIEBER: But it seems to me that,
2 since you're within bounds with regard to the safety
3 evaluation, as long as you're inside that curve,
4 wherever you end up in there is -- satisfies the
5 requirements for that reactor.
6 MEMBER ABDEL-KHALIK: That's what I'm
7 trying to find out, whether they can be within bounds
8 at all --
9 MS. CUBBAGE: The intent of the
10 presentation yesterday was just to give you a hint
11 that this is coming. We're not asking for any formal
12 feedback on this issue. I mean, I understand the
13 interest, but at this time we are not asking for
14 feedback on it.
15 CHAIRMAN CORRADINI: So I guess the -- I
16 think for all of us I guess, when it's appropriate,
17 we'd like to see the --
18 MS. CUBBAGE: Absolutely. Yes.
19 CHAIRMAN CORRADINI: Okay.
20 MEMBER ABDEL-KHALIK: Thank you.
21 MEMBER ARMIJO: But basically, the bottom
22 line is that -- at least I want to make sure I
23 understand it -- the area is burnup-dependent, that
24 area will change depending on burnup.
25 CHAIRMAN CORRADINI: They are looking for

1 the envelope that's --

2 MEMBER MAYNARD: That's no different than

3 for any of the other accidents. You have to evaluate

4 it. You have to look at what is the worst case:

5 beginning the life -- middle of life, what conditions,

6 low temperature, high temperature, for each accident.

7 MEMBER ARMIJO: I just want to make sure

8 that the -- and the maximum reduction in power that

9 you can get by this technique is of the order of 15

10 percent.

11 DR. SAHA: That is correct.

12 MEMBER ARMIJO: It's not going to be 20,

13 25 percent, at any other time in the cycle?

14 DR. SAHA: Probably not. Around 15

15 percent.

16 MEMBER ARMIJO: It's around 15, okay.

17 MR. MARQUINO: So the analogy to the power

18 flow map on the operating plants is that -- the

19 operator, there is points in the cycle where the slope

20 of the power flow map is different. Okay? And

21 changing core flow might put the core on a trajectory

22 that moves it outside the power flow map.

23 But the operator doesn't do that because

24 that's part of the plant's license, and he operates

25 within the plant's license. So from the same basis,

1 if there was a core which 15 F, temperature change,
2 produced an eight-degree power change, the operator is
3 not going to increase the feed temperature up to 500 F
4 to get a 15 percent power change, because this
5 envelope is the licensed operating condition for the
6 plant.
7 MEMBER ARMIJO: Okay.
8 MEMBER ABDEL-KHALIK: Hopefully, that --
9 I guess maybe the topical report will have the
10 information on how the Doppler power defect changes
11 with burnup, and how the moderator void coefficient
12 changes with burnup.
13 MR. MARQUINO: Do we have thermal
14 hydraulics?
15 DR. SAHA: If I may clarify, this
16 particular report -- NEDO-33338 -- even the title
17 indicates it is basically safety evaluation. So there
18 is another report, Initial Core Report, I guess, from
19 the nuclear side. I think in that report, I don't
20 quite remember the number of that --
21 MS. CUBBAGE: The transients?
22 DR. SAHA: No. Yes.
23 MS. CUBBAGE: Or the core? The initial
24 core or the initial core transients?
25 DR. SAHA: Initial core design.

1 MS. CUBBAGE: Okay.

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

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

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

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

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

1 MEMBER ABDEL-KHALIK: But, you know, the
2 reason why this whole discussion started is there is
3 a statement here that says Chapter 15 review
4 significantly affected by GEH's new proposed reactor
5 power controls by varying the degree feedwater.
6 MR. SHUAIBI: Right. And we will need to
7 look at that and make sure that if there are any
8 negative impacts that we've addressed them, and that
9 we have resolved them, and we will let you know how
10 that comes about. I agree with you. I agree. We're
11 in agreement, I think.
12 MEMBER SHACK: Okay. Thank you.
13 CHAIRMAN CORRADINI: Back to the program.
14 MR. MARQUINO: Well, thanks for the
15 introduction process, and I'd like to thank the ACRS
16 members and the NRC staff for their thoughtful review
17 of our design and the professional discussion we had
18 yesterday. I will cover the first part of Chapter 15,
19 the safety analysis chapter for ESBWR.
20 And Chapter 15 starts with a
21 classification of events. We have four event classes
22 -- anticipated operational occurrences, or AOOs which
23 are expected during the life of the plant. This
24 includes normal operation and evolution, startup,
25 shutdown, and unplanned occurrences and failures, like

1 load rejections.

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

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

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

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

19 CHAIRMAN CORRADINI: Perfect.

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

1 So a sensor failure won't cause a
2 transient, a controller failure won't cause a
3 transient, and then, if there -- what we can't do as
4 much about is the mechanical failures in the plant,
5 like a valve failing open or closed, or a pump
6 spuriously increasing in speed or decreasing in speed.
7 So what we've done in those areas is use
8 multiple actuators, so that if -- if we have, say, 12
9 bypass valves, and one of the valves fails to open on
10 demand, the effect is not as severe.
11 MR. WALLIS: So the purpose is to show
12 that it's a better plant, because some of the
13 accidents are unlikely and have very low consequences?
14 Is that the purpose?
15 MR. MARQUINO: That's the purpose. I
16 think this is a win-win situation for the public and
17 the utilities. The public benefits because there is
18 fewer initiating events, and the utility benefits
19 because this class has different acceptance criteria
20 from the AOO class, so that we can improve the fuel
21 economics of the plant.
22 MR. WALLIS: So by not calling them
23 accidents, you can say that your plant has fewer
24 accidents than other plants? The potential for fewer
25 accidents, is that the idea?

1 MR. MARQUINO: Well, in --

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

3 way.

4 MR. MARQUINO: In the PRA -- actually, we

5 don't take a lot of credit for this in the PRA. There

6 were some questions from the ACRS about that, and we

7 don't take a lot of credit in the PRA, but we

8 specifically want to take credit in the CPR evaluation

9 for this.

10 Another benefit is improved availability.

11 A plant operates for a longer fraction of the cycle.

12 Next slide.

13 CHAIRMAN CORRADINI: I think we are going

14 to keep on coming back to this, because I am still

15 cloudy, but let's keep on going.

16 MR. MARQUINO: Okay. In general, I want

17 to go through -- you see, I'm going through this

18 pretty quickly, and then we'll see what discussion

19 points you want to hear more about. And after the

20 staff presents, if you have more questions, we're

21 prepared to answer them. If we can't answer them on

22 the spot, come back.

23 15.1 is the nuclear safety operational

24 analysis. It's similar to failure modes and effects

25 analysis. This material predates the PRA, so you'll

1 see it in operating plants, FSARs, as well. It is not
2 as detailed as a PRA.
3 The purpose of this is to document the
4 primary success path credited in the safety analysis,
5 and then that feeds into the tech specs. There has
6 been some interaction with GE and the NRC on the tech
7 specs, asking, how did we develop the tech specs? How
8 do you know that the system, structures, components
9 and the tech specs are adequate? And we point back to
10 this evaluation, and, when necessary, we make changes
11 to it.
12 For example, the control rod drive
13 hydraulic system, the high capacity system that we
14 talked about yesterday, is not a primary success path
15 in the safety analysis, because the ICEs and the
16 safety-related ADS and GDCS systems back that up in
17 terms of water level inventory.
18 But that's not too clear in our Chapter 15
19 analysis, so the staff is asking us about it, and
20 we've got to clean it up to make sure that that is
21 clear, and the tech spec representation was right.
22 Next slide, please.
23 15.2 is the first safety analysis section
24 in Chapter 15, and throughout the rest of my
25 presentation, I'll use braces and italics to indicate

1 limiting events. The section demonstrates that ESBWR
2 meets all the AOO acceptance criteria., specifically,
3 the critical power ratio that indicates a good heat
4 transfer condition to ensure clad integrity is
5 maintained such that 99.9 percent of the fuel rods do
6 not enter transition boiling.
7 MR. WALLIS: Is it true that this -- the
8 AOOs don't really invoke or use any of the special
9 safety features of the ESBWRs, such as the gravity-fed
10 cooling, and so on? They're just like normal BWR
11 AOOs?
12 MR. MARQUINO: The GDCS and the ADS
13 systems, that's true. We specifically have designed
14 the plant to avoid actuation of those systems. We use
15 the IC for the loss of feedwater-type events in AOOs.
16 One of the interactions we had with the
17 staff was on the safety limit CPR. That is part of
18 our analytical method for previous plants, but it's
19 not part of the TRACG analytical method. So we did
20 not include a safety limit CPR in the tech specs. The
21 safety limit was 99.9 percent of the fuel rods avoid
22 transition boiling.
23 The staff requested that we put a safety
24 limit CPR in the tech specs to provide them regulatory
25 oversight on fuel changes, and we've added a steady

1 state safety limit CPR back in the tech specs.

2 Reactor pressure --

3 MEMBER ABDEL-KHALIK: Given the

4 uncertainty in the applicability of the GEXL

5 correlation to the GE-14E fuel, how can you do that

6 now?

7 MR. MARQUINO: Well, that GEXL correlation

8 is kind of plug-and-play in our safety analysis. So

9 yesterday, in Chapter 4, you were informed by Russ

10 Fawcett on the conservatism that we expect, and the

11 tests that we're going -- that we've conducted to

12 confirm it. And you're going to get a test report,

13 we're going to confirm that correlation, and, if

14 necessary, we can change the correlation and rerun the

15 safety analysis. And we don't expect a perturbation

16 to the operating limit on that. We think it will --

17 the new tests will show the operating limit is

18 conservative.

19 MEMBER ABDEL-KHALIK: So the point is, you

20 may have to revisit all of this if it turns out that

21 you have to modify the GEXL correlation based on the

22 new full-scale testing of the GE-14E bundle?

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

24 risk.

25 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.

1 The feedwater pump trip is assumed,
2 because the feedwater would spray cold water in the
3 vessel dome and drop reactor pressure. So to minimize
4 the uncertainty in this analysis, we just assumed the
5 pumps trip.
6 If that -- so given that we've bottled up
7 the reactor and disabled all -- most of the mitigation
8 features, the pressure is going to increase to the SRV
9 setpoint. It takes -- it still takes about 38 seconds
10 for that to happen. And when it happens, if even only
11 one SRV opens, it's sufficient to stop the pressure
12 increase, and there is no dynamic overshoot in
13 pressure, as most of the earlier plants have.
14 So this also feeds into the CPR response
15 for the pressurization events, like load rejections.
16 We see very low CPR consequences for those events.
17 MEMBER SIEBER: That's all due to the size
18 of the reactor vessel: the fact that you've been able
19 to lessen the effect of the -- all of these
20 parameters?
21 MR. MARQUINO: Yes. And most of the new
22 volume is filled with steam, to cushion
23 pressurization.
24 Section 15.3 is the infrequent event
25 section, so this is the event class that was added.

1 Here we show that the radiological consequences are
2 less than 2.5 rem TEDE.
3 MR. WALLIS: I didn't understand this at
4 all. I mean, you have events where there is no fuel
5 damage, and then you assume 1,000 fuel rods are
6 damaged. It doesn't make any sense to me.
7 CHAIRMAN CORRADINI: I think they're
8 required to do that.
9 MR. WALLIS: But it doesn't make any
10 sense, though. It's ludicrous, so it --
11 CHAIRMAN CORRADINI: Well, I'm sorry.
12 MR. WALLIS: -- it doesn't have to --
13 CHAIRMAN CORRADINI: I should let you
14 explain. I'm sorry.
15 MR. WALLIS: The thousand is just some
16 number picked out of the air when the real number
17 should be close to zero or zero.
18 MR. MARQUINO: No. In -- well, in the
19 licensing analysis, this -- there are some events in
20 this class, or there's one event in this class that
21 would fail about half that many fuel rods.
22 MR. WALLIS: There is one event in here.
23 MR. MARQUINO: Yes.
24 MEMBER ARMIJO: What event is that?
25 MR. MARQUINO: Realistically, it's the

1 loss of feedwater heating, assuming failure of the
2 SRI.
3 MR. WALLIS: Because you've gotten into --
4 you've got into -- to go beyond nuclear boiling,
5 although you don't uncover. Is that what it is or --
6 MR. MARQUINO: Right. Right.
7 MR. WALLIS: Okay.
8 MR. MARQUINO: And that event is slow, so
9 that -- that condition would exist long enough that
10 there actually might be fuel failure.
11 MR. WALLIS: So this thousand is something
12 imposed on you by the regulation?
13 MR. MARQUINO: No, it's not. A thousand
14 was set by analyzing the events, calculating the
15 number of rod failures, and then picking a number that
16 bounded the actual rod failures for the dose
17 consequences.
18 MR. WALLIS: And so it gives you a bad
19 image, though. I mean, it looks rather superficially
20 when you read this stuff - it says there's a thousand
21 fuel rods damaged when, in fact, it's not true for
22 most of these events.
23 MEMBER BANERJEE: Are there events where
24 you get significant fuel rod damage?
25 CHAIRMAN CORRADINI: I think he is going

1 to come -- are you going to come to this in the
2 presentation, or is this the best place to ask these
3 questions?
4 MR. MARQUINO: This is the best place to
5 ask these questions.
6 CHAIRMAN CORRADINI: Okay. So can you
7 repeat the bounding event, so that we're all on the
8 same page?
9 MR. MARQUINO: Okay. There are two events
10 of concern in this category -- loss of feedwater
11 heating, assuming failure of the highly reliable SRI
12 and SCRRI function. You see the event frequency is
13 something like once in 4,000 years, that order of
14 magnitude. And then, the other event of concern is a
15 pressurization event, load rejection with failure of
16 all the bypass valves.
17 They have similar CPR changes, but the
18 pressurization event is terminated by a scram very
19 quickly. So, realistically, there wouldn't be any
20 fuel rod failures in that event considering all of the
21 time and temperature data that is available.
22 CHAIRMAN CORRADINI: So remind me of your
23 acronym. So the first one is limiting. So loss of
24 feedwater heating and failure of?
25 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

1 the fuel in water.

2 MR. MARQUINO: Yes.

3 MEMBER BANERJEE: Or is it a dryoUT?

4 MR. MARQUINO: Okay. It's a point I think

5 Dr. Saha wants to correct me on.

6 DR. SAHA: Yes. This is Pradip Saha from

7 GEH. I just want to clarify, you know, we do -- we

8 have a very, very conservative assumption. We assume

9 that, as soon as a rod goes into boiling transition it

10 fails. We all know that that is not true. I just

11 want to --

12 MEMBER BANERJEE: Yes. But what we are

13 asking right now is; what sort of a boiling transition

14 is it?

15 DR. SAHA: It gets a dryout time, because

16 we use a GEXL correlation, which is --

17 MEMBER BANERJEE: But what -- do you

18 actually have a dryout mechanism here, that you don't

19 have lots of water in the core, or not in that local

20 region?

21 MR. WALLIS: How does it dry out if it's

22 covered with water?

23 MEMBER SIEBER: It can't.

24 MEMBER BANERJEE: Is it film boiling?

25 Explain to us what it is.

1 CHAIRMAN CORRADINI: I was going to say
2 the correlation is exceeded.
3 MEMBER BANERJEE: That doesn't -- that is
4 not what we are asking. What is the mechanism? What
5 is the mechanism --
6 DR. SAHA: Okay. The GEXL correlation, as
7 we all know, it is a critical quality boiling
8 correlation, and this has got, I don't know, maybe 20
9 or 25 constants.
10 MR. WALLIS: The symptom you get is that
11 the temperature begins to increase?
12 DR. SAHA: Correct.
13 MR. WALLIS: But it doesn't say it goes up
14 very high.
15 DR. SAHA: No, not very high. That is why
16 I have come here and explained that, as soon as this
17 GEXL correlation limit is exceeded, which Professor
18 Corradini --
19 MR. WALLIS: It assumes.
20 DR. SAHA: -- said it rightly, then we
21 assume that there is fuel failure, which is highly
22 conservative. That's all.
23 MR. WALLIS: What kind of damage do you
24 then assume happens?
25 DR. SAHA: Okay. Maybe we are --

1 MR. WALLIS: That is also --

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

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

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

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

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

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

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

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

1 MR. MARQUINO: Well, we don't postulate a
2 failure mechanism at this point, because we -- to get
3 into further justification of which rods fail and
4 which rods don't fail, to go to a time and temperature
5 basis of the analysis, that would involve model
6 development, NRC review. We simply --
7 MEMBER ARMIJO: Well, you are silent on
8 the mechanism. You said it exceeds the correlation.
9 We count the number of rods that exceed the
10 correlation. We say they're failed.
11 MR. MARQUINO: Yes.
12 MEMBER ARMIJO: And you have a gap
13 release.
14 MR. MARQUINO: Yes. I'll defer to 15.4 to
15 talk about the dose. Well, I'll defer to the 15.4
16 section to talk about the dose analysis.
17 MEMBER BANERJEE: So let me ask you again,
18 because I want to be sure, there is lots of water
19 around still when this is happening, because it's a
20 film boiling transition.
21 MR. MOEN: That's correct.
22 MEMBER BANERJEE: All right. That
23 clarifies it. So it is not a dryout transition, then.
24 Let's not call it dryout.
25 MR. MOEN: Correct. Okay.

1 MEMBER ABDEL-KHALIK: So let me follow up
2 on that. For this, say, a loss of feedwater heater --
3 heating transient, at what elevation do you reach the
4 minimum CPR?
5 MR. WALLIS: It must depend on time of
6 cycle.
7 MR. MARQUINO: Near the top of the fuel
8 bundle.
9 MEMBER ABDEL-KHALIK: Is it near the top?
10 MR. WALLIS: It's rather --
11 MR. MARQUINO: Near the top of the fuel
12 bundle.
13 MEMBER ABDEL-KHALIK: So it may still be
14 a dryout.
15 MR. WALLIS: It may still be a dryout.
16 CHAIRMAN CORRADINI: I don't think they
17 know. I think those --
18 MEMBER BANERJEE: We are not getting a
19 straight answer, then, about what the mechanism --
20 CHAIRMAN CORRADINI: But I think -- I
21 guess -- just to interpose, I mean, that's -- this is
22 all interesting, but I think their approach is -- is
23 bounding in the sense that they go -- they go across
24 the correlation, they assume failure, they assume gap
25 release, and look at the worst case. And then, if

1 they fit, they're okay, they move on.

2 MEMBER ABDEL-KHALIK: Provided, of course,

3 that they are entirely within the range of the

4 correlation.

5 MEMBER ARMIJO: Very conservative.

6 MEMBER BANERJEE: Depending on the

7 mechanism, they can --

8 MEMBER ABDEL-KHALIK: I don't know what

9 full-scale testing --

10 MR. WALLIS: Radiation heat --

11 MEMBER ABDEL-KHALIK: -- whether you are

12 within the full range of the correlation.

13 DR. SAHA: This is Pradip again, Pradip

14 Saha from GEH again. Let me just clarify, we all

15 know, when we say transition boiling, does not mean it

16 is all steam. You know, maybe there is just a vapor

17 film at the wall, at the heated wall, and there are

18 still entrained droplets in the core of the flow.

19 Some of the droplets, they come back to the wall

20 again.

21 So when we do the testing, you know, full

22 bundle testing, basically whenever the temperature

23 goes up beyond the normal, or when you get nuclear

24 boiling, by say 20 degrees or 30 degrees Centigrade,

25 and then declare that it has now in the dryout.

1 So dryout does not mean all steam. So
2 that's all I wanted to --
3 MEMBER BANERJEE: So your criteria for
4 dryout is a temperature rise and not a rate of
5 temperature rise?
6 DR. SAHA: I think as far as I know --
7 and, again, you know, these are the details about the
8 testing procedure and all of that --
9 MEMBER BANERJEE: That's very important.
10 DR. SAHA: -- and that's --
11 CHAIRMAN CORRADINI: We're going to have
12 to go back and look at this when we do the Stern Lab
13 report --
14 DR. SAHA: That's correct.
15 CHAIRMAN CORRADINI: -- via the staff.
16 DR. SAHA: That is correct.
17 MR. WALLIS: So you can prevent all of
18 this by scramming the reactor.
19 CHAIRMAN CORRADINI: Yes.
20 MR. WALLIS: You just don't want to do it.
21 You want to --
22 CHAIRMAN CORRADINI: They assume the
23 failure. That's what they said. There's two
24 additional failures -- the SR something and the SC
25 something.

1 MR. WALLIS: It's not the scram that
2 fails. It's not an ATWS.
3 MR. MARQUINO: Well, in terms of scram,
4 there might not be an automatic scram in this event,
5 because the power level approaches -- in our TRAC
6 analysis, it comes up slightly higher than the scram
7 setpoint in some cases. And initially, we -- in the
8 equilibrium core analysis in the DCD, we didn't credit
9 the scram in that case. So there might be an operator
10 action to effect this scram.
11 MEMBER ABDEL-KHALIK: So what was the
12 basis for selecting the 115 percent high flux strength
13 setpoint?
14 MR. MARQUINO: That is based on our
15 operating experience. It has enough margin that noise
16 doesn't cause inadvertent trips. It allows us to have
17 some mild transients and not initiate a trip in the
18 BWR.
19 MEMBER SIEBER: Local transient
20 particularly.
21 MEMBER ARMIJO: Do you do a clad strain
22 analysis in that event, in feedwater heater at 116
23 percent?
24 MR. MARQUINO: Yes. That's one of the
25 RAIs I think we've got from the staff. We did clad

1 strain analyses for the AOO events, the MOPs and TOPs,
2 mechanical overpower and thermal overpower analysis.
3 Craig, do you have anything to add to
4 that?
5 MR. GOODSON: Not that I recall.
6 MEMBER ARMIJO: You know, if you remember,
7 just roughly, is it far less than the one percent
8 strain criteria that you get during this event?
9 MR. MARQUINO: These two events, I don't
10 think we have an issue.
11 MEMBER ARMIJO: But you did calculate it.
12 There is a number someplace?
13 MR. MARQUINO: I have to check on whether
14 we did an exact calculation or we just looked at the
15 heat flux change in the event. These two events are
16 pretty global, so the local peaking effects aren't too
17 bad in terms of the LHTR.
18 The SRI and SCRRI features of a plant are
19 what cause us to do a specific clad strain evaluation,
20 because those produce local peaking and LHTR
21 increases. The power shifts to the top of the fuel,
22 and that is where we're doing specific strain
23 evaluations.
24 MEMBER SIEBER: But the fact remains is
25 you don't go above 2,200 degrees, right? And you

1 don't oxidize more than 17 percent. You are still
2 coolable when you're done, which is a basic
3 requirement.
4 MR. MARQUINO: That's right. And this --
5 MEMBER SIEBER: Even if it doesn't trip.
6 CHAIRMAN CORRADINI: So can we get to
7 this, unless this is the point that we shouldn't do
8 it. I guess I wanted to understand -- the
9 radiological consequences is pinned, because it is
10 still a consequence for an AOO or for a DBA? That is
11 where this infrequent event gets me fuzzy.
12 MR. MARQUINO: This is not the consequence
13 for a DBA. This is 10 percent of the consequence of
14 a DBA.
15 MR. WALLIS: Right. So you have defined
16 a new regulatory category?
17 MR. MARQUINO: No. No. It was in -- it
18 was in the regulations already, and I think other --
19 and I think --
20 CHAIRMAN CORRADINI: If this a better
21 thing for the staff to discuss, we can wait.
22 MS. CUBBAGE: It's a fraction of the dose
23 limit, so it -- there is precedence, and GE proposed
24 the 2.5 rem criteria. The staff has not disagreed
25 with that --

1 CHAIRMAN CORRADINI: Okay.

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

5 CHAIRMAN CORRADINI: Okay, fine. Thank
6 you.

7 Go ahead. I'm sorry.

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

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

18 Next slide, please.

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

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

1 MR. MARQUINO: The IC didn't fail. So
2 even in the load-reject with failure of all the bypass
3 valves, the IC functioned and it would keep the SRVs
4 from lifting.
5 MEMBER SIEBER: Okay. Thank you.
6 MR. KIRSTEIN: All right. My name is Erik
7 Kirstein. I'll be discussing -- briefly discussing
8 Section 15.4, the radiological consequences of design
9 basis accidents.
10 You can see in the first bullet we have
11 listed the various DBAs that we have considered in
12 15.4. You'll notice the control rod drop accident.
13 Actually, we did not -- as we discussed yesterday, we
14 didn't calculate the dose consequences of the control
15 rod drop accident.
16 However, I guess in this context, we'll
17 talk about the 15.3 thousand-rod failure accident. We
18 followed the methodology. The thousand rods that
19 failed probably did not -- the dose consequence at
20 calculation of the methodology of the control rod drop
21 accident, as specified in Regulatory Guide 1.183.
22 In the next bullet, you can see, as I had
23 mentioned, the dose calculations that we have
24 calculated in 15.4 were performed in accordance with
25 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

1 other hand, ESBWR keeps water over the core in all of
2 the events. But in dose consequence terms, the
3 regulatory guides require us to assume significant
4 core damage and --
5 MR. WALLIS: Well, this seems to me
6 ludicrous.
7 MR. MARQUINO: Well, you know, considering
8 Three Mile Island, I understand the philosophy --
9 CHAIRMAN CORRADINI: I think the staff has
10 an input.
11 MS. CUBBAGE: They are required by
12 regulation to evaluate the dose.
13 MR. WALLIS: But if the regulations are
14 ludicrous, they shouldn't be enforced. They should be
15 changed.
16 MEMBER SIEBER: Well, then, we need to get
17 a rulemaking.
18 MS. CUBBAGE: What I'd like to say is, you
19 know, I know you're seeing that the ESBWR has a large
20 margin to core uncovery for a design basis LOCA. But
21 we don't allow --
22 MR. WALLIS: Not when it covers something
23 for the public which says --
24 MS. CUBBAGE: -- people to melt the core
25 for any plant.

1 MR. WALLIS: -- there are going to be
2 accidents that irradiate people when they don't. It
3 doesn't make any sense, does it?
4 MEMBER SIEBER: That's where SOARCA came
5 from.
6 MR. WALLIS: Right.
7 CHAIRMAN CORRADINI: I think -- I think
8 what the staff is saying politely is this bounds it.
9 And the effort to make it more precise is --
10 MS. CUBBAGE: It's the balance between
11 prevention and mitigation.
12 MEMBER KRESS: These are design basis
13 accidents, and that's what they are for -- to develop
14 the design. They don't have anything to do with
15 reality.
16 MEMBER BANERJEE: It's the wrong
17 discussion.
18 MR. WALLIS: Well, I am just protesting.
19 CHAIRMAN CORRADINI: Once again.
20 MR. WALLIS: I guess I have to be quiet,
21 but I am really mystified by what you're doing.
22 MR. KIRSTEIN: I think you have a
23 potential helper. I like what I'm hearing.
24 (Laughter.)
25 The resulting doses that we've calculated

1 for design basis accidents meet the criteria of -- the
2 regulatory criteria of 10 CFR 50.34A and GDC-19 for
3 the control room operators. And as we've pointed out
4 -- well, in dose space, we do deal with a lot of
5 conservatism, and what we've done to add a level of
6 conservatism is; all of the accidents, with the
7 exception of the LOCA, we conservatively assumed no
8 credit of the control room emergency --
9 MR. WALLIS: Why don't you call them IEs?
10 Then, you might be able to reduce this?
11 (Laughter.)
12 MR. KIRSTEIN: But, yes, we assume no
13 credit for emergency charcoal filtration for all of
14 the accidents, with the exception of the LOCA.
15 For a little bit more detailed discussion
16 of the accident scenario that we considered in the
17 LOCA, I'd like to turn it back over to Wayne Marquino.
18 MR. MARQUINO: The ESBWR containment
19 system removes some fission products in a LOCA event.
20 They would plate out on containment structures, the
21 walls of the containment. Some would be transported
22 into the PCC, because there's a flow through that from
23 the steam generated by the core, and be removed in the
24 condensate of the PCC.
25 To quantify that, we used the MELCOR code

1 to calculate a fission product removal coefficient,
2 and we investigated a range of scenarios with
3 different thermodynamic conditions, because those
4 conditions affect the removal and the release -- the
5 conditions relative to when the release occurs affects
6 the removal and the overall effect.
7 The specific scenarios we looked at
8 included low pressure core failure LOCA, specifically
9 a bottom drainline LOCA, with failure of the IC, SLCS,
10 GDCS, and we assumed the ADS system worked. So we
11 have a leak at the bottom of the vessel. The ADS
12 system functions and depressurizes the vessel, but
13 then no other water comes in, and eventually we get
14 core damage.
15 Consistent with the alternate source
16 term --
17 MEMBER BANERJEE: So the equalization line
18 doesn't work here?
19 MR. MARQUINO: Right, right.
20 MR. WALLIS: So there is real core damage,
21 then.
22 MR. MARQUINO: Right, right. So we --
23 MEMBER SIEBER: Sooner or later it doesn't
24 work.
25 MR. MARQUINO: So we assume multiple

1 multiple failures to the --

2 MEMBER BANERJEE: Why do you presume so

3 many failures? Is there a reason for it?

4 MR. MARQUINO: Because, consistent with

5 the alternate source term methodology, which --

6 MR. WALLIS: You keep assuming failures

7 until you get a source. That's again ludicrous, isn't

8 it?

9 MR. MARQUINO: So this --

10 MR. WALLIS: You might as well just assume

11 the source and forget about what the accident is,

12 right?

13 MEMBER BANERJEE: So let me understand.

14 The GDCS fails, the equalization line doesn't open,

15 and you have a bottom drainline failure or something

16 like that.

17 MR. MARQUINO: Bottom drainline break,

18 yes.

19 MEMBER BANERJEE: Break, okay. So this is

20 the scenario.

21 MR. MARQUINO: Yes.

22 CHAIRMAN CORRADINI: But something

23 eventually works.

24 MR. MARQUINO: Yes. The alternate --

25 CHAIRMAN CORRADINI: Or else we go into

1 another regime.

2 MR. MARQUINO: Yes. So where we draw the

3 line between this evaluation and the PRA with, you

4 know, failure, core on the floor, is we recover core

5 cooling just before the bottom head failed. So we ran

6 the MELCOR code until it predicted the bottom head

7 failed, and then we ran it again and turned the ECCS

8 systems on just before that.

9 MEMBER BANERJEE: So what is the scenario

10 now? What starts to work at this point?

11 MR. MARQUINO: Then, we turn everything

12 on.

13 MR. WALLIS: Well, why does that work?

14 Everything else didn't work. Why does this suddenly

15 work?

16 CHAIRMAN CORRADINI: I think they're

17 developing a stylized scenario to test their fission

18 product removal system in containment.

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

20 CHAIRMAN CORRADINI: It's not supposed to

21 be --

22 MR. WALLIS: There's nothing realistic

23 about it, whatsoever.

24 CHAIRMAN CORRADINI: That's the impression

25 I get.

1 DR. WHITE: We are causing it to fail.

2 CHAIRMAN CORRADINI: Staff seems to be

3 okay with that interpretation.

4 MEMBER BANERJEE: But there is no physical

5 mechanism. I mean, you are doing this to get the

6 timings, right? I mean, you are going through this

7 scenario to get the timings. So to get realistic

8 timings, but then is that a realistic scenario when

9 things come back on due to something happening or --

10 MR. MARQUINO: Well, I'd say operator

11 action would be --

12 MEMBER BANERJEE: Okay.

13 MR. MARQUINO: -- the thing that -- you

14 know, that would make this like a -- I'm not a PRA

15 expert, but, you know, let's say this -- this is

16 probably like a 10^{-7} event.

17 MEMBER BANERJEE: Well, yes, forget it.

18 I mean, you are going through this at a stylized

19 scenario, so it has to be a stylized scenario as to

20 how the cooling comes back on.

21 MR. MARQUINO: Yes.

22 MEMBER BANERJEE: So operator action

23 brings it back on --

24 MR. MARQUINO: Yes.

25 MEMBER BANERJEE: -- in some ways.

1 MR. MARQUINO: Yes.

2 MEMBER BANERJEE: And how many hours do

3 you have for that?

4 MR. MARQUINO: Well, that -- again, there

5 is not -- it's not that we investigated, well, if this

6 happened, how long will it take the operator to act?

7 Because the --

8 MEMBER BANERJEE: Well, let's say how many

9 hours before the bottom of the vessel starts to fail.

10 How many hours is that?

11 MR. MARQUINO: We're talking like two

12 hours, three hours.

13 MEMBER BLEY: We're asking questions that

14 make this sound like a real scenario, and my

15 impression is --

16 CHAIRMAN CORRADINI: It's not.

17 MEMBER BLEY: -- you're turning switches

18 to get the source term you want.

19 CHAIRMAN CORRADINI: Right.

20 MEMBER BLEY: You would be better off not

21 to say everything you did, just said we dummied up the

22 source term.

23 MEMBER BANERJEE: No, because they want

24 the timing.

25 MEMBER SIEBER: They actually have to do

1 it, though, because you have to make sure you didn't
2 miss one that's more severe.
3 MR. WALLIS: Well, I'm very puzzled
4 because I looked -- I thought in Chapter 15, I was
5 going to see analysis of accidents.
6 CHAIRMAN CORRADINI: That was in
7 Chapter 6.
8 MR. WALLIS: Well, so -- I know I saw it
9 in Chapter 6, too. But Chapter 15 seems to be in a
10 different world all together.
11 CHAIRMAN CORRADINI: Well, but I think
12 that's a function of the system is that they said that
13 it's not uncovered, so that they still have to go
14 through and show that all of their various systems are
15 designed with some limit. So in some sense, they are
16 developing --
17 MR. WALLIS: They don't protest at that
18 when --
19 MEMBER BANERJEE: Defense in depth.
20 CHAIRMAN CORRADINI: I don't think the
21 staff would listen to the protestations for very long.
22 That's what I --
23 MR. MARQUINO: We did -- we had some good
24 interactions with the staff, you know, from -- we
25 submitted our Rev 0 in August, and I think in

1 September or October we had a phone call from Jay Lee,
2 and we started discussing this, and we had meetings
3 with them.
4 So we've gone through all of the
5 regulations with them, and in order to have a
6 challenge to the containment, the containment is
7 supposed to contain radioactivity in the event, okay?
8 It's leak-tight, and we have passive removal
9 mechanisms here. We don't have a standby gas
10 treatment system. So this is how we demonstrate that
11 everything is going to be okay in our containment,
12 even if --
13 MR. WALLIS: That makes a lot of sense, if
14 it's defense in depth that you're talking about. But
15 don't call it a LOCA analysis, and don't call it an
16 analysis of an accident.
17 MEMBER BANERJEE: No. They are calling it
18 containment fission product removal system.
19 MR. MARQUINO: Yes. I think what we need
20 to clean up or clarify is that the design basis LOCA
21 doesn't produce any fuel failures, but in spite of
22 that this is what we do for the dose analysis, and
23 it's conservative. We have a few words like that in
24 Chapter 15, but we should probably make it clear.
25 CHAIRMAN CORRADINI: That might be good.

1 MR. SHUAIBI: I guess in terms of the
2 regulatory structure and how we deal with these kinds
3 of things, we can take a shot at that when we're up at
4 the table.
5 CHAIRMAN CORRADINI: Okay.
6 MR. SHUAIBI: We'll try to explain why it
7 is that we do things that go beyond where we think the
8 Chapter 15 and how the AOOs and the accidents take
9 you. It is defense in depth, but we'll take a shot at
10 trying to explain them.
11 CHAIRMAN CORRADINI: Move ahead.
12 MR. MARQUINO: Okay. So we have these
13 three different scenarios to look at how the passive
14 fission product removal works under different
15 conditions. We have significant core damage in all of
16 the scenarios, as I said, and we recover ECCS just
17 before the lower head fails.
18 MEMBER BANERJEE: I guess what Graham was
19 concerned about, and in a way we are, is when we first
20 saw this, you know, concept, we had the impression
21 this was going to be a lot safer than anything we have
22 seen.
23 There is nothing going to happen at LOCA,
24 the core is never going to uncover, and all of these
25 advantages that we are really very far from dryout

1 limits, and there are very few things that will give
2 us problems, the passive system was working fine. We
3 didn't need -- we needed blowers, and all this sort of
4 stuff.
5 Now, when you tell the story this way,
6 that doesn't come out, that this system is way beyond
7 what we've seen in terms of its safety implications,
8 because nothing happens during a LOCA.
9 MR. MARQUINO: I agree with that. I'm
10 kind of frustrated that we don't have the opportunity
11 to present a more nominal evaluation.
12 CHAIRMAN CORRADINI: Well, you haven't
13 shown us the PRA yet, so don't worry. You'll have
14 your chance.
15 (Laughter.)
16 MEMBER BANERJEE: You know, PRA is okay,
17 but what you really want to say is, nothing happens
18 during a loss of coolant accident.
19 MEMBER MAYNARD: Chapter 15 is more about
20 evaluating, I guess, the regulatory requirements and
21 meeting the regulatory requirements is a safety
22 analysis of, this is what we really expect to happen.
23 It's to show the conservative in meeting the bounding
24 analysis, meeting the regulatory requirements on what
25 have to be assumed.

1 CHAIRMAN CORRADINI: Right.

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

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

8 MEMBER SIEBER: It's not a realistic
9 analysis.

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

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

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

1 CHAIRMAN CORRADINI: You must have read my
2 e-mail.
3 MR. MARQUINO: I guess, if I may, one
4 thing --
5 MEMBER BANERJEE: Well, I think it does a
6 disservice to the concept. And it doesn't come across
7 as being --
8 CHAIRMAN CORRADINI: But I think Mr.
9 Marquino's point, and I think we've got to move on, is
10 that perhaps they can rewrite how the DCD is
11 presented, but I do think, by regulation, they must
12 show this -- that they are bounded on the regulation.
13 MEMBER SIEBER: Then, it has got to be
14 written in a legal different way to show that.
15 MR. KRESS: And regulations specify that
16 you can use this source term, alternative source term,
17 in your analyses or not, if you can justify another
18 source term. It is so hard for most plants to justify
19 a different source term. It's easier just to go ahead
20 and use it and show that you meet these stylistic
21 accident conditions, which are in the regulation. You
22 have to meet the regulations. That's the rule.
23 MR. WALLIS: It's like saying a patient
24 goes in the emergency room, you've got to treat cancer
25 whether the patient has cancer or not.

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

2 MEMBER MAYNARD: I don't think that's a

3 good analogy, because that may be if you're trying to

4 qualify whether the hospital is capable of treating

5 cancer or not, but it's not getting to the patient.

6 I think this is important but not -- not for the

7 ESBWR. I mean, we're talking about changing

8 regulations, and they are talking about complying with

9 the current regulations. I think we need to --

10 MR. KRESS: We would have gotten rid of

11 all of this if we would have got our version of the

12 technology nuclear --

13 (Laughter.)

14 CHAIRMAN CORRADINI: Let's go on.

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

16 MEMBER BANERJEE: Well, at least it should

17 be presented as a defense in depth argument.

18 MR. KRESS: It's meeting the regulations

19 as they are written.

20 CHAIRMAN CORRADINI: So can we -- I think

21 we've got to let the -- our colleagues from GEH move

22 on.

23 MR. MARQUINO: Okay. Before I leave this

24 slide, I just -- because the staff is going to talk

25 about this, I want to briefly mention scenarios 2 and

1 3. Scenario 2 is a high pressure core failure LOCA.
2 Again, it's a bottom drainline break failure of the --
3 of all of the systems, including ADS, so the vessel
4 doesn't depressurize. It's got a hole in the bottom.
5 It's squirting the coolant out. The core uncovers.
6 The core failure is at a higher pressure, and, again,
7 then we recover the ECCS systems, depressurize, and
8 let the systems flood the core.
9 Scenario 3 is no LOCA, no break, no high
10 pressure systems, loss of AC power and feedwater, IC,
11 SLCS, and ADS. And, again, we let the accident
12 progress until just before bottom head failure, and
13 then we allow the systems to function and reflood the
14 core.
15 Okay. Now, Mr. Kirstein is going to cover
16 the pH evaluation.
17 MR. KIRSTEIN: Yes, one quick slide. We
18 considered the pH in containment pools, formation of
19 acids. We credited SLCS injection for buffering to
20 keep the pH up. A couple of contributors to decrease
21 -- to the pH analysis were the degradation of cable
22 due to radiolytic conditions of containment, and also
23 production of nitric acid, among others.
24 And the evaluation of pH in containment
25 pools, we intend on revising that for DCD, Revision 5.

1 MR. KRESS: Any effect of the fission
2 products?
3 MR. KIRSTEIN: I'm sorry?
4 MR. KRESS: No, no, not radiation, just
5 the effects of the fission products themselves. A lot
6 of them are --
7 MEMBER SIEBER: They're chemicals.
8 MR. KRESS: Yes.
9 MEMBER BLEY: What is leading you to
10 revise it, by the way?
11 MR. KIRSTEIN: I'm sorry?
12 MEMBER BLEY: What is leading you to
13 revise it in the next DCD? Is there specific chemical
14 reactions or something you're accounting for you
15 didn't before?
16 MR. KIRSTEIN: I believe one change we do
17 have to make, and it's not necessarily a pH
18 consideration, I believe the NUREG-1465, the alternate
19 source term, also forces us to enter the alternate
20 source -- the source term into the suppression pool in
21 conjunction to containment. And we didn't do that for
22 the prior revision.
23 MR. MARQUINO: Yes. And, frankly, there
24 is an error in our analysis, and we didn't consider
25 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.

1 MR. KIRSTEIN: Yes.

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

6 MR. WALLIS: And the pH.

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

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

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

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

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

24 MR. WALLIS: It's another one of the
25 things you're forced to assume, or is this a realistic

1 thing, or what is that?

2 MR. MARQUINO: The rod withdrawal?

3 MR. WALLIS: Yes, during startup or during

4 refueling. You are supposed -- it's not a very good

5 thing to do, withdraw rods during --

6 MR. MARQUINO: No, it's not.

7 MR. WALLIS: Something you have to assume,

8 or what is that?

9 MR. MARQUINO: Well, no, it's -- we are

10 using a probability treatment on it, and it's an

11 infrequent event. We've had some staff questions

12 about what happened at the Japanese plants, and we see

13 two differences. One is their procedure compliance --

14 MR. WALLIS: So this is another defense in

15 depth thing. It might happen; that's why you have to

16 see what the consequences are.

17 MEMBER BANERJEE: Well, it has happened.

18 It has a slip problem, yes. Several times.

19 MR. WALLIS: So we don't need to worry

20 about how likely it is. We just need to say that

21 you've analyzed it and you find that this -- you meet

22 the TEDE requirements, is that it?

23 MR. MARQUINO: Yes.

24 MR. WALLIS: We don't need to discuss the

25 probabilities of it at all. No? All right. Fine.

1 MR. KRESS: Do you lower the water level
2 in the core to deal with the ATWS?
3 MR. MARQUINO: Yes. Yes.
4 MR. KRESS: And do you need that when the
5 SLC operates, or the SLC shuts it all down?
6 MR. MARQUINO: Well, we -- the SLC could
7 bring the reactors subcritical with the water level up
8 high. It's much more effective with the water level
9 low and that's factored into, say, the pool
10 temperature here.
11 MEMBER BANERJEE: What do you mean by
12 SLCS-bounding? I guess, Mohammed, you explained this
13 to us, right?
14 DR. ALAMGIR: I haven't gotten to that
15 slide yet, but --
16 (Laughter.)
17 MEMBER ARMIJO: You probably will never
18 get there.
19 DR. ALAMGIR: The specific line you are
20 looking at?
21 MEMBER BANERJEE: Just the title.
22 DR. ALAMGIR: This is a limiting event.
23 MR. WALLIS: You'll have to speak to the
24 mic.
25 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.

1 There are other additional bounding inputs
2 that we have considered in the calculation. For
3 example, feedwater enthalpy has been increased to 105
4 percent. So we have pushed the limit for these MSIV
5 closure transients.
6 MR. WALLIS: Do you know how to analyze
7 the mixing of the boron with the other water?
8 MEMBER BANERJEE: He is going to tell us.
9 DR. ALAMGIR: I am going to show you a --
10 we have --
11 MEMBER BANERJEE: I'm sorry.
12 MR. WALLIS: You're going to show us.
13 Okay.
14 DR. ALAMGIR: We have a TRAC analysis
15 where we do a conservative calculation in order to
16 define what conservative is.
17 MR. WALLIS: Okay. Thank you.
18 DR. ALAMGIR: And then, we back it up by
19 showing a realistic analysis.
20 MR. WALLIS: So you are bounding
21 assumptions about the SLC mixing, as well.
22 DR. ALAMGIR: That's correct.
23 MR. WALLIS: Okay.
24 MEMBER MAYNARD: I believe the staff has
25 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.

1 MEMBER ABDEL-KHALIK: I know this is the
2 result for this particular transient, but which
3 transient gives you the highest suppression pool
4 temperature?
5 DR. ALAMGIR: This is the one.
6 MEMBER ABDEL-KHALIK: This is the one that
7 gives you the highest suppression pool temperature?
8 DR. ALAMGIR: It has more power.
9 MEMBER ABDEL-KHALIK: Now, at 163 degrees,
10 the partial pressure of steam is 5 psi. And if I look
11 at the transient that was presented yesterday, the
12 highest pressure in the containment was about 53 psi.
13 So that means the partial pressure of non-condensables
14 is about 50 psi. Does that make sense?
15 MR. WALLIS: That makes sense.
16 DR. ALAMGIR: You saw the LOCA results
17 yesterday?
18 MEMBER ABDEL-KHALIK: We saw the steam
19 line break, yes.
20 DR. ALAMGIR: Okay. This is an ATWS
21 simulation where we do -- do calculate the total
22 pressure in the containment, and it is below 45 psig,
23 the design.
24 MR. WALLIS: Where does it come from?
25 MR. MARQUINO: I am not clear on the

1 question. Are you asking about the LOCA containment
2 pressure, or the ATWS containment pressure?
3 MEMBER ABDEL-KHALIK: I was trying to find
4 out where we stand with this transient, so he told me
5 first that this transient produces the highest
6 containment temperature.
7 DR. ALAMGIR: In ATWS.
8 MEMBER ABDEL-KHALIK: In ATWS, okay.
9 MEMBER MAYNARD: For special events.
10 MEMBER ABDEL-KHALIK: All right. So let's
11 focus on those. You're telling me that for this
12 particular transient the total containment pressure
13 was 45 psi. Is that correct?
14 DR. ALAMGIR: That's the design limit.
15 It's below that. The numbers are below that.
16 MR. WALLIS: Well below that.
17 MEMBER BANERJEE: So what was the -- what
18 was the maximum containment pressure?
19 DR. ALAMGIR: Can you please look up? I
20 don't --
21 MR. WALLIS: You don't have it?
22 DR. ALAMGIR: We'll be able to provide it.
23 You have it on -- it's in the DCD as well. It's one
24 of the key output parameters.
25 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

1 pool through the SRVs. That heats the COLA, and
2 purging the drywell of non-condensables through the
3 SRV flow. So some of the SRVs discharge into the
4 drywell, and the steam flow will bring non-
5 condensables into the wet well air space. So we've
6 got a warm pool and compressed low air space.
7 But you -- you know, we avoid SRV opening
8 in ESBWR, so --
9 MR. WALLIS: Well, I think what happens is
10 that the non-condensables are in the wet well, and so
11 they get compressed in there. So that's how you get
12 the high pressure.
13 MEMBER ABDEL-KHALIK: Well, that's what
14 I'm trying to figure out, whether the --
15 MR. WALLIS: The drywell is full of steam,
16 right? That's the way you get a high pressure.
17 DR. ALAMGIR: We've put conservative
18 assumptions. We assume all of the non-condensables is
19 in the wet well.
20 MR. WALLIS: That's right, so it's the --
21 that's why they get -- that's how the pressure gets so
22 big. All of the non-condensables is going to the wet
23 well. It's a much smaller volume than they started
24 at, so they are compressed.
25 MEMBER BANERJEE: You probably just make

1 a conservative assumption there.

2 DR. ALAMGIR: In addition to not allowing

3 the pool to mix.

4 MEMBER BANERJEE: Not allowing the pool to

5 mix?

6 DR. ALAMGIR: I mean, the SRV. I'm sorry,

7 the suppression pool, after the SRV discharge, we

8 don't let it mix.

9 MR. MARQUINO: But that -- but for ATWS,

10 we mix the pool.

11 MEMBER BANERJEE: Yes, you must.

12 DR. ALAMGIR: I mean, there is no active

13 system or anything like that.

14 MEMBER BANERJEE: No, but --

15 DR. ALAMGIR: Natural separation, natural

16 convection, whatever you call it.

17 MEMBER BANERJEE: I am puzzled by this

18 now. If you are only getting a 5 psi pressurized, due

19 to the saturation, is that a mixed pool temperature,

20 or is it the pool surface temperature that --

21 MR. MARQUINO: We go up to --

22 MEMBER BANERJEE: Go back to the previous

23 slide.

24 MR. MARQUINO: No. We go up to 29.9, so

25 we're increasing the pressure about 15 psi, and the

1 split is, like, 5 due to the saturation pressure
2 increase and 10 due to the compression.
3 MEMBER BANERJEE: But that's assuming a
4 well mixed pool, isn't it?
5 MR. MARQUINO: It is, yes.
6 MEMBER BANERJEE: That's what I thought.
7 Otherwise it's too small.
8 MR. MARQUINO: Yes. The reason we have
9 concerns about stratification in the LOCA is --
10 MEMBER BANERJEE: It's a different
11 problem.
12 MR. MARQUINO: -- it's coming in in point
13 -- like three-quarters of a meter within the surface
14 in the long term. In this ATWS, it is discharging
15 either through the vents or through SRVs, and it's
16 coming in lower in the pool.
17 MEMBER BANERJEE: Right. So it should mix
18 up the pool.
19 MR. MARQUINO: Yes.
20 DR. ALAMGIR: There is no active mechanism
21 that --
22 MEMBER BANERJEE: But that's sufficient.
23 DR. ALAMGIR: Yes, that's sufficient.
24 Thanks for clarifying, Wayne.
25 All right. Now I'll transition to the CFD

1 analysis, but before that let me mention why we
2 consider TRAC analysis for the same MSIV ATWS
3 transient as bounding.
4 In the TRAC calculation, if we -- can you
5 please put up Figure 4.1.1 from DCD? We will first
6 show a format, and then show how the TRACG analysis
7 has been configured to make it bounding for boron
8 mixing.
9 MR. WALLIS: Well, how does TRAC make it
10 subcritical, if it doesn't let anything in?
11 DR. ALAMGIR: Well, there is a -- I will
12 just show you that. In general, let me just try it
13 this way -- that if you consider the core shroud as
14 the outer circle, then from the center line of the
15 core to the core shroud we divide it into three
16 segments, three rings, with proportionately an equal
17 number of bundles.
18 We block -- SLCS comes -- boron comes in
19 in outer ring. We block the outer ring all the way,
20 except near the core plate where there are leakage
21 holes into the bundle, so it can flow down in the
22 peripheral bypass and then go into the fuel bundle,
23 but not directly into the center of the core radially.
24 That's what we define as conservatism in TRAC. We do
25 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

1 that up, we have two SLCS systems. They come in from
2 opposite azimuths to the vessel. They go into the
3 shroud, and then branch, split and branch, so that at
4 four locations, 90 degrees apart, we have a vertical
5 pipe in the peripheral bypass area. The peripheral
6 bypass is the space between the outermost fuel bundle
7 and the core shroud, and then we also distributed
8 axially, so at four locations on that vertical pipe
9 there is a nozzle that injects the boron tangentially
10 to the shroud. And we'll show you some CFD --
11 MEMBER ARMIJO: Well, you've got 16 points
12 of entry for boron --
13 MR. MARQUINO: Yes.
14 MEMBER ARMIJO: -- the way you describe
15 it.
16 MR. MARQUINO: Yes.
17 MEMBER BANERJEE: And tangentially, not
18 radially.
19 MR. WALLIS: It's injected into the
20 downcomer, isn't it? Or does it go --
21 MR. MARQUINO: It's in between the bypass.
22 MR. WALLIS: But shouldn't it be injected
23 into the core, not into the bypass?
24 DR. ALAMGIR: Here is how it works. There
25 are two pipes that come in, penetrate the core shroud.

1 MR. WALLIS: Right.

2 DR. ALAMGIR: Then, each pipe becomes a

3 semi-circle or a sparger.

4 MR. WALLIS: In the bypass.

5 DR. ALAMGIR: Inside the bypass, just

6 inside the bypass.

7 MR. WALLIS: How does it get from the

8 bypass to where it does some good?

9 DR. ALAMGIR: That's what we'll show.

10 Then, at the end of this semi-circle are injectors,

11 and there are four elevations at which --

12 MR. WALLIS: But it has to get down, and

13 then up, and into the fuel somehow.

14 MR. MARQUINO: That's right. So to

15 understand why we do that, the BWR ATWS emergency

16 procedures direct the operator to lower water level,

17 and we actually have an automatic feedwater run-back

18 in ESBWR to do that.

19 MR. WALLIS: Yes.

20 MR. MARQUINO: So during the -- at the

21 time the boron injects, the water level is low, and

22 we've stopped circulation from the downcomer into the

23 core. So if we inject it into the downcomer, the

24 boron wouldn't get in.

25 MR. WALLIS: Oh, okay.

1 MR. MARQUINO: So we considered that this
2 location -- and what we've done, then, is set up an
3 internal natural circulation loop between the bypass
4 and the fuel channels. There's holes at the bottom of
5 the fuel bundles that let flow come in from the
6 bypass. So that's why our design is the way it is.
7 MR. WALLIS: But it relies on some
8 internal mixing inside the core to somehow get that --
9 MR. MARQUINO: Yes.
10 MR. WALLIS: -- stuff from the outside
11 into the middle.
12 MR. MARQUINO: Right. Right.
13 MEMBER BANERJEE: You don't directly
14 inject it into the core in any way. It just comes
15 into the bypass.
16 DR. ALAMGIR: The peripheral bypass.
17 MR. MARQUINO: Yes.
18 MEMBER BANERJEE: Peripheral bypass.
19 DR. ALAMGIR: Yes.
20 MR. WALLIS: It might be better to spray
21 it in the top.
22 MR. MARQUINO: Well, the BWR 5 and 6
23 plants have a high pressure core spray over the upper
24 plenum, and they inject the boron there. But,
25 again --

1 MEMBER BANERJEE: You've got chimneys now,
2 right?
3 MR. MARQUINO: We have chimneys. We don't
4 have that sparger. And, additionally, when you spray
5 it there, because the flow is coming out of the core,
6 it is going to -- some if it is going to get pushed
7 out and go down anyway. So that's why we have the
8 design --
9 MR. WALLIS: Have you got boiling going on
10 during all of this process?
11 MR. MARQUINO: Yes.
12 MR. WALLIS: So CFD isn't going to do you
13 much good.
14 MR. MARQUINO: No, it's single phase in
15 the bypass region.
16 MR. WALLIS: Okay, in the bypass.
17 MEMBER BANERJEE: There is no boiling in
18 the bypass?
19 MR. MARQUINO: No.
20 MEMBER BANERJEE: In these conditions?
21 MR. MARQUINO: No.
22 MR. WALLIS: Okay. Well, I guess we can
23 -- this is a subject to investigate.
24 MEMBER BANERJEE: Okay. So can you show
25 us -- you don't have a little diagram of this

1 injection system anywhere?

2 MEMBER SIEBER: There is a schematic of

3 it.

4 DR. ALAMGIR: I think we went into --

5 MEMBER BANERJEE: He is talking about a

6 sparger with a nozzle at the end. I mean, it is quite

7 a complicated-sounding system.

8 MR. MARQUINO: We can get it up. I've got

9 it on my computer. Is Jerry here? Because I --

10 MEMBER BANERJEE: Well, you can do it

11 later.

12 MR. MARQUINO: We can do it another time,

13 if need be. After a break, we'll get something up.

14 MEMBER BANERJEE: All right.

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

16 CHAIRMAN CORRADINI: Switch back to

17 your --

18 MEMBER ARMIJO: That's a torturous path,

19 to go through all of those gaps.

20 MEMBER BANERJEE: Yes. The only thing is

21 that we'd like to see the layout to understand how

22 realistic a CFD calculation might be, or how realistic

23 even TRAC's assumptions might be.

24 MR. MARQUINO: Okay. Do you --

25 MEMBER BANERJEE: To understand the

1 geometry of these events.

2 MR. MARQUINO: Do you want to --

3 MEMBER BANERJEE: Later.

4 MR. MARQUINO: -- take a break or let us

5 like flip computers or something?

6 MEMBER BANERJEE: No. I think --

7 CHAIRMAN CORRADINI: We want you to finish

8 by 10:10.

9 (Laughter.)

10 MEMBER BANERJEE: Give us the results

11 right now, and then we'll discuss the realism of the

12 results later. So let's see the bottom line first.

13 CHAIRMAN CORRADINI: Can we go back to

14 your presentation?

15 DR. ALAMGIR: I was going to say, if you

16 are going to show the geometry, then we don't need it.

17 I was going to say where the jets are and --

18 MEMBER BANERJEE: Yes. Why don't you show

19 us where the jets are. That's fine.

20 DR. ALAMGIR: So if you imagine a circle

21 circumscribing this core, that will be the core

22 shroud. The pipe that brings the SLCS fluid is the

23 point over here. Comes in through this non-uniform

24 area, so it would come in here, one pipe, branch out

25 into --

1 MR. WALLIS: It goes through the core
2 shroud, then.
3 DR. ALAMGIR: I'm sorry?
4 MR. WALLIS: It does go through the core
5 shroud.
6 DR. ALAMGIR: Yes. And then, there are
7 two pipes. One coming in from this side, the other
8 coming from the opposite side.
9 MR. WALLIS: And that's how it's diffused
10 through the core?
11 DR. ALAMGIR: I will show you where the
12 injectors are first, and then -- then, it branches out
13 into a sparger, which is a semi-circle, a sparger. It
14 ends up -- one end of the sparger ends up in -- along
15 these flaps, just like that, and the other end
16 vertical along that flap. And so there is a
17 corresponding pair.
18 This sparger then ends up with a nozzle
19 that has two injectors.
20 MR. WALLIS: Which points inwards.
21 DR. ALAMGIR: Which then they are at a
22 slightly -- in an angle more, so they don't inject
23 normally, don't inject slightly in an angular fashion.
24 Two sets of injectors right along these flaps.
25 MR. WALLIS: The ideal that it penetrates

1 through there or not?

2 DR. ALAMGIR: Through the spaces. I guess

3 to be able to spray or inject in this region, and then

4 hopefully it will get through these, and it does.

5 MR. WALLIS: Hopefully?

6 DR. ALAMGIR: And it does.

7 MR. WALLIS: Hopefully?

8 DR. ALAMGIR: Yes.

9 (Laughter.)

10 You always hope for the best, and then

11 you --

12 (Laughter.)

13 CHAIRMAN CORRADINI: Prepare for the

14 worst, hope for the best.

15 MEMBER BANERJEE: The spargers themselves,

16 of course, have holes in them, right?

17 DR. ALAMGIR: The spargers are -- they

18 don't have holes, but they end up with --

19 MEMBER BANERJEE: Why do you call them

20 spargers, if there are no holes?

21 CHAIRMAN CORRADINI: It's the header.

22 DR. ALAMGIR: It's the header.

23 MEMBER BANERJEE: Okay. Terminology. I

24 thought the thing had little holes and then two

25 nozzles, so now it's just a header.

1 DR. ALAMGIR: Header with nozzles at the
2 end.
3 MEMBER BANERJEE: At the end, okay.
4 DR. ALAMGIR: And there are four such
5 elevations, so four such headers. The top-most one is
6 at the middle of the bypass, height-wise, elevation-
7 wise.
8 MEMBER BANERJEE: Okay.
9 DR. ALAMGIR: So we end up with 32 holes.
10 MEMBER ARMIJO: So the issue is migration
11 of that boron through the gaps between the bundles.
12 DR. ALAMGIR: Correct.
13 MEMBER BANERJEE: Well, it is -- also, it
14 goes down the bypass and comes up from the bottom,
15 right?
16 DR. ALAMGIR: It can do -- realistically,
17 it can do both.
18 MEMBER BANERJEE: Yes.
19 DR. ALAMGIR: Go down as well as migrate.
20 MR. WALLIS: And what's happening? Is it
21 that it's boiling in the core, or at some level -- up
22 to some level?
23 DR. ALAMGIR: A single phase.
24 MR. WALLIS: It's all single phase?
25 DR. ALAMGIR: In the bypass. But --

1 MR. WALLIS: No, in the core. It's got to
2 get into the core, so it's got to go into a boiling
3 region of some sort.
4 DR. ALAMGIR: Correct.
5 MEMBER BANERJEE: Can you show us the
6 geometry of the system that is feeding the bottom?
7 What does it look like, or describe it to us?
8 DR. ALAMGIR: Yes.
9 MEMBER BANERJEE: From the bypass to the
10 core inlet.
11 MR. MARQUINO: I think the best thing is
12 for us to get through the slides. We have a movie,
13 and then, if we can get this material together that
14 you're asking for and show you.
15 MR. WALLIS: Maybe another day. We have
16 to investigate this.
17 MR. MARQUINO: Yes. Well --
18 CHAIRMAN CORRADINI: I think you should
19 finish up, because you guys want to show a video of
20 the -- of a simulation, is that correct?
21 DR. ALAMGIR: A slide first, and then
22 two --
23 MEMBER BANERJEE: But just in words, can
24 you just describe how it's coming in?
25 CHAIRMAN CORRADINI: Let's do it in words

1 later. Let's move on. I really think we've got to
2 finish.
3 DR. ALAMGIR: Realistically, or in TRAC
4 conservative analysis? Which one?
5 MR. WALLIS: Realistically.
6 DR. ALAMGIR: Realistically, what I would
7 expect. And I have seen the animation, and that's how
8 it looks like. Convection is the dominant mode, not
9 diffusion. Let me clarify that.
10 MR. WALLIS: Okay. Diffusion would take
11 forever.
12 DR. ALAMGIR: Any cooling for diffusion
13 for TRAC, I know it takes forever, yes.
14 You would expect that more of it will go
15 down readily because of -- it's heavier, and then
16 spread out to the core plate, across the core plate,
17 and then find the holes in the lower part of the
18 bundles.
19 It will also fall down like a jet, try to
20 find the spaces convenient to it, and eventually reach
21 towards the center line, affecting the bundle.
22 Now, boron negative reactivity, whether
23 it's inside the bypass or inside the core, is --
24 doesn't really matter. But if it goes really inside
25 the core, its effect is right away. So what we will

1 see is the CFD analysis for boron is only for the
2 spaces external to the channels boxes.
3 We also show how it is ingested into the
4 channels. That is the scenario --
5 MEMBER ARMIJO: In this analysis, the
6 boron doesn't get inside the channel. There is no way
7 that the boron can get in, or --
8 DR. ALAMGIR: We are showing how it --
9 MEMBER BANERJEE: It can from the bottom.
10 DR. ALAMGIR: Yes. We are showing how it
11 reaches the leakage holes, and how much of elemental
12 boron is ingested into the bottom. But not what
13 happens when it goes inside.
14 MR. WALLIS: In fact, the control rods
15 aren't there, most of -- it helps it to get in, is it?
16 DR. ALAMGIR: The case we analyzed with
17 all rods out. Also, we analyzed the sensitivity case
18 where all rods are in for a particular --
19 MEMBER BLEY: Some rods are in.
20 MR. WALLIS: I think they blocked the flow
21 passage.
22 DR. ALAMGIR: Because some rods were in,
23 and then -- but not --
24 CHAIRMAN CORRADINI: So can we move on
25 with the presentation?

1 DR. ALAMGIR: Yes. We will go to the
2 slide that has two red curves, please, in the
3 presentation.
4 MS. CUBBAGE: All right, all right, all
5 right.
6 MR. WALLIS: I think we're spending time
7 on this because it's a realistic case where something
8 bad might really happen.
9 MEMBER BANERJEE: Unlike the other
10 scenarios we have seen.
11 DR. ALAMGIR: Okay. Let me clarify a
12 couple of things. One is that we are just bringing
13 your recollection. The case I just made, the TRAC --
14 in TRAC analysis, the outermost ring is solid. I
15 mean, the -- not the outermost, the second ring is
16 solid. That means it cannot penetrate radially into
17 the bypass. It has to go down and come up.
18 Therefore, here what we are showing is the
19 red curves are CFD analysis, the black curve is TRAC,
20 and we are showing mass of boron first in the bypass
21 as a function of time. And 185 seconds is
22 approximately the time, or 190 seconds, when the SLCS
23 system is turned on.
24 We are seeing that in CFD analysis the
25 mass is much more than in TRAC, because in TRAC, we

1 don't allow it to migrate radially.

2 MR. WALLIS: What does this do to

3 criticality? Can you show that on the map, too?

4 DR. ALAMGIR: That is in DCD.

5 MR. WALLIS: Oh, it's in the DCD. But

6 that's what really matters, isn't it?

7 DR. ALAMGIR: Yes, we have enough negative

8 reactivity insertion, so --

9 CHAIRMAN CORRADINI: They are just showing

10 -- the way I view it is you are showing the bounding

11 analysis of TRAC shows reactivity insertion. Reality

12 is probably much better.

13 DR. ALAMGIR: Right. We are showing a

14 delayed and less --

15 MR. WALLIS: TRAC does almost nothing.

16 MEMBER MAYNARD: Yes, I wouldn't even use

17 it.

18 MR. WALLIS: TRAC makes it go down and

19 come up again.

20 DR. ALAMGIR: Go down and then approach

21 the leakage holes and come up.

22 MR. WALLIS: Is that included in this

23 curve here?

24 DR. ALAMGIR: On the right-hand side?

25 MR. WALLIS: Does this include the other

1 way it goes in?

2 DR. ALAMGIR: I will explain the

3 difference between the two curves.

4 MR. WALLIS: But TRAC seems to be showing

5 almost nothing going in at all. So there's just --

6 DR. ALAMGIR: The left-hand curve is the

7 mass of boron in the bypass spaces. The right-hand

8 curve shows the mass that is going into the channels

9 through the leakage holes.

10 MR. WALLIS: Almost nothing.

11 DR. ALAMGIR: Total mass, simulated mass.

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

13 work.

14 DR. ALAMGIR: No, that's --

15 PARTICIPANT: TRAC says it goes up by

16 about three kilograms.

17 DR. ALAMGIR: No. She should understand

18 that this is the actual elemental mass of boron, not

19 just the liquid carrying it. So --

20 MR. MARQUINO: TRAC says that enough goes

21 in to shut the core down within about a minute.

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

23 minutes.

24 MR. MARQUINO: Okay. Two minutes. TRAC

25 says the core shuts down in two minutes.

1 MR. WALLIS: But on the figure it seems to
2 be putting in almost nothing. I mean, one or two
3 kilograms. It's enough?
4 MR. MARQUINO: It doesn't take much.
5 DR. ALAMGIR: Even then it does shut it
6 down.
7 MEMBER ARMIJO: Well, what would you have
8 to do to TRAC to make it look more like the CFD
9 results? You've done a lot of artificial things with
10 TRAC.
11 MR. MARQUINO: So let me explain why we in
12 this case --
13 MEMBER ARMIJO: But it shuts it down.
14 Does it shut it down?
15 MR. MARQUINO: Yes.
16 MEMBER ARMIJO: Okay.
17 MEMBER ARMIJO: What is the boron mass
18 kilogram that shuts it down? You know, draw a
19 horizontal line. At what point does TRAC shut it
20 down?
21 DR. ALAMGIR: If you look at --
22 MEMBER ARMIJO: Is it 1 or .5 or where?
23 DR. ALAMGIR: About 320 seconds we shut
24 down in TRAC.
25 CHAIRMAN CORRADINI: I think what they're

1 asking, though, is --

2 MR. MARQUINO: How many kilograms --

3 DR. ALAMGIR: If you look at the area

4 under this black curve, that is equivalent to the --

5 MR. MARQUINO: -- zero kilograms.

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

7 MR. MARQUINO: 3.0 kilograms.

8 MEMBER ARMIJO: Well, TRAC never gets

9 there.

10 MEMBER BANERJEE: This is not area --

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

12 MR. WALLIS: You don't get three on the

13 right there. On the right you get about one or one

14 and a half or something.

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

16 half. Right.

17 MR. WALLIS: Well, maybe we need to look

18 at this separately another day.

19 CHAIRMAN CORRADINI: I would suggest they

20 move on. We'll look at this separately. I have it

21 listed.

22 DR. ALAMGIR: So, in summary here, it

23 lists -- summarizes --

24 (Laughter.)

25 That's fine. I needed a break.

1 The conclusions are that there is
2 increased radial transport in the realistic CFD
3 analysis, great amount of boron entering the fuel
4 bundles compared to TRAC, and that that affects the
5 shutdown of the core. It's faster.
6 MR. WALLIS: So what do you propose to
7 argue now? That you should use CFD?
8 DR. ALAMGIR: We propose to argue that our
9 TRAC analysis is conservative, so, therefore, the
10 numbers we have provided in DCD that show certain
11 margin is even better with the realistic analysis.
12 MEMBER BANERJEE: Well, we will have to
13 look at this very carefully.
14 MEMBER ARMIJO: Well, maybe I missed the
15 point. But by looking at your chart, I'd say that you
16 won't be able to shut it down if you depend on that
17 analysis. But there must be a line there that I'm
18 missing that says --
19 MR. UPTON: Way, this is Hugh Upton with
20 GEH. Are you guys being misled? Because what's
21 plotted here is just the boron mass in the inner ring,
22 in the inner core.
23 MR. WALLIS: The inner core. Well,
24 basically, you should --
25 MR. UPTON: So it's not the total mass.

1 MR. WALLIS: -- fuel core and other parts
2 of the core.
3 MR. MARQUINO: There's a lot more boron
4 that's in the peripheral.
5 MR. WALLIS: Other parts of the core.
6 MR. UPTON: Correct.
7 MR. WALLIS: So if you would plot it -- if
8 you had plotted the reactivity, that might have helped
9 us.
10 MEMBER BANERJEE: I think this is too
11 superficial for us to read any --
12 DR. ALAMGIR: And let me clarify the
13 driving reason for showing this plot is that there has
14 been some curiosity in terms of whether boron will be
15 able to penetrate.
16 MR. WALLIS: Right.
17 DR. ALAMGIR: And that this --
18 MR. WALLIS: But you have experiments, do
19 you, and you have CFD, which -- just experiments?
20 DR. ALAMGIR: We have experiments in --
21 yes.
22 MEMBER BANERJEE: It's pretty hard to --
23 well, to do experiments -- I mean, CFD with boiling
24 stuff. So if the bypass -- in that bypass region, we
25 are not boiling, then it might be more realistic.

1 DR. ALAMGIR: That is the case.

2 MEMBER BANERJEE: Okay.

3 DR. ALAMGIR: We'll move on to the first

4 movie, which is -- which will show jet 1.

5 MR. WALLIS: Is this a movie of CFD or of

6 TRAC?

7 DR. ALAMGIR: This is the CFD

8 calculations, and that shows the lowest injector, and

9 it will show two of the nozzles on the side and about

10 30 to 45 seconds, how the boron spreads into -- these

11 are from outside to the center of the core.

12 MEMBER BLEY: On that other chart, when

13 you say inner core, how small a region are we talking

14 about?

15 DR. ALAMGIR: There are three rings. If

16 you divide 1,132 by three, that's the number of

17 bundles roughly in each.

18 MEMBER BLEY: Okay. Is the red the boron?

19 DR. ALAMGIR: Okay. So let's turn it on

20 again. I didn't look at the --

21 MR. WALLIS: Do you have a time scale here

22 somewhere?

23 DR. ALAMGIR: Yes. Not on this one,

24 but --

25 MEMBER BANERJEE: It must be 320 seconds.

1 MR. WALLIS: But you say some of it comes
2 in and goes out again, isn't that --
3 DR. ALAMGIR: Okay. So the injectors are
4 in these two corners, upper end of the pipe. And you
5 see the red injectors that inject the boron.
6 MR. WALLIS: It's interesting. You put a
7 pipe in one place, and then you take it all the way
8 around and then inject it somewhere else.
9 DR. ALAMGIR: And it spreads out along the
10 periphery, then inward. And we can pause it at any
11 moment you want.
12 MR. WALLIS: So when is it subcritical?
13 Almost right away, when the yellow gets in there?
14 DR. ALAMGIR: From what we know in TRAC --
15 MR. WALLIS: I'm a bit surprised that the
16 red is sort of fluctuating. It goes in and out again,
17 and it also seems rather like a heartbeat. What code
18 did you use?
19 MEMBER BLEY: What is the effects -- I
20 can't read the scale, but --
21 DR. ALAMGIR: The scale is .1, and this is
22 zero.
23 MEMBER BLEY: Yes.
24 DR. ALAMGIR: And so red, yellow, and
25 orange, those are good.

1 MR. WALLIS: And green is what you need to
2 make it subcritical, is it, or --
3 DR. ALAMGIR: That is not really
4 superimposed -- timing, and so on, mass of boron. But
5 we see -- it's possible to --
6 CHAIRMAN CORRADINI: I think we should
7 move on, and I think this is a topic we will want to
8 investigate further in a separate get-together.
9 DR. ALAMGIR: How about a free movie? I
10 have a second one.
11 CHAIRMAN CORRADINI: Okay.
12 DR. ALAMGIR: Let's get --
13 MEMBER BANERJEE: Amuse us.
14 CHAIRMAN CORRADINI: Not too much
15 amusement today. We want to --
16 DR. ALAMGIR: Critical slides on an
17 injector, just five degrees offset. So you see the
18 four injectors, they are injecting, and you see that
19 they go in and then slosh around.
20 MR. WALLIS: So it flows along the core
21 plate and --
22 DR. ALAMGIR: Yes, and also at the
23 location of the injectors.
24 CHAIRMAN CORRADINI: This is still
25 external to the subassemblies.

1 DR. ALAMGIR: External to the
2 subassemblies, yes. One more time, Dr. White, and
3 then my curiosity will --
4 MR. WALLIS: It seems to really build up
5 at that -- whatever that place is that is part way in
6 there.
7 DR. ALAMGIR: That is the center of the
8 core. It's --
9 MR. WALLIS: That's the center of the core
10 there? Which -- no, the place there. What is this
11 other blue bar there, the big blue bar?
12 DR. ALAMGIR: Oh, this -- we are looking
13 at an offset, a five-degree offset, so we are probably
14 seeing --
15 MR. WALLIS: What is that big bar there?
16 MR. MARQUINO: I think that is where the
17 -- so the thin lines or gaps where you're looking at
18 the space between the sides of a channel, and there is
19 one place where a channel is exactly lined up.
20 CHAIRMAN CORRADINI: It sliced it. So you
21 are looking at it longitudinally rather than width-
22 wise, that's all.
23 MR. WALLIS: Oh, okay. So it's
24 artificial. It doesn't mean much.
25 MR. MARQUINO: So this CFD analysis has

1 proved that if you inject a dense fluid into a less
2 dense fluid, the dense fluid will settle at the
3 bottom.
4 MEMBER ARMIJO: That gravity works.
5 (Laughter.)
6 CHAIRMAN CORRADINI: Okay. Are you --
7 what's next?
8 MR. MARQUINO: We're done with the CFD.
9 I think we have one slide on the other special events.
10 CHAIRMAN CORRADINI: Well, that would be
11 good. I was told that you guys wanted to show a CFD
12 of your special events.
13 DR. ALAMGIR: Dr. White just pulled up
14 another one, and, as we close, this is as if you are
15 inside a soft drink can looking at the rim, and it's
16 coming at you.
17 MEMBER BANERJEE: X-rated color fiction.
18 CHAIRMAN CORRADINI: So did you want to
19 show a simulation of another special event?
20 MR. MARQUINO: No.
21 CHAIRMAN CORRADINI: Oh, okay.
22 MR. MARQUINO: No, we just have one slide
23 on the other special events in 15.5.
24 CHAIRMAN CORRADINI: Okay.
25 MEMBER BLEY: But just to make sure -- if

1 we never looked at this again, it's GEH's claim that
2 even with TRACG and all of the conservatisms that you
3 put in, and the way you set it up and run it, you can
4 shut this plant down.
5 MR. MARQUINO: Right.
6 DR. ALAMGIR: Yes.
7 MEMBER BLEY: The CFD just says you are
8 very conservative, but that's -- you don't need it.
9 MR. MARQUINO: Right.
10 MR. WALLIS: Well, I think with TRACG you
11 keep removing conservatisms until it works, and then
12 you still have some left.
13 MR. MARQUINO: Yes. To be truthful, there
14 was numerical diffusion -- before we did this
15 blockage, when we compare it to the test, it was
16 numerical diffusion, so we put the blockage in, and
17 the blockage is very conservative but it still meets
18 the acceptance criteria, so we're good.
19 MS. CUBBAGE: All right. Last slide in.
20 DR. ALAMGIR: Oh, yes. What's summarized
21 here are the special events, some of the measures
22 against acceptance criteria. The one level limiting
23 event is station blackout. It is just summarized in
24 here.
25 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.

1 MR. WALLIS: That's probably the most
2 important thing.
3 CHAIRMAN CORRADINI: Other questions for
4 the members?
5 MR. WALLIS: A lot of water above the
6 core.
7 CHAIRMAN CORRADINI: We'll take a 10-
8 minute break. Back at 10:30.
9 (Whereupon, the proceedings in the above-
10 entitled matter went off the record at
11 10:20 a.m. and resumed at 10:32 a.m.)
12 CHAIRMAN CORRADINI: Why don't we begin?
13 I was told that I've erred on the side of 15 minutes
14 is the canonical time, but we've got most of everybody
15 back, so let's get started.
16 Mr. Bavol? Bavol?
17 MR. BAVOL: Bavol.
18 CHAIRMAN CORRADINI: Bavol. Excuse me.
19 You'll start us off?
20 MR. BAVOL: Yes, I will.
21 CHAIRMAN CORRADINI: Okay.
22 MR. BAVOL: Good morning. For those of
23 you who were not present at yesterday's presentation,
24 my name is Bruce Bavol. I'm the lead project manager
25 for ESBWR design certification review for Chapter 15,

1 Transient and Accident Analysis.

2 Our team of reviewers will be briefing the
3 Subcommittee today on the ongoing review of ESBWR DCD,
4 and the following sections are going to be covered,
5 15.1, Introduction; 15 Alpha, Event Frequency
6 Determination; 15.2, Anticipated Operational
7 Occurrences; 15.3, Infrequent Events; 15.4, Accident
8 Analysis; and then we'll be talking about ATWS and
9 boron mixing. And also, we are going to be answering
10 the Committee's questions as we go along.

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

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

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

25 With that, I would like to introduce

1 George Thomas and Section 15.1.

2 MR. THOMAS: Good morning. I want to talk

3 about these four topics, the slide pages on the ESBWR,

4 and the events of evolution and the acceptance

5 criteria and the analysis method and the requirements.

6 So ESBWR GEH eliminated more than 10

7 activeESF systems. Also, there were four I&C channels

8 for the safety systems, and there were triple

9 processors for the control systems. And all the I&C

10 in the ESBWR are all pivotal, so because of all this

11 we agreed that the event frequency will be much less

12 than the current operating boiling water reactors.

13 MR. WALLIS: What do you mean it's

14 expected to be less? Do you mean you're going to hold

15 them to higher standards?

16 MR. THOMAS: Because they've got this N

17 minus 2.

18 MR. WALLIS: Just a general statement.

19 Does it mean anything in terms of regulation?

20 MR. THOMAS: The regulations don't --

21 MR. WALLIS: Do you want new reactors to

22 have a lower frequency? Is there any kind of an

23 expectation in terms of numerical values?

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

25 expectation.

1 MR. WALLIS: Just --

2 MS. CUBBAGE: It was meant to say that we

3 agree with GE's --

4 MR. WALLIS: Just a kind of general

5 statement. It's not a regulatory statement of any

6 sort?

7 MR. THOMAS: It's a staff that did it, you

8 know, based on the --

9 MR. WALLIS: But does it imply anything in

10 terms of how you're going to regulate?

11 MS. CUBBAGE: No.

12 MR. THOMAS: No.

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

14 you.

15 MR. THOMAS: In the regulation, right.

16 Okay. The next one.

17 This terms the AOOs, infrequent events,

18 DBA, all these terms came before for -- I just want to

19 say all of these terms are defined in our standard

20 review plan, the new standard review plan which we

21 issued in March. So these terms are already commonly

22 known, actually.

23 Next one.

24 This table gives the details of the

25 criteria and the frequency of each category. Okay?

1 And for this we assumed the pump is going to operate
2 for 100 years instead of 60 years. So the events, you
3 know, the AOOs, actually define which can have a more
4 than 10^{-2}. Okay?
5 The infrequent will be less than 10^{-2}, and
6 the criteria for both AOOs and infrequent events are
7 -- there is no core inquiry. But the pressure is
8 different, the RPV pressure. For the AOOs, the
9 criteria is that it should be below 1,375 psig, but
10 for infrequent events that can go up to 1,500 psig.
11 So there is a difference between these two categories.
12 And we had a problem in accepting this
13 estimated criteria of 1,500 psig. We went to have
14 discussions with GE. And we made a decision, because
15 according to ASME Section 11 requirement, you know, if
16 the RPV pressure exceeds 1,375 psig, then they had to
17 do the inspection and the analysis. So which one --
18 that one we said, okay, you know, that can go up to
19 Level C for these infrequent events.
20 CHAIRMAN CORRADINI: But your judgment --
21 I just want to make sure I understand your judgment.
22 Your judgment was because the frequency is small --
23 MR. THOMAS: Right.
24 CHAIRMAN CORRADINI: -- was lower, you
25 allowed them to come up to the criterion of 1,500.

1 MR. THOMAS: Level C limit.

2 CHAIRMAN CORRADINI: Okay. Thank you.

3 MR. THOMAS: Next one.

4 For the special events, you can see the

5 criterias are different on a case-by-case basis.

6 Station blackout, ATWS, you know, they all vary from

7 each case. You know, it's all different.

8 CHAIRMAN CORRADINI: But in some sense,

9 just to make sure I understand, too, with the

10 infrequent events, it was a staff judgment to come

11 down to 2.5 rem.

12 MR. THOMAS: Right.

13 CHAIRMAN CORRADINI: Of the TEDE --

14 MR. THOMAS: Right.

15 CHAIRMAN CORRADINI: -- versus --

16 MR. THOMAS: Right.

17 CHAIRMAN CORRADINI: Okay.

18 MR. THOMAS: That's a very small fraction

19 of the 25.

20 CHAIRMAN CORRADINI: Yes, I understand.

21 MR. THOMAS: 25 is the limit.

22 CHAIRMAN CORRADINI: Sure.

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

24 --

25 MR. WALLIS: You're accepting this, or is

1 this the GE-Hitachi proposal?

2 MR. THOMAS: What?

3 MR. WALLIS: You are accepting this 2.5,

4 and all that sort of thing? Are you allowed to do

5 that?

6 MR. THOMAS: We've got -- the limit is 25,

7 so we are saying that it is --

8 MR. WALLIS: You are accepting this new

9 category of accidents. Is this going to appear in the

10 regulations somewhere?

11 MR. THOMAS: Yes. The regulation says it

12 should be -- can go up to 25 rem.

13 MR. SHUAIBI: Because there is not a

14 regulation -- there is not a specific regulation on

15 every AOO and transient that is analyzed in

16 Chapter 15. So this is -- your question is: is this

17 their proposal, or is this something that we are

18 accepting? It's both. They proposed it.

19 We went through a long discussion with GE

20 about what this means and what it means in the context

21 of the frequency of the event and the consequences of

22 the event. And what we're briefing you today on is

23 that they proposed it, we've gone through that

24 discussion, we're accepting it.

25 MR. WALLIS: You are accepting it.

1 MS. CUBBAGE: And it is consistent with
2 regulations and other regulatory practice of similar
3 situations.
4 MR. WALLIS: So it has been done before?
5 MS. CUBBAGE: Not exactly, because we
6 haven't licensed an ESBWR before. But there are
7 similar situations where there is precedence for
8 having an event that is not a design -- the design
9 basis event that has a dose criteria that is a
10 fraction of the Part 100 limits.
11 MEMBER ABDEL-KHALIK: How do these -- how
12 does this accident category compare with the Condition
13 3 category in the whole ANS accident classification
14 scheme?
15 MR. THOMAS: The BWR, we don't really
16 follow that standard. We mostly --
17 MEMBER ABDEL-KHALIK: I understand.
18 MR. THOMAS: You know, we are following
19 the regulations, and in the regulations there are
20 really two categories, AOOs and the accidents.
21 CHAIRMAN CORRADINI: I think what he's
22 asking you is -- that might be true, but did you
23 happen to compare?
24 MEMBER ABDEL-KHALIK: Yes. Right.
25 MR. THOMAS: In our standard review plan,

1 we -- they are not having this standard at all. I
2 don't think the NRC endorses this standard. You know,
3 in the old SRP, the standard was not there.
4 MEMBER ABDEL-KHALIK: Okay.
5 MR. THOMAS: Okay. This is the same
6 approach we always use in the Chapter 15. High
7 frequency events can have a small consequence, and the
8 lower frequencies can have more severe consequence.
9 So this concept is not new at all, because they are
10 always this way from the beginning. So we are not
11 deviating from this approach.
12 Most of the events in Chapter 15 are all
13 outlined the Part D, and we are going to talk about
14 Part D today in the afternoon. And our position is
15 that, you know, all AOOs and the infrequent events
16 identified in the SRP, which are applicable for ESBWR,
17 should be analyzed. And we don't do the Chapter 15
18 review or base it on a PRA. We are doing, you know,
19 deterministic type of review.
20 So even though we calculate the event
21 frequency, we don't do that review based around PRA.
22 And when the COL applications come, then are we going
23 to do only the limiting case, if they don't change the
24 fuel. If they keep the same 14E, then the same thing,
25 you know, then they are allowed to do all these events

1 again in the COL stage. They have to do only the
2 limited cases.
3 Now, Dr. John Lai will talk about the
4 event frequency. Oh, sorry, I've got one more, right?
5 Yes. Right.
6 MR. WALLIS: There was something you said
7 in your SER, the draft, that TRACG was not qualified
8 for these new kind of events, the IEs? And there
9 seemed to be -- the implication seemed to be that they
10 can't use it for --
11 MR. THOMAS: I think this afternoon we are
12 going to cover Chapter 31. At that time, we will go
13 through TRACG for --
14 MR. WALLIS: Well, I read on page 5 that
15 TRACG is not qualified for this new category of
16 events, these IEs. So how can they use it for --
17 MR. THOMAS: No. In the subject of the
18 topical report, most of the events there are analyzed,
19 AOOs. They are not --
20 MR. WALLIS: Yes. But now there is a new
21 category for which you can't use TRACG, apparently.
22 MR. THOMAS: Yes. That is one of the open
23 items in Chapter 31.
24 CHAIRMAN CORRADINI: Can we get a
25 clarification from the staff about that?

1 MS. WILSON: Yes. Hi, Dr. Wallis. It's
2 more of a semantic thing. When the topical report for
3 TRACG on AOOs was submitted, I don't think at that
4 time GE had created the new category and separated the
5 events out. So the events that TRACG is qualified for
6 covers the infrequent events, but the topical report
7 just hadn't been updated to that point, so just that
8 -- the language --
9 MR. WALLIS: Maybe it needs to be --
10 MS. WILSON: -- was not updated.
11 MR. WALLIS: -- more clearly stated, then,
12 because I got the impression from what I read in your
13 draft SER that you couldn't use it for -- it hadn't
14 been qualified for AEs. I mean, that maybe just needs
15 to be clarified.
16 MR. DONOGHUE: I think you've got to
17 understand that we are writing an SE that was based on
18 Rev 3 and some preliminary information. And, you
19 know, now as more information is coming in, yes, we
20 have to update it. Right.
21 MR. THOMAS: Okay. We had a couple of
22 issues. You know, we went through this. Initially,
23 we did not want to put the safety limit of CPR in the
24 technical specifications, and they want to put only
25 the criteria. And we went through our discussions

1 with GE, and GE agreed to the safety limit in CPR. So
2 that was an issue we spent a lot of time.
3 And this one, ASME Level C issue, I
4 already talk about that one.
5 CHAIRMAN CORRADINI: So could you take a
6 bit of time, just a minute, about the third bullet?
7 So what was -- I remember reading about this, but I
8 didn't appreciate the difference. GEH was suggesting
9 that acceptance criteria of 99.9 for fuel rods, and
10 your response was what?
11 MR. THOMAS: We wanted a numerical value
12 in the technical specification displayed in the
13 current plants, so that if there is -- in regulatory
14 actions, we had to put a penalty for the MCPR. So
15 that whenever you do a licensing action, we change the
16 safety limit MCPR.
17 CHAIRMAN CORRADINI: So the SLMCPR --
18 MEMBER BANERJEE: They want a spec on
19 that.
20 MR. THOMAS: Right.
21 CHAIRMAN CORRADINI: Right. The spec --
22 but it's a different spec. GEH was proposing a
23 different spec, which unless -- I'm trying to
24 understand the subtle difference. It would avoid the
25 same problem. The --

1 MR. THOMAS: They don't have any number
2 there. They only say this criteria, 99.9 percentage
3 of the fuel rods would be expected to avoid boiling
4 transition.
5 CHAIRMAN CORRADINI: Right.
6 MR. THOMAS: They didn't want to put any
7 number there. So we --
8 CHAIRMAN CORRADINI: That's a number.
9 That's just a different way of expressing the number.
10 I'm not --
11 MR. THOMAS: No, no, that was the
12 criteria. That's not the actual number.
13 MEMBER BANERJEE: I think it is a lot
14 easier to deal with the way they are doing it.
15 MR. THOMAS: Right. Mostly it comes with
16 a -- I think it most likely may be like 1.19, and the
17 operating limit will be like 1.30. So there is a lot
18 of margin, and, you know, so that number 1.19 can be
19 there for, you know, a long time, if they don't, you
20 know --
21 MEMBER BANERJEE: And you will put your
22 uncertainty on that number specifically, right?
23 MR. THOMAS: No, that comes with the
24 number.
25 MEMBER BANERJEE: And then, you will

1 put --

2 MR. THOMAS: And we --

3 MEMBER BANERJEE: -- your penalty on that.

4 MR. THOMAS: -- we will review that

5 number, and we --

6 MEMBER BANERJEE: If necessary, yes.

7 MR. WALLIS: Now, this SLMCPR is something

8 that is plant-specific, isn't it?

9 MR. THOMAS: Yes.

10 MR. WALLIS: And I have always been

11 mystified by them.

12 CHAIRMAN CORRADINI: So let me just -- I'm

13 still not there yet. I'd like to hear from GEH about

14 this.

15 MR. MARQUINO: Okay. A lot of the

16 discussion with the staff had to do with the fact that

17 there is not a DNBR meter or a CPR meter in the plant.

18 And they pointed out the part of 10 CFR that requires

19 -- it says something like a plant parameter must be

20 measured and be a safety limit.

21 So we weren't asking for a change in the

22 99.9 value, but it was discussion about how is that

23 measured, and where we compromised on was to put a

24 safety limit, steady state CPR value in the tech spec

25 as the safety limit CPR. And if we make a significant

1 fuel change where we want to change that number, that
2 allows the staff to review the justification of the
3 change.
4 CHAIRMAN CORRADINI: Okay. Thank you.
5 MR. SHUAIBI: Dr. Corradini, I guess the
6 short answer from our perspective is that by putting
7 safety limit MCPR in the tech specs it allows more
8 regulatory control over the changes that they could
9 make. They would have to come in for review if they
10 make certain changes when we have safety limit MCPR in
11 a tech spec, whereas if you put 99.9 percent, the way
12 it's worded in there, it gives more flexibility. So
13 that was kind of the discussion and debate that we
14 went through.
15 CHAIRMAN CORRADINI: Okay. Thank you.
16 MR. THOMAS: Just a bit on the temperature
17 operating domain. We already had discussions about
18 this yesterday, and this will come back under our
19 Chapter 15 review, so --
20 CHAIRMAN CORRADINI: We'll come back to
21 this.
22 MR. THOMAS: Yes, right. Dr. John Lai
23 will talk about this.
24 DR. LAI: Yes, my name is John Lai. I am
25 in the PRA Branch for reviewing ESBWR and boiling

1 water related PRA issues. I am going to talk about
2 the staff evaluation of Chapter 15 Alpha, just that
3 appendix.
4 I actually was hoping GE, you know, would
5 make a presentation before me -- that, you know, you
6 won't be the first one to hear me talking about that.
7 There are three methodologies used to
8 determine the infrequent event frequency. The first
9 one is the initiating event is modeled in the ESBWR
10 PRA. The number is directly taken from the ESBWR PRA.
11 The example is like for a turbine trip we have an
12 initiating event frequency there, just taken directly
13 from the PRA.
14 But in some instances, the more detail is
15 required, then additional analysis, not giving the
16 PRA, are conducted. For example, for the turbine trip
17 with total turbine bypass valve failures, so that gets
18 into a little bit more detailed evaluation, is
19 presented in 15 Alpha, 15A.
20 The second one is the event frequency is
21 determined on the actual BWR, with experience. But,
22 you know, GE takes the credit for the new design. For
23 instance, for stuck open lead valve frequency, they
24 are not using the numbers directly from the operating
25 experience. They are taking the credit of the new

1 designs. I don't know if I need to get into the
2 detail on that or not. Yes?
3 CHAIRMAN CORRADINI: No.
4 DR. LAI: No?
5 CHAIRMAN CORRADINI: I understand what
6 you're saying.
7 DR. LAI: Okay.
8 CHAIRMAN CORRADINI: Keep on going.
9 DR. LAI: All right. The next slide,
10 please.
11 The third one is, for events involving
12 multiple hardware failures or --
13 MR. WALLIS: Wait a number. this
14 frequency -- the only criteria you have is that it's
15 lower than 10^{-1}, 10^{-2}.
16 DR. LAI: Exactly.
17 MR. WALLIS: Is the only criterion.
18 DR. LAI: Right.
19 MR. WALLIS: It's not very difficult to
20 meet that.
21 DR. LAI: Right. So --
22 MR. WALLIS: So it's not a very useful
23 criterion.
24 DR. LAI: Yes. My job is just, you know,
25 verify that, for all of these IE --

1 MR. WALLIS: But the real criterion for
2 this category is consequence, isn't it?
3 CHAIRMAN CORRADINI: No. No, it's
4 frequency.
5 MR. WALLIS: How do you decide --
6 CHAIRMAN CORRADINI: This is selection
7 criteria.
8 MR. WALLIS: How do you decide it's not a
9 design basis accident?
10 CHAIRMAN CORRADINI: Frequency.
11 MR. WALLIS: Frequency? Consequence
12 doesn't come into it?
13 CHAIRMAN CORRADINI: If it's too frequent,
14 you're going to put a more stringent requirement on
15 it.
16 MR. WALLIS: If you had a frequency -- so
17 that an infrequent event could be worse in consequence
18 than a DBA?
19 CHAIRMAN CORRADINI: No. One-tenth the
20 consequence.
21 MR. WALLIS: Oh. So the consequence is
22 really what matters? The one-tenth the consequence is
23 what really makes them different.
24 CHAIRMAN CORRADINI: So the curve that you
25 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

1 estimates of the hardware failures, including the
2 common cause failure, CCF, and the human errors, the
3 events. Using this methodology are a lot of feedwater
4 heating, also with the control rod run-in, and
5 inadvertent shutdown of cooling function operations.
6 The staff reviewed all the 16 infrequent
7 event frequencies, and we issued the two RAIs, and
8 they have been subsequently resolved. So we found the
9 results are acceptable.
10 Okay. If there are no more questions, I
11 can introduce Dr. Lois.
12 DR. LOIS: Thank you. It seems to me that
13 just about everything I had to say has already been
14 discussed. Chapter 15.2, the AAOs and all that's been
15 said in 15.3 for 15.2, which has been pointed out a
16 number of times, is still a work in progress. We
17 still have some responses to receive.
18 We already received -- resolved some of
19 our original RAIs. However, they are not reflected in
20 my couple of slides that I have coming up.
21 As Mohammed Shuaibi pointed out, this is
22 based on Rev 3 of the DCD, and Rev 4 is out, and Rev 5
23 is forthcoming, which is not reflected in what --
24 MR. WALLIS: Can I go back to my argument
25 here? Why isn't a LOCA an IE? It doesn't have any

1 consequences. It's infrequent, so why couldn't it be
2 called an IE?
3 CHAIRMAN CORRADINI: We're not asking what
4 consequences it has. We're asking what consequences
5 it's allowed to have.
6 MR. WALLIS: Oh. So the whole thing is an
7 imaginary game again, right?
8 CHAIRMAN CORRADINI: Well, it's a limit.
9 It's a limit.
10 MS. CUBBAGE: The ESBWR is being licensed
11 under our traditional licensing regime, our
12 traditional regulations. They are deterministic. GE
13 simply justified having a greater consequence for some
14 traditional AOOs based on their lower frequency.
15 MR. WALLIS: What matters here --
16 MS. CUBBAGE: Everything else is --
17 MR. WALLIS: What matters to me is not
18 your games you are playing. It's what perception the
19 public has when they look at what you're doing. You
20 have defined a new class of accidents. You are saying
21 that the -- that they are somehow different. And
22 then, you are saying there are a certain kind of
23 stylized accidents which we still call DBAs, for
24 reasons which are not clear to me.
25 You are changing the words which describe

1 your job. And that to me is a very important thing.
2 You can't just casually do it.
3 MS. CUBBAGE: Okay.
4 MEMBER SIEBER: They will still be AOOs,
5 right?
6 MR. DONOGHUE: When you say you -- we
7 casually did something, you know, we changed the SRPs.
8 We went through a process that involved public
9 interaction. So, you know, I think we are doing
10 things in accordance with the regulations. We have
11 modified our guidance. We followed the procedures to
12 modify the guidance, and that's what we are using for
13 this review. I understand, you know, your point, and
14 there are, you know, mechanisms to use to change the
15 requirements that we are supposed to satisfy. But
16 that's what our reviewers are using -- the regulations
17 and the guidance that are in place. Okay?
18 MR. MARQUINO: I have to stick up for the
19 staff here.
20 (Laughter.)
21 This is an area where the regulations were
22 very complex, and we had to go through them, together
23 with the staff, and GE was asking for something that
24 was non-traditional. But we believe that it is
25 covered by the current regulations, and we were able

1 to work through to agreement eventually.

2 And to answer your specific question about

3 DBAs, basically, what we are doing here is, as Amy

4 said, there was a set of events called AOOs, and some

5 of the events that were in that bin weren't really

6 AOOs by the GDC definition, which is expected during

7 the life of the plant.

8 So all GE was asking for is these events

9 really aren't AOOs, and we can show you that they are

10 not AOOs, and we want to move them into something else

11 with relaxed acceptance criteria. And we are able to

12 work through and do that.

13 MEMBER BANERJEE: But did you need the

14 relaxed acceptance criteria?

15 MR. MARQUINO: In terms of needs, our

16 customers would like these relaxed acceptance

17 criteria, because it gives them better fuel economics.

18 CHAIRMAN CORRADINI: But why would -- I

19 mean, logically, if I have something -- if I have

20 something that is not going to occur once in the plant

21 lifetime, but once in 100 plant lifetimes, why

22 wouldn't I allow for a relaxed acceptance criteria?

23 I don't want to impose the consequence of an AOO --

24 MEMBER BANERJEE: I'm only asking a

25 rhetorical question.

1 CHAIRMAN CORRADINI: Oh.

2 MEMBER BANERJEE: Did you --

3 MR. MARQUINO: Well, we could have

4 licensed the plant with a higher operating CPR limit,

5 and there would be more fuel bundles required every

6 refueling outage because of that.

7 MEMBER BANERJEE: So you get relaxation on

8 the OLMCPR.

9 MR. MARQUINO: Yes.

10 MEMBER BANERJEE: Is that what you were

11 looking for?

12 MR. MARQUINO: Yes.

13 MEMBER BANERJEE: Okay. That actually

14 explains why you are doing it.

15 MR. MARQUINO: But, Dr. Wallis, I also

16 want to add that for a LOCA --

17 MEMBER BANERJEE: Nobody does stuff for

18 nothing.

19 MR. MARQUINO: Dr. Wallis, I also want to

20 add that the frequency of a LOCA is not just less than

21 10^{-2}. It's much less than that. So if you want to

22 put numbers on, what's the frequency of a LOCA, and

23 what's the frequency of an infrequent event, it would

24 be less than 10^{-2}, but it would be much less, so you

25 may want us to go 10^{-4}, or something like that, to say

1 it's a DBA. So there is -- it makes sense what we're
2 doing.
3 MEMBER BANERJEE: So how much do you gain
4 on the OLMCPR?
5 (Laughter.)
6 From 1.4 to 1.3, or something like this?
7 MR. MARQUINO: It's about .05. If you
8 look in Chapter 15.3 --
9 MEMBER BANERJEE: .05.
10 MR. MARQUINO: Yes. We have the deltas in
11 15.3, so you can look at the worst delta in 15.3, the
12 worst delta from 15.2, and that's what we're gaining.
13 MR. WALLIS: So this is a relaxation of
14 the regulations that enables you to do something you
15 couldn't otherwise do.
16 MR. MARQUINO: Not a relaxation of the
17 regulations. It's within the -- it's sort of the
18 traditional BWR licensing basis. It's a change to
19 that, but it's still within the regulations.
20 MEMBER BANERJEE: It's based on our
21 frequency argument now.
22 MR. WALLIS: Within the regulations, if
23 you didn't have these IEs --
24 MR. MARQUINO: Yes, because we would be
25 conservatively putting IE events in the AOO category.

1 MEMBER BANERJEE: For the IE events, the
2 OLMCPRs are not calculated the same way, because the
3 frequencies are different. Therefore, the
4 uncertainties are different, and everything changes,
5 right?
6 MR. MARQUINO: Yes. Now you are getting
7 into the details of the analysis for the IEs. We set
8 the operating limit based on the AOO events, and then
9 we will do checks on the IE events to make sure that
10 that 1,000 fuel rod failure number doesn't change as
11 we come up with future core designs.
12 MR. WALLIS: Have you gone through that
13 procedure, or is it still to come?
14 MR. MARQUINO: No. Well, we've gone
15 through it for the equilibrium core and the initial
16 core.
17 MEMBER BANERJEE: For the IEs.
18 MR. MARQUINO: Yes.
19 CHAIRMAN CORRADINI: Okay. Go ahead.
20 DR. LAI: Actually, to echo what Marquino
21 said, a review of 15.2, the AOOs indicate that number
22 one, the number of frequencies implied number of these
23 events. And, number 2, that the design is sometimes
24 more forgiving than the classical BWRs that we already
25 have experience with.

1 Okay. Let's go on to the 15.3. For the
2 frequent events, we essentially analyzed them, or
3 reviewed them rather, like what classically in the
4 standard review plan is referred to as an accident,
5 regardless of what GEH -- what they call them.
6 The, of course, LOCAs you can review
7 separately, and what was said before -- the operating
8 limit for the MCPR is 1.3. As far as we are
9 concerned, as far as this review is concerned, these
10 values assumed -- and going back to Dr. Wallis'
11 argument before -- the topical report for the -- on
12 which this is based and the analysis was done has not
13 reached us.
14 Mainly we assume that that report is
15 correct, that that -- the code on which this analysis
16 was based will turn out to be okay. It's in that
17 context that we are stating that the margins of the
18 ESBWR with respect to the upper limit are larger than
19 what --
20 MR. WALLIS: But this OLMCPR does change
21 from plant to plant, doesn't it?
22 DR. LOIS: That is with the fuel change,
23 eventually. What is reviewed there is the equilibrium
24 plant that Mr. Marquino referred to --
25 MEMBER BANERJEE: But is this partly due

1 to the fact that some AOOs have moved to the IEs now?
2 DR. LOIS: Yes, that's part of it. Yes.
3 MEMBER BANERJEE: There is, of course,
4 other aspects, too.
5 MR. MARQUINO: Well, the other aspect is
6 what we were -- we have written down, that we want to
7 see the -- with the 14E fuel, we want to see the data.
8 MEMBER BANERJEE: Right.
9 DR. LOIS: In that case, then let me
10 concentrate on some of the differences we had, and the
11 arguments and the questions that we've asked GE.
12 There are two transients -- the regular load ejection
13 and the pressure regulator failure -- that they
14 developed, for obvious reasons if you think about it
15 -- very sharp power peaks. And the DCD did not
16 contain an analysis of that either for the clad stress
17 or possibly fuel melting. Those questions have been
18 answered in the Rev 4, which is not included here in
19 this review.
20 Next one.
21 The other problem we had with this is the
22 DCD stated that either these were impossible, not
23 going to happen, or inconceivable if you wish, and
24 some of them they said, "Well, yes, it may happen.
25 However, it will be prevented with the extensive

1 instrumentation and the design of the plant."

2 As Mohammed Shuaibi pointed out yesterday,

3 we asked GE to analyze them, find out what the

4 consequences are, what the frequencies are, and then

5 we will decide how to dispose of them, and where in

6 that stage --

7 MR. WALLIS: It is very difficult to

8 estimate the frequency of something like this. It is

9 very difficult to estimate the frequency.

10 DR. LOIS: Well, John Lai might have a

11 response to that.

12 DR. LAI: The staff -- in my section, we

13 are looking to this analysis by GE. GE's approach is

14 by using the -- we call it function linking analysis.

15 Eventually, just take in consideration all the data

16 amount possible, and come up with the initiating

17 event.

18 MR. WALLIS: So this analysis has been

19 submitted, and you're reviewing it now, or is it in

20 progress? Finished?

21 DR. LAI: This would be considered an AOO?

22 DR. LOIS: No, these are IEs. Which is

23 actually the classical --

24 MR. WALLIS: Because the frequency is

25 low --

1 DR. LOIS: Yes.

2 MR. WALLIS: -- you hope.

3 MEMBER BANERJEE: In spite of the fact

4 that it has occurred certainly in Japan, well, that is

5 one of the reasons that we are going to --

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

7 MEMBER BANERJEE: -- in 1999. However, of

8 course, this design is different from the --

9 MR. WALLIS: So it's --

10 DR. LAI: But they also thought it was

11 pretty safe, I'm pretty sure.

12 DR. LOIS: Yes. As a matter of fact, I

13 went back and I checked and reviewed the argument that

14 the designer of that class of plants were offering and

15 what they said, the words were pretty much alike. The

16 arguments were pretty much the same. So --

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

18 DR. LOIS: It's an IE.

19 MR. WALLIS: So they have to submit an

20 analysis showing that the consequences are below a

21 certain thing?

22 DR. LOIS: Yes. Hopefully, that is what

23 is done. Yes. And --

24 MEMBER BANERJEE: Do you buy these

25 arguments, I mean, in spite of what happened in --

1 DR. LOIS: We're not there yet, we're in
2 the process of getting to that point. From what we
3 know so far, this is -- I would like to say that this
4 is more resilient to the conventional plans to these
5 transients that we have examined so far.
6 MR. WALLIS: Okay.
7 DR. LOIS: And, again, as I said, it is a
8 work in progress. We still expect more information to
9 --
10 MR. WALLIS: If the frequency became very
11 low, could it become a DBA, and then --it would be
12 allowed to have bigger event consequence?
13 DR. LOIS: Yes, it already has been
14 decided.
15 MR. WALLIS: I'm really mystified by this.
16 Again, this is --
17 DR. LOIS: Yes.
18 MR. WALLIS: -- if you accepted a much
19 lower frequency than you might want to accept, it
20 could become a DBA, and then you would be -- they
21 would be allowed to have worse consequences?
22 DR. LOIS: Well, we don't know that yet.
23 And --
24 MR. WALLIS: But it could be. It could
25 be --

1 MR. SHUAIBI: Let me try -- I guess let me
2 try to -- let me try to address that. I guess, you
3 know, had they come in and said we wanted to do that,
4 we would have had two years of discussion with them
5 about why is it okay to call something a DBA. We have
6 not gone there, so the what if scenarios, what if they
7 had proposed let's call these DBAs or --
8 MR. WALLIS: If you don't know what it is,
9 call it a DBA, because that gives you the most
10 stringent requirements for consequences.
11 MR. SHUAIBI: No. These consequences are
12 not the DBA consequences.
13 MR. WALLIS: Less stringent.
14 MR. SHUAIBI: Or less stringent than the
15 DBA requirements.
16 MR. WALLIS: No. DBA requirements are --
17 the consequences are more stringent.
18 MR. SHUAIBI: No, no. I want to make sure
19 -- no. The AOOs have --
20 MR. WALLIS: That makes no sense. The
21 most infrequent thing should have the biggest
22 consequence, right?
23 MR. SHUAIBI: It does. We may be talking
24 past each other I guess.
25 MR. WALLIS: But that means they are the

1 biggest consequence.

2 DR. LAI: In addition to which -- what

3 Mohammed said, the standard review plan already names

4 the DBAs, and GE agreed to analyze those named in the

5 standard review plan as DBAs.

6 Thank you.

7 MR. WALLIS: Well, they have no -- what is

8 the incentive to make it an IE, then?

9 MEMBER BANERJEE: For this specific

10 accident, to make it an IE, I mean, this seems a

11 little bit of a stretch, right?

12 MR. WALLIS: Maybe, maybe not.

13 MEMBER BANERJEE: Well --

14 MR. WALLIS: It depends on the design

15 and --

16 MEMBER BANERJEE: But the experience

17 indicates that designs are fallible in this area.

18 MR. WALLIS: It has happened, right. It

19 has happened.

20 DR. LOIS: Well, it depends on --

21 MEMBER BANERJEE: And we design and say

22 this happens. If you look at the original -- as you

23 say, you read the original Japanese, and the design

24 looks infallible also, and then it fails.

25 DR. LOIS: Well, this design is different.

1 MEMBER BANERJEE: It's more infallible.
2 (Laughter.)
3 DR. LOIS: This design, it appears to have
4 the frequencies of those events are lower, and the
5 consequences are also lower. So that pushes
6 everything --
7 MEMBER BANERJEE: The frequencies will be
8 hard to prove, I would think, on this case.
9 DR. LOIS: Well, I would not argue with
10 this. However, there is some experience in quite a
11 number of those.
12 MEMBER BANERJEE: There's been a number of
13 events. It's not just Shika. There have been others.
14 I can probably give you a list of the Japanese ones.
15 DR. LOIS: It's priority work.
16 MEMBER BANERJEE: Yes. I'm sure you have
17 it, yes.
18 MR. SHUAIBI: But I guess that's where our
19 questions come from, is we look at what they propose,
20 we, you know, evaluate it to determine whether we
21 accept it or not, and we ask them questions to justify
22 what they propose. And I think that is exactly what
23 Lambros is saying is we know of some events that have
24 occurred, and we want them to look at this in that
25 context and show us and demonstrate and prove to us

1 that this is something that we should accept. We
2 haven't accepted it yet.
3 MR. LEE: Thank you.
4 MR. SHUAIBI: Is that --
5 MR. LEE: Excellent. Thank you.
6 CHAIRMAN CORRADINI: I'd like to switch
7 out the next group here -- a new team.
8 Okay. I'd like to introduce Jay Lee, and
9 he is going to be covering Chapter 15.4 and
10 Chapter 6.5.
11 MR. LEE: Good morning. Yes. As Bruce
12 said, I will be discussing Section 15.4. And I
13 noticed this morning that GE-Hitachi got by with only
14 three slides, and I have only 23 slides, and so --
15 (Laughter.)
16 -- this is not right.
17 CHAIRMAN CORRADINI: Something is wrong.
18 MR. LEE: I may have too detail in my
19 slides.
20 CHAIRMAN CORRADINI: So feel free to skip
21 a few.
22 (Laughter.)
23 MR. LEE: More detail than what you
24 expected or you anticipated --
25 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

1 wording really appears in more than one place, in
2 52.47, and also 10 CFR 50 -- excuse me, 10 CFR
3 50.34(a)(1), and also in siting criteria, 10 CFR 100.
4 So this particular regulation appears more
5 than one place, and it says that the fission product
6 released assumed for this variation, for siting
7 variation, shouldn't be based upon a major accident.
8 It doesn't say that, oh, this major accident, whether
9 it's a LOCA or a large break LOCA or a small break
10 LOCA, but it's just based on major accident. And,
11 further, it states that --
12 MR. WALLIS: It says it has to be based on
13 possible accidental events, and if it's something
14 impossible --
15 MR. LEE: Yes.
16 MR. WALLIS: -- you don't have to
17 postulate it, do you?
18 MR. LEE: Right. Possible accidental
19 events, such as fuel handling accidents, or main steam
20 line break accident, control rod accident -- and I'll
21 discuss those a bit later -- and this regulation
22 further states that with the substantial meltdown of
23 the core and for the source term, it says appreciable
24 quantities of a fission product.
25 It doesn't say how much of activity is

1 going to be released, but it just states this
2 quantities and -- so, really, regulation doesn't
3 specify any particular source term, but just mentioned
4 that we have to consider this amount of fission
5 product release into the containment from the reactor
6 core.
7 And the major accident and possible
8 accidental events that -- just stated in the
9 regulation is listed in SRP 15.3, Reg. Guide 1.183,
10 and the staff -- we listed major accident as a LOCA,
11 loss of coolant accident, typically a large break LOCA
12 accident. And possible accidental events is, like I
13 said, you know, such as main steam line break accident
14 or coolant accident, small line break accident, or
15 some other possible accident.
16 That regulation also stated that
17 appreciable quantities of fission product released, or
18 substantial meltdown of the core. This is given in
19 the regulations.
20 CHAIRMAN CORRADINI: So at this point I
21 guess, just to clarify, the way I view this -- and
22 maybe this is an incorrect way, so I guess I'd look
23 for your clarification -- is in some sense the
24 alternative source term is the starting point. And
25 one looks for an envelope of accidents, however non-

1 mechanistic --

2 MR. LEE: That's correct.

3 CHAIRMAN CORRADINI: -- that would get you

4 to that source term, and then you look to the

5 containment and the systems within it to show that you

6 can bottle up or --

7 MR. LEE: Mitigate.

8 CHAIRMAN CORRADINI: -- that you can

9 mitigate the source term.

10 MR. LEE: Right. Yes. Like we discussed

11 this morning, GE discussed three particular accident

12 sequences.

13 CHAIRMAN CORRADINI: Right, right. Right.

14 MR. LEE: We made MELCOR -- such a way

15 that -- so it will say, yes, you've got fuel melt or

16 core melt. We have to have that fission product in

17 the drywell, you know. That's the starting point for

18 evaluating the deviation.

19 And this NUREG has, as you know, the four

20 faces of release: CAD release, early SL release -- we

21 discussed this NUREG with ACRS way back in 1994 or so

22 in the 406th and 407th ACRS meeting, and you prepared

23 a letter agreeing with us. We're using this NUREG for

24 the advanced reactor design, and SOL is using only GAP

25 and early invested releases for our evaluation.

1 So, really, regulatory issue for the
2 review in this particular section, for 15.4, what the
3 reviewer, he or she should keep in mind reviewing this
4 section, is: does the ESBWR design, or any other
5 design, provide adequate irrigation of radiological
6 consequences in the event of a major reactor accident
7 to meet the dose criteria?
8 Here we discussed this morning about
9 prevention against the mitigation. This prevention is
10 prevention of a core melt. The staff presented
11 yesterday Chapter 6 dealing with ECCS systems,
12 including the isolation condenser and standby control
13 system, gravity drain, gravity-driven cooling system,
14 and automatic depressurization system. Those are all
15 ECCS system, and they are for preventing a core melt.
16 The mitigation part that I dealt this
17 morning is just the mitigation, and prevention is of
18 course first line of defense. The mitigation is
19 defense in depth. And, Dr. Wallis, you asked this
20 morning that -- where all of this activity is coming
21 from, and this is not realistic to assume this.
22 But, you know, in the case in point like
23 a TMI accident, the prevention part, they didn't play
24 a role and the mitigation did. So this is strictly
25 defense in depth.

1 MR. WALLIS: No, I understand that.

2 MR. LEE: Yes. It's in the regulation.

3 MR. WALLIS: I understand that.

4 MR. LEE: We follow that.

5 MR. WALLIS: So it gives me, you know --

6 as my colleague, Dr. Kress, said, reason to maybe

7 reexamine what you're doing with regulations. When we

8 get into beyond design basis, we seem to tolerate

9 containment failure probabilities of .1, and yet when

10 we're doing this we don't do anything like that at

11 all.

12 So the real things that hurt the public

13 are the ones where we should probably be worried

14 about.

15 MR. LEE: Right.

16 MR. WALLIS: All of this other stuff,

17 maybe it has an effect on safety, maybe it doesn't.

18 MR. LEE: Right. And the fission product,

19 the way it's really releasing from the ESBWR reactor

20 design into the environment, we have two release

21 points, which is the containment leak and the main

22 steam isolation valve. Containment leak is the object

23 of the steam pole weight percent, and MSIV leak, which

24 bypass the containment as well as bypass the reactor

25 link, is at 200 cfh. These values are chosen by

1 applicant, and they are in the ESBWR tech spec as a
2 surveillance requirement.
3 And I understood that you raised a
4 question about the potential leakage from isolation
5 condenser. In the case of isolation condenser, the GE
6 design has four radiation monitors for each isolation
7 condenser pool compartment. There are four of them.
8 And any high radiation signal from two radiation
9 monitors out of the four will cause automatically main
10 steam flow into the isolation condenser, and also
11 condensate return line valve. It will cause -- it
12 will isolate that. And also, the isolation condenser
13 will come in at the LOCA signal before automatic
14 depressurization system come on.
15 So, really, any steam or water in this
16 condenser is very low in activity to begin with, if
17 any.
18 CHAIRMAN CORRADINI: So jus tone -- maybe
19 my memory is wrong, but I thought 10 CFR 100 had a
20 containment performance of .1 percent of volume per
21 day, and here you have a leak of .4. I thought it was
22 .5 I read.
23 MR. LEE: No. The regulation doesn't
24 specify any containment leak. This containment leak
25 rate is strictly chosen by applicant to meet, and it's

1 coming in the few next slides, but --

2 CHAIRMAN CORRADINI: But you have to have

3 surveillance, right?

4 MR. LEE: Yes, they are. As I say, they

5 are tech spec values, and they have to test I think

6 every -- every five or 10 years. A certain period

7 they do have to test and meet a requirement. This

8 leakage rate varies with a different reactor design.

9 Okay. Technical topics of interest is

10 this, that ESBWR design doesn't provide an active

11 fission product mitigation system, such as safety-

12 related spray system, which I believe is most

13 efficient mitigation system to remove a fission

14 product in a containment.

15 ESBWR, they don't provide any safety-

16 related filtration system other than the ones in the

17 control room that have been built in the system. So

18 like a current operating PWR, all of them has like a

19 standby gas treatment system, which removes the

20 aerosol particulate, a HEPA filter, and they have a

21 charcoal filter to remove iodine. Those are very

22 effective in mitigation -- active mitigation system.

23 ESBWR, they do not have any such active

24 mitigation system. Instead, the design provides the

25 six -- I listed here the passive fission product

1 mitigations. I'll go each item in subsequent slides,
2 but the first one is the fission product, natural
3 deposition in the containment. This is somewhat
4 similar to the AP600 and AP1000 approach. They also
5 claimed fission product removal by this natural
6 deposition. This plays a very major role in the ESBWR
7 design for removing a fission product.
8 And the next one is fission product
9 removal by passive containment cooling system. Of
10 course, this is very unique to the ESBWR design inside
11 of containment.
12 MR. WALLIS: How does it remove? Does it
13 flow into the condensate or something?
14 MR. LEE: Yes, the subsequent slide will
15 show -- I'll explain in more detail.
16 Also, they rely on low containment leak
17 rate. In this case, they have a .4 weight percent --
18 but they -- the fission product holdup in the reactor
19 building, and control room pH water in the containment
20 pools to prevent any iodine reevolution from the
21 water, and also fission product natural deposition in
22 the main steam line and main condensers.
23 Those are the mitigation that GE depends
24 on their ESBWR design, and I'll go each item in more
25 detail.

1 The first and foremost important is the
2 fission product natural deposition process in the
3 containment, and which staff performed an independent
4 confirmatory calculation to verify the fission product
5 removal rate proposed.
6 MEMBER BANERJEE: How did GE perform these
7 calculations?
8 MR. LEE: GE proposed that calculation in
9 their DCD.
10 CHAIRMAN CORRADINI: But they used MELCOR
11 also.
12 MR. LEE: Yes.
13 CHAIRMAN CORRADINI: That's what I --
14 MR. LEE: Right.
15 CHAIRMAN CORRADINI: That's what I think
16 you --
17 MR. LEE: Doing this work using a MELCOR,
18 we did ask Sandia National Lab to help us to run this
19 MELCOR code and to verify their number. And, in fact,
20 we have two principal investigators from the Sandia is
21 here to assist perhaps any questions you may have.
22 And this deposition process involves three
23 processes in gravitational settling. This occurs
24 mainly in the containment drywell, containment
25 atmosphere. And the diffusiophoresis, this is the

1 process that mainly occurs in the PCCS condenser and
2 the thermophoresis is.
3 And the diffusiophoresis is, of course,
4 associated with steam condensation on the heat sink.
5 In this case, it is the heat exchanger tubes.
6 CHAIRMAN CORRADINI: And then, once it's
7 deposited, would it wash away with the condensate?
8 MR. LEE: Yes, it will.
9 CHAIRMAN CORRADINI: Okay.
10 MR. LEE: And I have the slide for --
11 CHAIRMAN CORRADINI: That's fine. I just
12 wanted to understand.
13 MR. LEE: -- later. Yes.
14 And we used the MELCOR code. Actually, we
15 used the ESBWR specific containment model in the
16 MELCOR code to get the thermal hydraulic conditions,
17 such as drywell pressure and steam and water flow
18 rates and the condensation rates. Those thermal
19 hydraulic conditions came from the MELCOR code.
20 And also, we performed -- maybe I should
21 say we are performing -- oh, okay, in this case we did
22 perform quantitative analysis of uncertainty in
23 predicting the removal rate using Monte Carlo sampling
24 method. This is -- again, Sandia did it for us, and
25 it shows in the next graph.

1 This is the accident scenario 1 that GE
2 described this morning. This is the reactor vessel
3 bottom drain line failure. This has -- well, this
4 assumed no isolation condenser, no standby liquid
5 control system, or no gravity-driven cooling systems
6 available. But automatic depressurization system will
7 work, and this is the removal rate we are comparing
8 with the GE values.
9 MEMBER BANERJEE: Now, you say used in
10 RADTRAD. Is that --
11 MR. LEE: RADTRAD is --
12 MEMBER BANERJEE: What is that?
13 MR. LEE: -- that's the computer code to
14 calculate the dose that GE used, and we would be using
15 also RADTRAD code.
16 MEMBER BANERJEE: But the black line is --
17 MR. LEE: The black line is GE values.
18 MEMBER BANERJEE: How did they calculate
19 that, with MELCOR, the same code?
20 MR. LEE: Yes, I believe they used the
21 MELCOR code to calculate --
22 MEMBER BANERJEE: And it was using a
23 different containment model, a different containment
24 nodalization, or what is different between the GE and
25 the Sandia calculations?

1 MR. KALINICH: Would you like me to
2 clarify this for you?
3 MEMBER BANERJEE: Yes.
4 MR. KALINICH: I probably don't need the
5 mic, but if you insist.
6 CHAIRMAN CORRADINI: They insist.
7 MR. KALINICH: Never had anyone tell me
8 I'm not loud enough.
9 CHAIRMAN CORRADINI: This is for
10 posterity, not for volume. This is to get it on tape,
11 not to --
12 MR. KALINICH: No problem. My name is Don
13 Kalinich. I'm with Sandia National Labs. I work for
14 Randy Gauntt, and I guess -- what's our department
15 called now?
16 MR. GAUNTT: Reactor Model Analysis.
17 MR. KALINICH: There we go. And basically
18 what we -- what was done was GE ran a full ESBWR
19 reactor model, so they had the full core package, a
20 containment. They ran the model, MELCOR predicted how
21 the core would fail, what the release would be, how
22 that release would go to the containment, and they
23 calculated a containment removal coefficient.
24 What we did is we had a separate ESBWR
25 MELCOR model. We took the containment-only portion of

1 that, and then we used the flows between the reactor
2 side and the containment side from the GE model as
3 boundary conditions on our model. So our containment
4 is modeled slightly differently. I mean, you still
5 have a drywell and a wet well, and all of that, but
6 how you nodalize it and what your heat structures
7 might look like, there is some differences. So --
8 MEMBER KRESS: When you say you use
9 MELCOR, MELCOR has meltdown models, fission product
10 release models.
11 MR. KALINICH: That's right.
12 MEMBER KRESS: You didn't do that.
13 MR. KALINICH: We didn't do that. What we
14 did is -- that's what GE did. GE did a full-on, let
15 MELCOR predict what's going to happen.
16 MEMBER KRESS: And nothing happens, right?
17 MR. KALINICH: No. Actually, it does,
18 because they go in and they do -- they walk through
19 this stylized scenario where basically they suppress
20 the GDCS operation, so that they get a core melt. And
21 then, right before they get lower head failure, they
22 turn the system back on, so that you have something --
23 MEMBER KRESS: So that's where they get
24 their source term.
25 MR. KALINICH: That's where they get their

1 source term.

2 MEMBER BANERJEE: But this is the source

3 term coming out of the --

4 MEMBER KRESS: Out of the containment --

5 into containment.

6 MR. KALINICH: In the containment from --

7 MEMBER BANERJEE: And what about

8 deposition within the system itself?

9 MR. KALINICH: That's what they

10 calculated.

11 MEMBER BANERJEE: Yes. No, no, I'm saying

12 within the primary cooling system.

13 MR. KALINICH: That would be included in

14 their calculation.

15 MR. LEE: Yes. NUREG-1465, those numbers

16 are already considered.

17 MEMBER BANERJEE: I'm just trying to

18 understand what you did.

19 MR. KALINICH: Well, I'm getting to that.

20 Okay? So that's what GE did. What we did is we

21 didn't run a full reactor model, because we wanted to

22 do an uncertainty analysis, and these models take on

23 the order of five to 10 days to run, and we wanted to

24 run 150 realizations. And even with a rack of

25 servers, it's just not tractable to run the full model

1 that way. So what we did was we said, okay, we just
2 want to run the containment side.
3 So we took a containment-only, just the
4 containment side, and we drove it using the results
5 from GE's work as boundary conditions.
6 MEMBER BANERJEE: But where was the
7 boundary condition?
8 MR. KALINICH: The boundary conditions
9 were --
10 MEMBER BANERJEE: At the break or whatever
11 it was?
12 MR. KALINICH: The break, the flows from
13 the SRVs, the flows from the DV -- the
14 depressurization valves, the flow back into the
15 reactor out of the GDCS pools. So, basically, if you
16 think about it, if you just kind of drew a line
17 between the containment and the reactor vessel, what
18 we did is anything that was passing in and out as
19 through a MELCOR flow path, we turned into a source or
20 a sink in our containment-only model.
21 And we have a report where we go in and we
22 say, "Here is what GE's results look like in terms of
23 drywell temperature, drywell pressure," and we compare
24 our results to it to show that we are getting the same
25 sort of behavior. So then what we did is rather -- so

1 the question now is: what source term did we use? We
2 used NUREG-1465, so we applied the NUREG-1465, you
3 know, what fractions come out in the gap, what
4 fractions come out for early in-vessel to the ESBWR,
5 core inventory, and then we just source those directly
6 into the drywell.
7 So we basically followed the regulatory
8 prescription, and then what we did is we varied the
9 aerosol physics parameters, things like what's the
10 mass median particle size diameter? What's its
11 geometric standard deviation? You know, things having
12 to do with Cunningham Slip Factor. There's about 12
13 of them, and we have those documented in a report,
14 what we did, how we picked them.
15 And we ran 150 realizations, and that's
16 what you're seeing here. So this --
17 MR. WALLIS: Why does it wiggle so much?
18 What's happening to make it bounce around?
19 MR. KALINICH: That's a good question.
20 And if you guys really want, we could try to sit down
21 and -- Not today. I don't think we want to. But we
22 have a report that explains that.
23 CHAIRMAN CORRADINI: I think that's what
24 we would like to get when it's appropriate from the
25 staff. But that would be the starting point.

1 MR. LEE: Yes. It is in draft form right
2 now, and we'll have it final form maybe sometime in --
3 CHAIRMAN CORRADINI: I'll let Amy tell us
4 when we're allowed to see it.
5 MR. WALLIS: But something is really
6 happening every time it goes up and down, something to
7 make it happen?
8 MR. KALINICH: Well, what this is looking
9 at is this is looking at the instantaneous removal
10 coefficient, and so any slight change in the behavior
11 gives you some wiggles in there. And, you know, I
12 mean --
13 MEMBER BANERJEE: But there are some
14 correlated wiggles.
15 MR. KALINICH: Well, we actually do -- we
16 actually have an -- we go in and we do a linear
17 regression on the uncertain parameters to see what is
18 driving the results.
19 MEMBER BANERJEE: So you have an
20 explanation for this? I mean, do you have an
21 explanation why that first dip occurs?
22 MR. KALINICH: Yes.
23 MEMBER KRESS: Is this primarily
24 diffusiophoresis?
25 MR. GAUNTT: I could offer a quick answer

1 to that.

2 MR. KALINICH: Okay.

3 MR. GAUNTT: My name is Randy Gauntt,

4 Sandia Labs. A quick answer to that is most of the

5 fine structure that you see there can be traced back

6 to thermal hydraulic nuances in the problem.

7 MEMBER BANERJEE: And what about the

8 correlated nuances, like all this behavior --

9 MR. GAUNTT: Well, all of those

10 realizations are using the same thermal hydraulic

11 driving conditions. So --

12 MR. KALINICH: Yes. The idea is to look

13 strictly at the uncertainty in aerosol physics.

14 MEMBER SIEBER: That's the spread.

15 MR. KALINICH: That's right. So this is

16 the spread. So any given realization, it is going

17 through the same thermal hydraulic signature. It's

18 just the distribution of particle sizes for the source

19 look different.

20 MEMBER BANERJEE: But say about one hour,

21 your removal coefficient is about two orders of

22 magnitude different from GE.

23 MR. KALINICH: Well, let me explain. The

24 GE curve -- what GE did is they ran one deterministic

25 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

1 aerosol physics? And we didn't use exactly the same
2 model, like --
3 MEMBER BANERJEE: Hopefully, both are
4 converted in some sense.
5 MR. KALINICH: And, in fact, I --
6 MEMBER BANERJEE: It shouldn't make any
7 difference at all.
8 MR. KALINICH: What makes me kind of happy
9 about this analysis is the fact that even though we
10 didn't use exactly the same sort of containment
11 nodalization, we get results that are very similar.
12 So that's -- it's nice to know that, you know, you go
13 in and you change that, and you don't get results that
14 are widely divergent. It makes you feel comfortable
15 that your models are reasonable.
16 MEMBER BANERJEE: Okay. Well, thank you.
17 MR. KALINICH: But that's basically what
18 you are looking at here is 150 realizations of our
19 work with GE's single deterministic realization laid
20 over top of it.
21 MEMBER KRESS: Each determination uses a
22 constant shape factor?
23 MR. KALINICH: Excuse me.
24 MEMBER KRESS: Each determination keeps
25 the shape factor constant?

1 MR. KALINICH: Yes. The shape factors
2 don't vary with time. They vary between realizations.
3 MEMBER KRESS: They vary between
4 realizations.
5 MEMBER BANERJEE: If I understand, you
6 varied these 12 parameters within -- what you said
7 were sort of three parameters and the problem within
8 a certain range in some way that --
9 MR. KALINICH: It would depend -- like,
10 for example, the mass median particle size diameter,
11 we used the triangle distribution with a lower bound
12 of .1 micron, a peak of two, and a max of five. And,
13 you know, like I said, each one of those -- there is
14 the distribution and there is an explanation for why
15 we believe that's a reasonable distribution to use on
16 those -- on that parameter. It will be in the final
17 report that we provide to the NRC.
18 CHAIRMAN CORRADINI: So in the final
19 report you used RADTRAD also for the dose?
20 MR. KALINICH: No, sir.
21 CHAIRMAN CORRADINI: You used mass --
22 MR. KALINICH: We're just predicting --
23 we're just providing the removal coefficients, and
24 then the NRC is going to do their own RADTRAD
25 analysis.

1 CHAIRMAN CORRADINI: Okay. Thank you.

2 MEMBER ABDEL-KHALIK: Is the aerosol
3 physics the major source of uncertainty in this
4 problem, or could it be the boundary conditions that
5 you took from GE's calculation?

6 MR. KALINICH: Could be.

7 MEMBER ABDEL-KHALIK: So how do you
8 ascertain that?

9 MR. KALINICH: Jay, do you want to answer
10 that question?

11 MR. LEE: No, it's not --

12 MR. KALINICH: No, you don't want to
13 answer it, or no, you --

14 (Laughter.)

15 MR. LEE: Doesn't want to answer it.

16 MR. KALINICH: I'm going to let Jay answer
17 that. Oh, I'm going to defer to my boss on this one.

18 (Laughter.)

19 I was -- this was the problem I was asked
20 to analyze.

21 MR. GAUNTT: I'm trying to process the
22 question. The only variant that is shown in those
23 plots, if you want to call them that, is due to the
24 variance from sampling over aerosol --

25 MEMBER ABDEL-KHALIK: That we understand.

1 MR. KALINICH: But they want to know if
2 like, for example, if there were things that would
3 influence the thermal hydraulic, would that be more
4 important than this?
5 MR. GAUNTT: Oh, I see. I see. Well, I
6 guess in a sense there are three separate scenarios
7 that we have analyzed here, and they all show
8 slightly, you know, different thermal hydraulic
9 transients. And so we've just run all three of those.
10 We have not tried to include thermal hydraulic
11 uncertainty in any given scenario we analyzed here.
12 MEMBER KRESS: This is primarily played
13 out in the --
14 MR. GAUNTT: Yes, and it's very --
15 MEMBER KRESS: How well you calculate
16 those. And probably a lot of it goes into the PCC --
17 MR. GAUNTT: It's a pretty fascinating
18 system. I think there are some more curves, some more
19 diagrams that Jay is going to show. But unlike, you
20 know, your traditional PWR analysis where things just
21 kind of fall out, or you may spray them out, or things
22 like that, this is a very dynamic system. And the
23 vessel, you know, it is designed to sit there and boil
24 water indefinitely. This steam goes into the drywell,
25 and it finds its way into the PCCS, and eventually

1 back into the vessel. So it's a big reflux system.

2 CHAIRMAN CORRADINI: So I guess I -- I

3 don't want to cut off this interesting discussion. We

4 have a time check. In half an hour you will -- the

5 whole team will be done.

6 MR. LEE: I'll try.

7 CHAIRMAN CORRADINI: You will be done in

8 half an hour, so I want you to decide how you want to

9 get there.

10 MR. WALLIS: How realistic --

11 MR. BAVOL: Go fast.

12 MR. WALLIS: How realistic are the thermal

13 hydraulics that go into this? Is this just a vessel

14 that is boiling off into an environment, and it's

15 something that's pretty well understood?

16 CHAIRMAN CORRADINI: They use the same

17 thermal hydraulics as the GE folks.

18 MR. WALLIS: Well, is that something that

19 is contrived, like the way they got to this state, or

20 is it a realistic thing?

21 MEMBER KRESS: Well, you have non-

22 condensables affecting the condensation rate.

23 MR. WALLIS: So it's realistic thermal

24 hydraulics now?

25 MEMBER KRESS: Oh, yes. It's pretty good

1 thermal hydraulics.

2 MR. WALLIS: Okay. So it's not contrived,

3 like how we got to the beginning of this.

4 MEMBER KRESS: And, again, it's assumed

5 well --

6 CHAIRMAN CORRADINI: The initial

7 conditions that initiate it, of course. The rest is

8 calculated.

9 MR. WALLIS: So we have some faith in the

10 thermal hydraulics. Okay.

11 MR. LEE: So the main point to show you,

12 this curve is the -- GE and our numbers is reasonably

13 agreed with, and that's --

14 MR. WALLIS: Well, you did -- you played

15 the same game and got the same result, so I'm trying

16 to figure out if the game is realistic. That's all.

17 MEMBER BANERJEE: Hopefully, MELCOR

18 doesn't give random answers. Hopefully, MELCOR

19 doesn't give random answers. We are reassured by

20 that.

21 MR. LEE: Yes. We did use the same MELCOR

22 code.

23 MR. WALLIS: We have to believe Tom Kress,

24 I think.

25 MR. LEE: Okay. This is just the same

1 curve and the same way we did, and this is for
2 accident scenario 2, as GE described it this morning.
3 There is a slight difference in the GE value and ours
4 from, let's say, five hours to the 10. GE values are
5 slightly higher than our numbers.
6 The Y-axis in the low scale, so we are
7 really talking about difference between .1 to the .5
8 removal rate. But when we reach this point, like
9 after six hours, most of the aerosol has been removed.
10 We are talking about the small, fine aerosol at this
11 stage of time.
12 MR. WALLIS: What matters is the
13 deviations from the values when they are big.
14 MR. LEE: Right.
15 MR. WALLIS: We don't really worry about
16 the small values. There are some fairly big
17 deviations at the beginning where it makes a
18 difference.
19 MR. LEE: We do have some explanation of
20 the way it -- the curve shapes, but we are not going
21 to go into detail. But we will give you an idea.
22 And the next curve is the accident
23 scenario 3. In this case, GE value is more
24 conservative.
25 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 --

1 MR. KALINICH: I don't think you want me
2 up there if you want to get through this.
3 CHAIRMAN CORRADINI: No, we don't. And I
4 think we can defer this at this point, since you
5 haven't gotten a dose calculation from this. I think
6 when that occurs, then we can look at it --
7 MR. WALLIS: Presumably, Sandia predicted
8 the integral of all of this removal?
9 MR. GAUNTT: Yes, we have. Yes.
10 MS. CUBBAGE: Right. I guess the --
11 MR. WALLIS: You're not going to tell us
12 that? Did you -- how much did you remove?
13 MR. GAUNTT: Out at that point in time,
14 it's -- I don't know how many nines we're talking
15 about, but it's -- it's mainly residual, very fine
16 aerosol that's hanging up in the wet well vapor space.
17 MR. KALINICH: Yes. If you take a look,
18 what's driving the latter time curves is what is going
19 on with the small amount of material that's hanging
20 out in the wet well. And I don't even need to say
21 this, because you're not going to finish.
22 MS. CUBBAGE: I know, but for the
23 transcript you have to be at a mic.
24 MR. LEE: Next slide.
25 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 --

1 MEMBER KRESS: Historically, you could use
2 contain, but --
3 CHAIRMAN CORRADINI: Historically, contain
4 is inside of MELCOR. Hector is inside of MELCOR. All
5 of those basic physics have been subsumed into MELCOR.
6 MEMBER BANERJEE: And General Electric
7 uses the NRC code.
8 MR. LEE: MELCOR, yes. I suppose they
9 could have used MAPCODE, for example.
10 CHAIRMAN CORRADINI: Then you'd have more
11 questions.
12 MEMBER KRESS: Yes, you'd have lots of
13 questions then.
14 CHAIRMAN CORRADINI: I think you should be
15 happy.
16 (Laughter.)
17 MR. LEE: Randy, do you want to describe
18 this open item, and then we'll --
19 MR. GAUNTT: Yes. Some work that is
20 ongoing right now for Jay is tied in with the dynamics
21 of iodine behavior in this reactor. And, in
22 particular, the chemistry leading to partitioning of
23 iodine, either in forms that are retained in the pools
24 or else that can be evolved out as an elemental form.
25 And this diagram here kind of shows the --

1 illustrates the cycle that is in place. In the ESBWR,
2 there is always water in the primary system, and it is
3 continually boiling. That is how the heat is
4 ultimately taken out of the core. That steam goes
5 into the drywell, ultimately through the PCCS system,
6 condenses in the PCCS and drains into the GDCS and
7 ultimately back to the vessel. So there is a
8 continuous cycle there refluxing through the system.
9 Now, in the regulatory model here that we
10 have, we toss in -- fission products into the drywell.
11 That is what the NUREG-1465 is, and those fission
12 products include cesium iodide, some amount of
13 elemental iodine. And in the chemistry model, what
14 happens ultimately is the cesium iodide begins its
15 life in the drywell as particulate. The PCCS -- they
16 are swept into the PCCS by the steam, pretty
17 effectively deposited on the water film in the PCCS.
18 Now, the cesium hydride -- the cesium
19 iodide is aqueous. And it makes its way back into the
20 vessel, and the chemistry model now assumes you have
21 CS plus and I minus. So you have this collection,
22 this sweeping, this scavenging of the cesium iodide.
23 It's gathered into the vessel, becomes aqueous.
24 MEMBER KRESS: It's in the vessel water.
25 MR. GAUNTT: It's in the vessel water.

1 MEMBER KRESS: Where there's a lot of
2 radiation.
3 MR. GAUNTT: Where there's a lot of
4 radiation.
5 MR. WALLIS: So, then, it's released again
6 when it comes out of the vessel? Is it steam?
7 MR. GAUNTT: Yes, it's a cycle here, and
8 we -- and we are out to characterize what is that
9 partitioning.
10 Now, in the vessel --
11 MEMBER KRESS: This is a lot different
12 than normal.
13 MR. GAUNTT: A lot different than your
14 normal sump kind of situation in --
15 MEMBER KRESS: Seems like you're just
16 moving iodine around.
17 MR. GAUNTT: You're moving it around, and
18 what we are attempting to do in our analysis is
19 understand the dominant rate processes here. Within
20 the vessel, there is iodine chemistry going on. It is
21 pH-dependent, and so our model considers the presence
22 of buffers, sodium pentaborate, it considers the
23 radiolysis of water, it considers the --
24 MEMBER KRESS: It won't have any nitrogen
25 in there, will it?

1 MR. GAUNTT: I'll get to the nitrogen. A
2 little bit of a research uncertainty is how much
3 cesium comes in as cesium hydroxide. And emerging
4 evidence from Febus experiments suggests a lot less
5 than we thought. And that has an impact on the pH of
6 the vessel water.
7 And the pH is really the principal thing
8 that determines how much iodine stays in that water
9 and how much gets evolved out in gaseous form. That's
10 the whole point of the water chemistry model is to
11 determine what that pH is, and then determine the
12 transport of gaseous iodine out of the water into the
13 air space in the upper vessel.
14 From there, it is swept out into the
15 drywell, and, again, back into the PCCS where gaseous
16 iodine can, once again, return into the water film and
17 be taken back to the vessel. So there are these rates
18 going on within the atmosphere of the drywell. There
19 is -- then, it gets worse. There is radiolysis in the
20 air, creating nitric acid.
21 In the lower drywell, there is radiolysis
22 and thermal attack on cable insulation that's
23 releasing hydrochloric. And both of these sources of
24 acid are also swept through the PCCS system, and they
25 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

1 to get a -- some sort of steady state thing in those
2 rate --
3 MR. GAUNTT: That's ultimately what we're
4 looking for is, what is quasi-steady I2 concentration
5 in the drywell?
6 MEMBER KRESS: And even if you have a leak
7 rate, it is going to -- it is going to try to hold it
8 at that steady state anyway. It's going to set there
9 and leak iodine out.
10 MEMBER BANERJEE: I guess the thing is:
11 what is really important here? What is the really
12 important series of steps here? What's the important
13 physics of chemistry?
14 MEMBER KRESS: Well, that's what they're
15 trying to find out.
16 CHAIRMAN CORRADINI: My guess is --
17 MEMBER KRESS: What is this going to have
18 to do with this determination of the pH? That's not
19 an easy task.
20 CHAIRMAN CORRADINI: If I might just
21 interject, the complete presentation has got to be
22 finished in 15 minutes. How are you doing?
23 MR. LEE: Probably five. Next slide,
24 please.
25 (Laughter.)

1 CHAIRMAN CORRADINI: Including your
2 colleagues next door there?
3 MS. CUBBAGE: Yes.
4 CHAIRMAN CORRADINI: What I guess I'm
5 trying to say is --
6 MR. LEE: One colleague has just one
7 slide.
8 CHAIRMAN CORRADINI: Let me characterize
9 -- let me just characterize it a bit differently. So
10 there is a lot of details in the physics that we'd
11 like to know. But if you don't have a dose
12 calculation to compare to what we have from the
13 applicant at this point, perhaps we can delay this
14 until we have something to compare and investigate the
15 details of why it is the same or different.
16 I mean, it's interesting, but we're going
17 to ask you for a bottom line, and I can see you don't
18 have one on this part. So I don't think I want to
19 discuss this and rediscuss it later.
20 MS. CUBBAGE: Right. But I do think at
21 this stage, since we are several years into the
22 review, we definitely would like the nod that we are
23 headed in the right direction, asking the right
24 questions.
25 CHAIRMAN CORRADINI: Go ahead.

1 MR. LEE: Okay. Now, this is the -- GE
2 also depend on the low containment leakage in the case
3 of ESBWR. They are proposing .4 percent, but they --
4 I just listed three more numbers. It's for comparison
5 purpose. And by the way, ESBWR do have a secondary
6 contained reactor building, so it was surrounding a
7 containment. So that may be a little bit higher, for
8 example, compared to the 81,000, which they do not
9 have a secondary containment.
10 And the ABWR, we certified with .5, and
11 the EPR is currently proposing .25, which is just for
12 the comparison. So every applicant, they pick their
13 own number --
14 CHAIRMAN CORRADINI: Right.
15 MR. LEE: -- and whether they can meet the
16 dose at the site boundary.
17 Okay. This is a second open item, open
18 issue. This has to do with fission type of hold up in
19 a reactor building. Now, GE is not asking any errors
20 of deposition or played out in this reactor building,
21 but they do assume 40 percent mixing efficiency, which
22 means they have a perfect mixing in a 40 percent value
23 over reactor building. The reactor building is big,
24 like more than two million cubic feet.
25 And so they are just using the usual and

1 hold up in the decay purpose, and they are assuming 50
2 percent per day leak rate from the reactor building.
3 We are discussing with GE right now as what is the
4 basis for -- technical basis for assuming 40 percent
5 mixing efficiency.
6 MEMBER BANERJEE: Doesn't this come out of
7 your MELCOR calculation?
8 CHAIRMAN CORRADINI: This is outside of
9 the drywell. This is the reactor building on the
10 other side.
11 MEMBER BANERJEE: Okay. Oh, I see.
12 MEMBER KRESS: MELCOR can do that, too.
13 CHAIRMAN CORRADINI: Once they do the
14 analysis.
15 MR. LEE: Yes, but they are not requesting
16 an aerosol removal.
17 CHAIRMAN CORRADINI: We're at the point
18 now where you're asking for justification for their
19 number.
20 MR. LEE: Yes.
21 CHAIRMAN CORRADINI: Okay.
22 MR. LEE: We are still negotiating. This
23 is open.
24 MR. UPTON: And GE would like to comment
25 on that when there is an appropriate time and tell you

1 what we're doing.

2 CHAIRMAN CORRADINI: Hold it for a moment.

3 MR. UPTON: Okay.

4 MR. LEE: The third open issue is control

5 of pH in the water over containment pools to prevent

6 iodine evolution. And there is -- like Randy

7 mentioned, there is acid formation of -- due to the

8 radiolysis of the cable insulation material producing

9 the hydrochloric acid, and also the nitric acid is

10 the --

11 MS. CUBBAGE: Yes, I think we've --

12 MR. LEE: -- reaction with the --

13 MS. CUBBAGE: I think we've covered this

14 issue already.

15 MR. LEE: Yes, okay.

16 MS. CUBBAGE: Right?

17 MR. LEE: So the base formation I think

18 Randy covered, cesium hydroxide. We are injecting

19 sodium pentaborate --

20 MR. WALLIS: I missed that. Is there

21 actually a plan to inject sodium pentaborate?

22 MR. LEE: Yes, that is the buffer.

23 MR. WALLIS: I wasn't sure. I missed that

24 when I read it.

25 MR. LEE: Yes. That goes to the

1 reactivity control, but certainly this will buffer the
2 water pH.
3 And the fourth and the last significant
4 open issue is aerosol deposition in the main steam
5 line and the main condenser. The GE ESBWR main steam
6 line, main steam drain line, and the main condenser
7 are all designed for the SSE criteria, and the main
8 steam isolation valve, like we discussed, is 200 cfh.
9 And GE is assuming that leak rate to continue for
10 entire duration of the LOCA accident, which is 30
11 days.
12 CHAIRMAN CORRADINI: So let me just make
13 sure I understand the point here. This is not that I
14 have failed to isolate. This is once I isolate, what
15 is leaked through the isolation.
16 MR. LEE: Right.
17 CHAIRMAN CORRADINI: Okay.
18 MR. LEE: It's leaking from --
19 CHAIRMAN CORRADINI: Within the --
20 MR. LEE: Right.
21 CHAIRMAN CORRADINI: Okay. Thank you.
22 MR. LEE: Yes. And we are performing
23 independent confirmatory calculations to verify that
24 removal rate GE proposed.
25 Now, these -- next to all of these

1 figures, we just received from Sandia last week.

2 CHAIRMAN CORRADINI: So let's move past

3 them.

4 MR. LEE: Okay. Significant open items,

5 we discussed all of these four items. Those are

6 significant. There are other open items, open issues,

7 but they are less significant and we are not going to

8 discuss them.

9 Okay. We have one COL action item. This

10 has to do with any COL applicant. What we have

11 referenced is ESBWR design has to demonstrate that

12 onsite chi over Q value is indeed less than what GE

13 hypothetically assumed chi over Q value.

14 CHAIRMAN CORRADINI: So this one is -- at

15 least I want to make sure I understand it -- so the

16 point is is that the applicant, relative to how I have

17 the fission product source diffuse and then create

18 dose, the applicant in any one particular site is

19 going to have to show it fits within this envelope.

20 MR. LEE: Yes.

21 CHAIRMAN CORRADINI: For the chi over Q.

22 MR. LEE: Right.

23 CHAIRMAN CORRADINI: Okay. Thank you.

24 MR. LEE: The next slide shows the values

25 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

1 of calculations --

2 MR. WALLIS: Yes, right.

3 CHAIRMAN CORRADINI: -- to show they are

4 okay.

5 MR. WALLIS: I can understand North Anna,

6 because it is a certain place.

7 CHAIRMAN CORRADINI: I think they may have

8 picked North Anna as one of their starting points.

9 MR. MARQUINO: This is Wayne Marquino.

10 This information is published in the plant FSARs. We

11 looked at a large number of sites which are potential

12 customers, and that was the basis for what we picked.

13 CHAIRMAN CORRADINI: Doesn't the utility

14 requirements document give you a site characteristic?

15 MR. MARQUINO: I don't think so. At least

16 that's not what we used.

17 MR. LEE: For example, in North Anna, in

18 the ESP, the chi over Q values are lower than the

19 current ESBWR proposed chi over Q values. But those

20 are the typical -- the numbers for the ABWR and AP1000

21 and USEPR.

22 MR. WALLIS: Any pictures here of -- I

23 don't see any pictures.

24 MEMBER BANERJEE: He has the last slide,

25 a color slide.

1 CHAIRMAN CORRADINI: Thank you very much.
2 MR. LEE: Thank you.
3 CHAIRMAN CORRADINI: Appreciate it.
4 Do we have the next part of the team?
5 MR. LEE: I'd like to introduce Ben Parks
6 and Chris Boyd. They are going to be discussing the
7 ATWS and the boron mixing.
8 MR. PARKS: These are the topics that we
9 are covering in this presentation. Let's move to the
10 next slide, please.
11 The staff's anticipated transient without
12 scram review, we observed that GE analyzed typically
13 limiting ATWS scenarios. The question comes up: how
14 do you know that an MSIV closure is limiting? There
15 is an evaluation of I think nine different types of
16 scenarios that include a failure to scram, and GE's
17 evaluation shows that the MSIV closure remains the
18 limiting one.
19 We looked at traditional acceptance
20 criteria. We're looking for a coolable geometry,
21 acceptable peak vessel pressure, containment
22 integrity. GE presented you with those values, those
23 parameters. And our open items right now are boron
24 mixing, and we are seeking to confirm that with the
25 CFD analysis and the TRACG applicability. The TRACG

1 applicability is under review currently.

2 Can we go to the next slide, please?

3 I noted an open item when I presented on

4 the standby liquid control system. There was a

5 question about the injection shutoff valves, but I

6 heard that this was discussed yesterday. Do we need

7 to address this now?

8 CHAIRMAN CORRADINI: Is this about

9 potential failure of the shutoff valves and continued

10 nitrogen injection?

11 MR. PARKS: Yes.

12 CHAIRMAN CORRADINI: Is that what you're

13 asking?

14 MR. PARKS: That's correct. We -- I did

15 another review after the meeting, and I discovered

16 that -- well, in terms of the ATWS analysis, three out

17 of four isolation condensers are available, so they

18 assume a degraded performance. But the valves are

19 installed in series, and they have a diverse power

20 supply. And the initiation -- or the shutoff logic is

21 a two out of four redundant level sensor system.

22 So I think that a failure is quite

23 unlikely, and they are also subject to the in-service

24 inspection program. So, I mean, they are safety-

25 related. So that is where we stand on that,

1 basically.

2 CHAIRMAN CORRADINI: I think that will

3 help us relative to the reliability. I feel some of

4 us are still thinking about, even if, what occurs. So

5 we can -- we can deal with that at a later time.

6 MR. PARKS: Sure. Then, finally, we

7 looked at boron mixing. Where we started with this

8 review was the fact that we have studies of scale

9 models from previous vintages of BWRs, and we think

10 because the injection geometry here is different, it

11 warrants a little bit further -- of course, a scale

12 model would be nice, but we don't have one, and that

13 is a very complicated and expensive task.

14 So our approach here is to -- first, we

15 asked GE to renodalize their TRACG model to provide a

16 more sort of limiting picture of boron transport.

17 And, second, for our own assurances, we pursued a CFD

18 calculation to get a better picture of how the boron

19 transports to compare it to the TRACG predictions.

20 MEMBER BANERJEE: Using a different code?

21 MR. PARKS: We used FLUENT .

22 MEMBER BANERJEE: Which is now owned by

23 the same company.

24 CHAIRMAN CORRADINI: They don't know that.

25 Don't burst their bubble.

1 MEMBER BANERJEE: Never mind.

2 MR. PARKS: Was that the case when we

3 started?

4 (Laughter.)

5 Our CFD analysis is a 45 million cell

6 model. It is of the bypass. We did not model the

7 fuel assemblies. We did model --

8 MR. WALLIS: Does it have two-phase flow

9 in it, or is it -- dual or single phase?

10 MR. PARKS: We modeled the lower portion

11 of the --

12 MR. WALLIS: All single phase.

13 MR. PARKS: -- course with all single

14 phase.

15 MEMBER BANERJEE: And you're only modeling

16 the bypass frequency.

17 MR. PARKS: That is correct.

18 MEMBER BANERJEE: And that is assumed not

19 to be boiling.

20 MR. PARKS: That is correct.

21 MEMBER BANERJEE: Right.

22 MR. WALLIS: Only in the core as well.

23 MEMBER BANERJEE: They are not analyzing

24 the core.

25 CHAIRMAN CORRADINI: They are looking at

1 the bypass, similar to a --

2 MR. PARKS: The interstitial is between

3 the assemblies we did model. But it bears mention

4 that most of the mixing behavior we observed were on

5 the bottom portions of the core, and our model only

6 covers a certain height of the core.

7 We got our geometry data to build this

8 model from audit activities. GE also provided us a

9 significant amount of data, and we also surveyed the

10 TRACG input data to get additional conditions,

11 boundary conditions.

12 We based it on the performance

13 requirements, things that we observed in the ITAAC

14 about the performance of the model.

15 MR. WALLIS: So how does your CFD model

16 the turbulent mixing, or whatever kind of mixing

17 process is going on here? Because it is mixing the

18 canvases isn't it?

19 MR. BOYD: It is just the standard -- they

20 used a standard turbulence model to model those jets.

21 MR. WALLIS: It applies to this kind of a

22 geometry, or --

23 MR. BOYD: The jets are high-speed jets,

24 and they jet out into that outer opening. And we used

25 a model that was most applicable for jets, although it

1 has not been validated for these specific jets.

2 I don't think that is really the issue.

3 What we have is a lot of entrainment. There is a lot

4 of flow coming down. Those jets are almost like

5 pressure washers. They have about the same velocity

6 as a pressure washer you'd get at Home Depot. There

7 is 32 of them. They are basically stirring everything

8 up out in that outer region and putting basically a

9 borated solution, which is then drawn in.

10 The path of least resistance to get into

11 the core is low, because the fuel supports have less

12 blockage than the channel boxes themselves. And what

13 you -- the jets put in something equivalent to about

14 500 gpm all in together. The flow coming down from

15 the top is an order of magnitude higher, so --

16 MEMBER BANERJEE: How is it coming?

17 MR. BOYD: The flow -- GE would have to

18 answer that. I used it as a boundary condition from

19 TRAC, but there is some flow in the channels --

20 MR. WALLIS: Circulation --

21 MR. BOYD: -- and it is going out in these

22 leakage paths, and it comes back down through.

23 So you've got an order of magnitude more

24 flow coming down. That flow has two choices. It can

25 come down through those little interstitional areas,

1 the lattice, and have to pass the blades, which are
2 inserted, or it can make its way out to the side,
3 which is what we found that it does. And then, it's
4 going to go down, get close to the bottom, and then
5 sweep in. Each channel is pulling.
6 So what you've got is this big flow
7 pattern that comes in and goes down, and then 10
8 percent of that are these jets that are 32 of them at
9 120-degree angles and 90-degree spread. They kind of
10 flood that area and mix it up pretty well.
11 I don't think the turbulence model is too
12 critical there, because it is pretty well mixed before
13 it starts in. And what you see is it swept in.
14 MR. WALLIS: It's convected in, really.
15 MR. BOYD: It is convected in, so the
16 TRACG model, not only when it puts that wall up and
17 holds flow out from going in, what it is really doing
18 is it is holding the flow that is coming down from
19 going out and sweeping it in. That's the real
20 conservativism of that wall.
21 So the channels in the middle that are
22 pulling flow in, they can pull flow straight down,
23 because there is a wall, where in the CFD calculations
24 they are really pulling more from the side, the flow
25 coming down goes out to the side and then sweeps in,

1 carrying the boron in.

2 So that is basically what is going on.

3 And we did a bunch of sensitivity studies. The main

4 concern I had was what -- well, what if I could feed

5 those bundles in the middle with some flow from up

6 top? So what I did is I took all of the flow and I

7 concentrated it into ring 1, and tried to shove flow

8 down through the middle, just to see if I could break

9 GE's calculation. It's still --

10 MR. WALLIS: And off to the side --

11 MR. KALINICH: It's off to the side.

12 That's the path of least resistance.

13 MR. WALLIS: So the bottom line is that

14 you get about as much boron in the core as they did?

15 MR. BOYD: Yes. If you look at our boron

16 versus time, we get the same traces that they do. The

17 only thing that is going to change the -- we did a

18 bunch of sensitivity studies, just to see what would

19 change it. And the only thing that changed it were

20 the obvious things. If you inject less into the jets,

21 you get less boron. And if you pool more out through

22 each channel, then you'll have less built up in the

23 core.

24 MEMBER BANERJEE: So these are your

25 predictions?

1 MR. BOYD: Those are -- I didn't put --
2 that Region A is the inner ring that they showed
3 earlier. And what you'll see is the black curve are
4 the NRC predictions, the red curve are the GE
5 predictions.
6 MR. WALLIS: It's the same.
7 MR. BOYD: I'm sorry. That's ring 3,
8 that's the outer peripheral region, and you'll see the
9 TRAC -- what that's showing is that TRACG is storing
10 boron out at that outer region. It's not letting it
11 in.
12 And then, you go into the inner region,
13 and you'll see the NRC predictions and the GE
14 predictions showing boron making it to the inner core,
15 TRACG showing none. Ours are a little higher because
16 of the way we did the lower -- they took their blades
17 and they made them as thick as the -- they blocked off
18 everything in there and cut out volume with their
19 blades, made a conservative approach that way.
20 I used an infinitely thin wall-thick
21 blade. I have a little more volume. I had upped the
22 resistance to make it flow the same, but I had more
23 volume. They did a complete blockage. They had less
24 volume. And then, my fuel supports are a little bit
25 smaller than theirs, so I have a little bit more

1 volume. That's why you'll see a little bit more boron
2 building up.
3 MEMBER BANERJEE: It's just a volumetric
4 effect.
5 MR. BOYD: That's a volumetric effect.
6 MEMBER BANERJEE: Yes.
7 MR. BOYD: But the penetration times look
8 very similar. The height of the boron layer I
9 compared, and it looks very similar.
10 MR. WALLIS: It's really the convection
11 pattern that does that, and it sweeps it in.
12 MR. BOYD: That's a convection issue. I
13 don't think the turbulence model matters at all. I
14 think we could dump the boron in there in different
15 ways and get the same answer.
16 MR. WALLIS: This is very reassuring. I
17 mean, it seems to me that we shouldn't -- we shouldn't
18 have these extraordinarily conservative TRAC models
19 which really mislead us about how dangerous it might
20 be when it isn't.
21 MR. PARKS: Well, they still comply with
22 the acceptance criteria.
23 MR. WALLIS: It's better to have a
24 realistic model like this.
25 MEMBER BANERJEE: Well, this is basically

1 a density-driven flow event?

2 MEMBER BANERJEE: There is actual

3 convection.

4 MR. BOYD: It is like a chimney-driven

5 flow.

6 MEMBER BANERJEE: I see. With a buoyancy

7 effect.

8 MR. BOYD: But there's cooling flow.

9 MEMBER BANERJEE: Yes.

10 MR. BOYD: Now, our CFD models were

11 drastically different, too. There were different

12 approaches we focused on different things.

13 MR. WALLIS: But it's the heating and the

14 vents he changed that's causing this motion, this --

15 MR. BOYD: In the channels, though, are

16 really driving it. And we're not modeling -- we're

17 modeling those boundary conditions, pulling in through

18 these little holes. So it --

19 MR. WALLIS: So the chimney effect, you

20 mean, is due to the heating effects.

21 MR. BOYD: Right.

22 MEMBER KRESS: What happens to the sodium

23 pentaborate over the long term? Does it stay in

24 solution, or do you boil off and take it with the

25 steam, or does it concentrate? And is there a

1 possibility of recriticality in the long term? You
2 still can't put the rods in, I suppose.
3 MR. PARKS: I don't believe so. I'm going
4 to defer to Wayne. I think we asked for a 72-hour
5 analysis, but that might have been SVO. Wayne?
6 MR. MARQUINO: Yes. The boron stays in
7 the liquid phase.
8 MEMBER KRESS: When the steam goes out?
9 MR. MARQUINO: Yes. There is a free
10 surface in the upper plenum here, so you have steam
11 coming up. The liquid stays in the vessel.
12 MEMBER BANERJEE: Not in the chimney? It
13 doesn't go up into the chimney, the boron?
14 MR. MARQUINO: No. The other -- what was
15 your other question?
16 MEMBER KRESS: Well, I was concerned about
17 recriticality in the long term.
18 MR. MARQUINO: Right. Right. Another
19 thing that we looked at was if you depressurized the
20 reactor, that actually causes voiding and a better
21 response. And then, at low pressure, we didn't see
22 the reactor go critical at the end of the
23 depressurization. So we do not see a recriticality
24 during the ATWS, even if you hit the depressurization
25 curve in the EPG.

1 MEMBER SHACK: Wasn't there some
2 pentaborate carryover in the MELCOR calculations?
3 MR. MARQUINO: In the MELCOR calculation,
4 there is transport of the sodium pentaborate through
5 the liquid phase, out the break, and into the lower
6 drywell.
7 MEMBER SHACK: So you're losing it that
8 way, then.
9 MR. MARQUINO: Yes.
10 MEMBER KRESS: In the liquid.
11 CHAIRMAN CORRADINI: Do you want to go
12 back to your original slides?
13 MR. BAVOL: That was our final slide.
14 CHAIRMAN CORRADINI: Oh, okay.
15 MEMBER BANERJEE: Could we have copies of
16 your backup slides?
17 CHAIRMAN CORRADINI: You will be able to
18 get copies. I think as we have had in the past with
19 the subcommittees, Gary will assemble it and send us -
20 on a CD.
21 MEMBER BANERJEE: Including the backup
22 slides.
23 CHAIRMAN CORRADINI: Sure, yes, as part of
24 it.
25 MS. CUBBAGE: Those that were presented.

1 MEMBER BANERJEE: Sorry?

2 MR. WALLIS: I mean, Chris has presented
3 a nice picture. What is the conclusion of the
4 management?

5 MR. SHUAIBI: The reason that we asked the
6 Office of Research to do this was to confirm that
7 whatever TRACG was doing was something that was
8 conservative, and that we could accept. So I think
9 what you've -- what we've done is the Office of
10 Research has done some CFD analyses. They have
11 confirmed that the analyses that were performed using
12 TRACG were in fact conservative. That is --

13 MEMBER BANERJEE: But there is still
14 some --

15 MR. SHUAIBI: And I'm looking at -- I'm
16 looking at Chris I guess to nod for me.

17 MR. PARKS: Yes, this is our draft report
18 at this point.

19 MEMBER BANERJEE: But there are still some
20 further studies with TRACG nodalization or something
21 going on, or not? Am I misreading --

22 MR. PARKS: The TRACG nodalization, that
23 would be a part of the Chapter 21 review.

24 MEMBER BANERJEE: Okay. But I had noted
25 -- maybe I just misread what you wrote there.

1 MR. PARKS: We had -- that was the
2 separation, because we were concerned that there was
3 I guess a bit of smearing of the boron --
4 MEMBER BANERJEE: Right.
5 MR. PARKS: -- that would non-
6 conservatively I guess overstate the boron mixing, and
7 so they separated the peripheral bypass, since
8 we're --
9 MEMBER BANERJEE: Oh, that was the
10 blocking thing they did.
11 MR. PARKS: Right. And you saw that on
12 our slide, where their prediction in ring 3 or ring 4
13 was higher.
14 MEMBER BANERJEE: Yes. Okay.
15 MR. WALLIS: So you would -- if you
16 believe this, you would be able to accept the use of
17 much less boron.
18 CHAIRMAN CORRADINI: They don't believe it
19 that much.
20 MEMBER BANERJEE: Let's not go there.
21 (Laughter.)
22 CHAIRMAN CORRADINI: They don't believe it
23 that much.
24 MR. PARKS: That hasn't been proposed.
25 CHAIRMAN CORRADINI: Other member

1 comments?

2 (No response.)

3 Okay. We'll recess for lunch. Back at

4 1:20.

5 (Whereupon, at 12:21 p.m., the proceedings

6 in the foregoing matter recessed for lunch.)

7 CHAIRMAN CORRADINI: All right. Why don't

8 we get started.

9 Wayne, you wanted to -- Mr. Marquino

10 wanted to begin with a couple of comments to help us

11 from the morning session. And you're going to show us

12 a video.

13 MR. MARQUINO: Okay. I just want to

14 follow up on one of the open items that Jay Lee of the

15 NRC staff mentioned, and then go over the Chapter 21

16 material, and then we'll have a LOCA movie that may

17 help explain our design better.

18 Going back to I think it was the previous

19 ACRS meeting, which included control room

20 habitability, one of the comments from the staff was

21 that we do not have a secondary containment in ESBWR.

22 That's an observation. What we have is a reactor

23 building that surrounds the primary containment. I

24 think that is related to the open item that Jay Lee

25 had, one of his five on reactor building mixing.

1 And before I talk to what we're doing to
2 address that, I want to summarize some of the
3 conservatisms that we have in analysis of doses. We
4 have the fuel failures that are assumed, even though
5 we don't actually fail the fuel in the LOCA. We don't
6 take credit for fission product removal mechanisms
7 after 12 hours.
8 We align the timing of the release to the
9 worst meteorological conditions, so we apply a bad chi
10 over Q at exactly the worst time in the event. We
11 assume the containment leakage is at the maximum value
12 at the containment design pressure throughout the
13 event for 30 days. We assume a high wind velocity
14 when determining the differential pressure for testing
15 the reactor building, which is inconsistent with the
16 worst chi over Q conditions, which correspond to
17 stable atmospheric conditions and low wind velocity.
18 And then, finally, we assume bounding site
19 characteristics. The actual at least first two sites'
20 characteristics produce a dose of about half of the
21 bounding chi over Q. So there's a number of
22 conservatisms in our dose calculation.
23 One thing that we did very simply in
24 analyzing the reactor building mixing is we simply
25 determined where the penetrations are. Those are the

1 main leak sources, and we determined the building
2 volume around those sources. We're asked for some
3 additional justification of that, and we'll be using
4 the GOTHIC computer code to develop a fairly detailed
5 3-D model of the reactor building to look at the
6 transport of radioactivity from the primary
7 containment source through rooms and HVAC ducts, and
8 then finally out of the building.
9 That will probably combine with the
10 reactor building differential pressure evaluation, so
11 that we look at the tradeoffs between high wind,
12 favorable chi over Q, low wind, low differential
13 pressure, lower leakage, but worse chi over Q.
14 So that's our plan, and I'd like to hear
15 any comments that the ACRS has on that approach.
16 CHAIRMAN CORRADINI: Let me ask one thing
17 about GOTHIC. Are you going to use the distributed
18 parameter model, or are you going to use the lumped
19 model, such as in MELCOR?
20 MR. MARQUINO: I don't know. I don't know
21 much about GOTHIC, but I'll take that.
22 CHAIRMAN CORRADINI: I mean, GOTHIC is
23 basically COBRA NC gone wild. And so it -- there is
24 essentially a 3-D -- three-dimensional version, a CFD
25 approach, and there is the essentially what I'll call

1 a lumped parameter approach like MELCOR, where you
2 essentially have volumes and an orifice between
3 volumes. I'm curious which one you intend to use for
4 your analysis.
5 MR. MARQUINO: Well, we may -- we think
6 it's important in some of the initial volumes to have
7 more detail of possible stratification, that that
8 would produce unfavorable mixing. As you get
9 downstream, that's probably less critical, and we
10 might use the lumped parameter option.
11 CHAIRMAN CORRADINI: Okay.
12 MR. WALLIS: All of these conservative
13 analysis -- assumptions, you're going to end up with
14 a prediction which meets the regulations.
15 MR. MARQUINO: Yes.
16 MR. WALLIS: So we don't need to worry.
17 MR. MARQUINO: That's right. So that --
18 I think that should give you some assurance. We're
19 asking when seeing the MELCOR evaluations by GE and
20 the staff and the uncertainties, those uncertainties
21 are covered by the overall conservatism of the --
22 MR. WALLIS: So we don't know it until we
23 see the bottom line that the staff comes up with.
24 MR. MARQUINO: Right.
25 CHAIRMAN CORRADINI: But we have seen your

1 -- I have to go back and check on the DCD, but that
2 will be the comparison point at the end, yes. The
3 staff will do these separate calculations.
4 MR. MARQUINO: Yes. Another reason I
5 bring this up is because see you in the DCD that we're
6 at 4.9 rem on the control room dose, and the
7 acceptance criteria is 5, and the -- offsite we're 20
8 something, and 25 acceptance criteria. We've
9 artificially -- we used the most conservative chi over
10 Q to push that dose up, basically to the maximum, to
11 give us maximum flexibility for siting the ESBWR.
12 MR. WALLIS: So this is on the worst day
13 of the year sort of thing?
14 MR. MARQUINO: Yes. That's another
15 conservatism I forgot to mention.
16 CHAIRMAN CORRADINI: Okay.
17 MR. MARQUINO: Okay.
18 CHAIRMAN CORRADINI: Do you think it would
19 be more -- I mean, just -- you can do it however you
20 want. Do you think it might be more beneficial to
21 show the video first, or after you talk about the
22 TRACG?
23 MR. MARQUINO: I think you'll have more
24 questions about the video, so I'd like to go through
25 the --

1 CHAIRMAN CORRADINI: Okay.

2 MR. MARQUINO: We have a very brief

3 Chapter 21 presentation, go through that, and then

4 show the video.

5 CHAIRMAN CORRADINI: Okay. That's fine.

6 MR. WALLIS: Is that because we'll

7 understand the video better than the -- we'll have

8 more questions?

9 (Laughter.)

10 CHAIRMAN CORRADINI: We'll go with your

11 decision. Go ahead.

12 MR. MARQUINO: Chapter 21 covers the

13 application methodology for various uses of TRACG, AOO

14 infrequent events, special events, and ATWS.

15 Next slide, please.

16 To give you some background, in the early

17 '90s, ESBWR project started with a test and analysis

18 program description to evaluate what testing would be

19 needed to license SBWR, and we knew we would be

20 applying the TRACG code. We were looking at what was

21 needed to qualify the TRACG code. We applied code

22 scaling applicability and uncertainty methodology to

23 developing that, including the phenomena importance

24 and ranking tables.

25 We then conducted the tests that were

1 identified as necessary, but in the mid '90s the SBWR
2 program ended and our licensing interactions with the
3 NRC were pretty much suspended at that time. But GE
4 continued internally with a larger output version of
5 SBWR/ESBWR.
6 And, internally, at GE the interest in
7 TRACG continued. We leveraged the work we had done
8 for SBWR, and in the late '90s we submitted for NRC
9 review and approval a TRACG for BWR 2 through 6 AOO
10 analysis.
11 And then, in 2002, we submitted the
12 TRACG 04 code for application to ESBWR, and a lot of
13 you were involved in that review.
14 Next slide, please.
15 So here we are. We have submitted
16 applications of TRACG that have been approved by the
17 staff. They are AOO analysis for BWR 2 through 6,
18 ATWS pressure analysis for BWR 2 through 6, which is
19 very similar to AOOs, ESBWR LOCA analysis, and ESBWR
20 stability analysis.
21 And then, we have two LTRs that are still
22 under review by the staff -- the ESBWR ATWS pressure,
23 clad temperature, and suppression pool temperature
24 application. And we talked about the boron mixing
25 related to that, incidentally, this morning.

1 And then, a recent submittal for ESBWR
2 AOO, infrequent event, special event -- this is kind
3 of a funny situation, because we had submitted a lot
4 of material to the staff in referencing different
5 LTRs, referencing the test analysis program
6 description and PIRTs. And there was a lot of
7 information that was disbursed, and this LTR basically
8 brings it all together. And it also provides details
9 on the results that are in the DCD and the uncertainty
10 analysis we did to support the operating limit.
11 Next slide, please.
12 So we covered the boron mixing in ATWS
13 this morning. Another significant RAI or set of RAIs
14 that we have is related to stability during ATWS, and
15 we are taking back some of your questions about
16 stability related to the chimney that we'll work
17 through.
18 CHAIRMAN CORRADINI: Let's just be clear.
19 So I think the thing that I heard from the other
20 members was that their concern was behavior within the
21 chimney, and also the coupling between the chimney and
22 how you had the bundle arrangement -- I think it's 16
23 -- 16 assemblies feeding one chimney and that
24 interplay.
25 MR. MARQUINO: Yes.

1 CHAIRMAN CORRADINI: Okay.

2 MR. MARQUINO: And we have this recent
3 LTR, which is very similar to the approved NED 32906
4 application of TRACG. In the transient analysis area,
5 Chapter 21, some of the RAI questions had to do with
6 hydraulic control unit failures during select control
7 rod insert. As I said, that's a local phenomena,
8 individual blades inserting.

9 The NRC asked us what would happen if a
10 blade or two blades paired to an HCU failed, and we've
11 provided a response to that, and we've made revisions
12 in the DCD to address it.

13 Next slide.

14 Okay. So I'd like to show you an
15 animation of the LOCA response, and Dr. Chester Cheung
16 is here to talk you through it. It's very short. I
17 think it's three minutes.

18 (Whereupon, the video began.)

19 MALE VOICE: The piping in any nuclear
20 powerplant is rigorously designed to stringent codes
21 and is routinely inspected for optimal safety and
22 performance. In the unlikely event of a pipe leak or
23 break, ESBWR passive safety features are designed to
24 prevent the nuclear reactor's core from overheating.
25 In fact, these safety features would keep the fuel at

1 or below its normal operating temperature for a period
2 of time established by the regulatory authorities.
3 If a pipe leaks or breaks, control rod
4 blades are automatically inserted into the reactor
5 core, stopping the nuclear reaction. The feedwater
6 system maintains a sufficient water level in the
7 vessel to avoid activating the passive core cooling
8 system. In the event that plant power is lost at the
9 same time that a pipe leaks or breaks, the ESBWR
10 passive safety systems activate to replace the power
11 operated systems.
12 With no electricity to pump water into the
13 reactor pressure vessel, the passive safety systems
14 utilize natural forces to flood and cool the core.
15 Triggered by the loss of power, heat exchanger tubes
16 drain water into the reactor pressure vessel. As the
17 tubes empty, steam from the reactor is drawn in and
18 condensed. This removes heat from the reactor and
19 transfers it to the IC pool in the upper part of the
20 building.
21 If the water level drops to a level below
22 that expected for common plant events, a time sequence
23 of depressurization and passive cooling begins.
24 Depressurization begins when the safety relief valves
25 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

1 up, and the fuel tubes remain intact. If any
2 radioactivity is released from the core, the
3 containment building prevents the release into the
4 environment. The ESBWR passive safety systems
5 automatically keep the reactor core consistently
6 cooled for 72 hours, unlike any operating nuclear
7 plant. The pools are sized to remove heat from the
8 core for three days. After that time, the upper pool
9 will be refilled.
10 In summary, accident events like pipe
11 breaks can be accommodated by the ESBWR passive safety
12 systems without any reliance on the AC power grid or
13 even emergency generators for three days with no core
14 heat up, unlike any operating nuclear plant today.
15 (Whereupon, the video ended.)
16 MR. WALLIS: It doesn't say anything about
17 the suppression pool.
18 MR. MARQUINO: It does.
19 MR. WALLIS: It doesn't, really. It
20 doesn't show anything bubbling into it.
21 MR. MARQUINO: It showed like steam --
22 MEMBER BANERJEE: From the SRV.
23 CHAIRMAN CORRADINI: But the equalization
24 line under current calculation isn't --
25 MR. WALLIS: No. But the event clearing

1 would happen as you pressurize the drywell.

2 CHAIRMAN CORRADINI: Well, I saw that. I

3 saw those --

4 MR. WALLIS: Did I miss that?

5 MEMBER ARMIJO: Well, it showed the level

6 in the downcomer.

7 MR. WALLIS: Oh, it did.

8 PARTICIPANT: It has these steam jets.

9 MR. WALLIS: That's an SRV line. That

10 doesn't show bubbling. There's bubbling around --

11 MR. MARQUINO: It falls around --

12 MR. WALLIS: There's a big bubbling, an

13 eruption --

14 MR. MARQUINO: It doesn't show pool

15 swells. All right.

16 MR. WALLIS: It doesn't show pool swell.

17 It's a very gentle --

18 MR. MARQUINO: These are very gentle,

19 little tiny bubbles.

20 MR. WALLIS: You show the non-condensables

21 coming in and --

22 DR. CHEUNG: It's a sanitized version.

23 (Laughter.)

24 It's a sanitized version.

25 MR. MARQUINO: Let me try to -- at least

1 the time sequence lines up with our TRAC results. We
2 informed it based on that. Yes, there's
3 simplifications, and we can't get into a lot of the
4 detail. We tried to put something together that shows
5 the systems functioning, so that people could have an
6 overall understanding.
7 MR. WALLIS: The SLC system operates as an
8 accumulator, even if you don't need the boron.
9 MR. MARQUINO: Yes.
10 MR. WALLIS: Always?
11 MR. MARQUINO: Yes. Triggers on low water
12 level.
13 MEMBER BANERJEE: I guess the last four
14 words "unlike any other reactors" or whatever, that's
15 sort of redundant.
16 MEMBER BLEY: It's a sales tool.
17 MR. MARQUINO: And this is available on
18 the GE website.
19 MEMBER BLEY: It's on the website.
20 MR. MARQUINO: Any other questions?
21 MEMBER KRESS: What makes the steam go up
22 that pipe?
23 MR. MARQUINO: What makes the steam go up
24 the pipe to the PCC?
25 MEMBER KRESS: Yes, instead of condensing

1 on the other surfaces.

2 DR. CHEUNG: The steam flow is much higher

3 than on the surface can condense. The surface

4 contains only a small amount.

5 CHAIRMAN CORRADINI: But the answer I

6 guess is it will condense everywhere, and that will be

7 your cold point to draw it there, right? I mean, Dr.

8 Kress' point I think is fair, is it?

9 MEMBER KRESS: I think --

10 CHAIRMAN CORRADINI: It will condense

11 everywhere to begin with.

12 MEMBER KRESS: Eventually, you may end up

13 with all the water on the floor, instead of feeding it

14 back to the core.

15 DR. CHEUNG: It depends on the break.

16 CHAIRMAN CORRADINI: Can we ask the

17 question a little bit differently? Have you -- in

18 your containment analysis which we are going to have

19 you come back and tell us about in detail, you have

20 considered the cold wall heat sinks and the proportion

21 of how much water condenses there versus on the PCCS,

22 right?

23 MEMBER KRESS: Supposedly MELCOR will do

24 that.

25 MR. WALLIS: Event clearing there.

1 DR. CHEUNG: We have models, the heat sink
2 structure in this, but we purposely ignore a lot of
3 structural heat pipings to maximize the energy that
4 will go into the containment system. But in the long
5 term, we --
6 MR. MARQUINO: The presentation you gave
7 yesterday included the results out to 30 days, which
8 considered the condensation on the structures that we
9 were asked about, right?
10 DR. CHEUNG: Yes. We estimate that all
11 the way up to 30 days. Does that answer your
12 question?
13 CHAIRMAN CORRADINI: But then, let's just
14 push the point one further, what Dr. Kress is asking.
15 So he might be asking, ideally, you'd like all the
16 water to go up to the PCCS, condense, the non-
17 condensables will be pushed back based on submergence
18 into the suppression, into the wet well. The water
19 will go into the GDCS, but there will be some losses
20 to the cold walls, and you've calculated how much you
21 lose that will be ending up in little dribbles and
22 drabbles inside the drywell, right?
23 DR. CHEUNG: Yes.
24 CHAIRMAN CORRADINI: Okay. We can look at
25 that in the detailed analysis. We'll want to look at

1 that.

2 MEMBER KRESS: May be a long-term cooling

3 problem.

4 CHAIRMAN CORRADINI: I think that's

5 actually probably early in time as we're going to get

6 the most condensation, because as soon as they build

7 up the temperature on the wall, it will shut itself

8 down just by --

9 MEMBER KRESS: Well, there's a lot of heat

10 capacity on those walls.

11 MR. MARQUINO: And another thing we should

12 tell them is the equalizing valve is there for

13 specifically that scenario. So if we lose too much

14 from the system, and it's on the floor of the drywell,

15 the water level in the core would drop, and then the

16 equalizing valve opens, floods it from the suppression

17 pool --

18 MEMBER KRESS: Ah, that's the thing I was

19 looking for.

20 DR. CHEUNG: And, actually, for the

21 current evaluation, all of the way up to 30 days, we

22 don't need the equalization line to open.

23 CHAIRMAN CORRADINI: Well, that's what

24 I want to get back to. I mean, it could open, but in

25 all your analysis you showed us yesterday under

1 Chapter 6, no eventuality of your limiting condition,
2 the main steam line break accident, which was your
3 limiting accident, did you need to have the
4 equalization line open.
5 DR. CHEUNG: No. We didn't --
6 CHAIRMAN CORRADINI: You were continuing
7 to have inventory, so you never got to the magical
8 switchpoint, which would have wanted that valve to
9 open. Is that not correct?
10 DR. CHEUNG: That's correct. Different
11 elevation. Up to 30 days, we don't need that. But if
12 we have N minus 2 problem, or N minus 2 failure,
13 that's like one of the pools, one of the three pools,
14 the water stayed behind. Then, we will have a defense
15 in depth system. The equalization line will come in,
16 and in that situation that suppression pool is about
17 10 meters from the RPV bottom. The top altitude is
18 7.5, so we have a head of 2.5 meter. So there is
19 plenty of water to make sure that the coil is covered.
20 MR. WALLIS: Can I ask you about the
21 vacuum breakers now? I mean, in order for the PCCS to
22 work, you have to have a positive pressure difference
23 from the drywell to the wet well, right? And I guess
24 the idea of the vacuum breaker is that, you know, you
25 pressurize the wet well, you've driven all of the non-

1 condensables in there.

2 So you want to relieve that pressure by

3 letting it breath it back into the drywell. But that

4 doesn't give you a positive pressure difference

5 between the drywell and the wet well to drive the

6 PCCS. So you must have a hydrostatic head somewhere

7 or something that makes it work. I don't understand

8 where that is.

9 DR. CHEUNG: Let me answer that. The

10 vacuum breaker opens if, and only if, the wet well

11 pressure is higher than the drywell pressure.

12 MR. WALLIS: Yes, it's higher than the

13 drywell pressure. It's got to be significantly lower

14 for the PCCS to work, though.

15 CHAIRMAN CORRADINI: Right. But it's a

16 timing issue, as I understand it, Graham. Early in

17 any of their accidents, all of the flow is down in

18 through the vents, and then they have a positive

19 pressure. The pop-it valve will open and --

20 MR. WALLIS: As long as the pressure is

21 rising in the containment, everything is fine. But

22 when you want to try to turn it around, that's when

23 you get into trouble. That's why you put the fans in

24 or someone put the fans in.

25 CHAIRMAN CORRADINI: The vacuum breaker is

1 not -- is designed to be leak-tight at that point.

2 MR. WALLIS: But then, you can't get the

3 PCCS to work.

4 CHAIRMAN CORRADINI: Well, it slowly,

5 slowly builds pressure.

6 MR. WALLIS: Oh.

7 CHAIRMAN CORRADINI: Because, as they

8 said, everything is being driven by the non-

9 condensables and --

10 MR. WALLIS: Well, then, it has to keep

11 building pressure in the drywell. But that's what you

12 want to turn around, though.

13 MR. MARQUINO: The PCC --

14 MR. WALLIS: How does it ever turn around

15 the pressure in the drywell?

16 MR. MARQUINO: The PCC will work without

17 a differential pressure, if it's full of steam. But

18 when it doesn't --

19 MR. WALLIS: But it soon gets filled --

20 eventually, it gets non-condensables if it's not

21 breathing out the non-condensables.

22 MR. MARQUINO: Right, right. When it

23 needs a differential pressure is to purge itself of

24 non-condensables.

25 MR. WALLIS: Right.

1 MR. MARQUINO: And we talked yesterday
2 about how it comes to equilibrium with the core steam
3 generation.
4 MR. WALLIS: But it doesn't if it can't
5 breathe out the non-condensables. It works as long as
6 the pressure keeps going up in the drywell, because
7 that breathes out the non-condensables. But it can't
8 turn it around and make it come down.
9 CHAIRMAN CORRADINI: Just one thing,
10 Graham. I think -- I mean, I agree with you from a
11 timing standpoint. If you look at one of their plots
12 in Chapter 6, even though the pressure is going up,
13 the drywell is still at a higher pressure than the wet
14 well.
15 MR. WALLIS: Because the pressure is going
16 up. But if the pressure -- if you want to get the
17 pressure down in the drywell, below the pressure in
18 the suppression pool, you have to do something.
19 CHAIRMAN CORRADINI: Right.
20 MR. WALLIS: And I don't know how you do
21 that without having a fan or something that -- to --
22 MR. MARQUINO: That's why we put the fan
23 in.
24 MR. WALLIS: But it's desirable not to
25 have this.

1 MR. MARQUINO: There's other ways.

2 DR. CHEUNG: Let me answer it the other

3 way. The PCC works not because of the -- the heat is

4 created by not enough steam condensed or the -- you

5 have --

6 MR. WALLIS: As long as the pressure is

7 going up in the drywell, it's okay.

8 DR. CHEUNG: Yes. But once you turn on a

9 fan, then the PCC becomes an active heat exchanger.

10 It does not depend on what's going on in the wet well,

11 because you have a forced flow circulation.

12 MR. WALLIS: You have a forced flow, but

13 you have to have that forced flow. Otherwise, you'll

14 never turn the pressure around. Isn't that right?

15 DR. CHEUNG: That's the idea of using the

16 fan is to force it.

17 MR. WALLIS: But the fan wasn't there

18 until recently.

19 CHAIRMAN CORRADINI: They would come to an

20 equilibrium that was below design pressure, but would

21 not necessarily decrease.

22 MR. WALLIS: It would never come down.

23 CHAIRMAN CORRADINI: It would come down

24 very, very slowly.

25 MR. WALLIS: Very slowly, yes. Okay.

1 Just -- why can't you make some kind of passive
2 arrangement that makes it turn itself around? That
3 would be very desirable.
4 CHAIRMAN CORRADINI: They could vent the
5 wet well.
6 MR. WALLIS: Yes.
7 CHAIRMAN CORRADINI: I mean, that's what
8 ABWR has as their final --
9 MR. WALLIS: You can vent the wet well.
10 CHAIRMAN CORRADINI: Yes.
11 MR. WALLIS: Yes.
12 CHAIRMAN CORRADINI: And get rid of the
13 non-condensable gas and bring down the overall level.
14 MR. WALLIS: Yes. But they won't do that.
15 CHAIRMAN CORRADINI: Well, they chose not
16 to.
17 MR. WALLIS: Okay. So I guess it's
18 clarified. Isn't it a bit artificial, because you're
19 trying to make it last for three days and then
20 something else has to happen.
21 DR. CHEUNG: After three days, we are
22 supposed to have simple systems bring it up.
23 MR. WALLIS: I was trying to tell my wife
24 that you have such a wonderful design that you could
25 just walk away from it. But you can't.

1 MS. CUBBAGE: For three days.

2 MR. WALLIS: You have to do something

3 after three days.

4 MR. MARQUINO: Well, we have to refill the

5 pool at three days. That has always been part of the

6 design, and now we've had --

7 MR. WALLIS: That's understandable, but

8 you're actually introducing a new -- a fan or

9 something.

10 MR. MARQUINO: Yes.

11 MR. WALLIS: When did the fan get

12 introduced?

13 MR. MARQUINO: Well, the fan was

14 investigated in the '90s during the PANDA testing. It

15 wasn't part of our original submittal. We --

16 MR. WALLIS: Because I've never seen it

17 until this time.

18 MR. MARQUINO: It was put back in in --

19 well, started telling the staff about it in the March

20 timeframe.

21 CHAIRMAN CORRADINI: So let me ask a

22 question about the venting. So did you consider this

23 in comparison to what ABWR has as a possibility?

24 Unless I misunderstand, does not ABWR have a venting

25 capability in the wet well as a final way to bring

1 down pressure?

2 MR. MARQUINO: Not in the design basis

3 accident analysis. In ABWR, like the BWR 6s, you get

4 a very significant drop in pressure from cold water

5 spilling out of the break and condensing the steam in

6 the drywell.

7 CHAIRMAN CORRADINI: Okay.

8 MR. MARQUINO: So that wet well, then, is

9 not needed in the design basis LOCA analysis.

10 CHAIRMAN CORRADINI: Beyond design basis.

11 Okay. That was my mistake. I'm sorry. Thank you.

12 MR. MARQUINO: Well, thank you very much

13 for your questions.

14 CHAIRMAN CORRADINI: Are we turning to the

15 staff?

16 PARTICIPANT: Unless you want to take a

17 long break.

18 CHAIRMAN CORRADINI: No.

19 (Laughter.)

20 MR. WILLIAMS: Good afternoon. My name is

21 Shawn Williams. I'm the Project Manager for

22 Chapter 21 of the safety evaluation report. As many

23 of you are aware, there is not a Chapter 21 of the

24 DCD. Chapter 21 covers testing and computer code

25 evaluation. The safety evaluation report speaks to

1 the information that was provided in topical reports
2 regarding the TRACG code and its qualification.
3 This is a list of the lead and supporting
4 reviewers. We wanted to have a special note for
5 Veronica Wilson, because she was the actual author for
6 nearly six of the SERs you saw, four of the topical
7 reports, Chapter 21.6, and Chapter 6.3. Of course,
8 she doesn't have the pleasure of presenting them,
9 but --
10 CHAIRMAN CORRADINI: Is she in the
11 audience, so we can get her?
12 (Laughter.)
13 PARTICIPANT: She's hiding.
14 MR. WILLIAMS: RAI status, 111 original
15 RAIs, 77 are resolved. Currently it says 34, but I
16 wanted to note there are about 10 to 15 Chapter 4 and
17 Chapter 6 RAIs that will also need to be resolved to
18 close out all of the Chapter 21 issues. Even though
19 there are 34 open items, GE has responded to about 12
20 of them that are still on staff's plate.
21 I'm going to hand it over to Ralph Landry,
22 who is going to give you an introduction of
23 Chapter 21.
24 MR. LANDRY: Good afternoon. I'm Ralph
25 Landry from the staff of NRO. The introductory

1 remarks I'm going to make are pretty short, and I want
2 to introduce the different staff members who are
3 responsible for the individual sections of the review.
4 You've already heard about the stability,
5 and you've heard about ATWS, and you've heard about
6 the AOOs. This afternoon we're going to talk about
7 the LOCA open items. We are going to talk about some
8 of the transient open items, and then a discussion
9 with the Committee.
10 So far, we have been to the Committee for
11 the testing and scaling of the TRACG support. That
12 was in 2004, as part of the acceptance review of TRACG
13 for LOCA. In 2004, we want to the Thermal Hydraulics
14 Subcommittee and the full Committee to approve use of
15 TRACG for LOCA analysis on ESBWR.
16 In 2006, we came to the Thermal Hydraulics
17 Subcommittee and the full Committee with a review of
18 the acceptability of TRACG for stability analysis for
19 ESBWR. We have been reviewing TRACG applicability for
20 ATWS and for transients, and those reviews will be
21 incorporated as part of the overall SER on the design
22 certification review.
23 As Wayne Marquino mentioned in his
24 presentation, we went to the Subcommittee and to the
25 full Committee on the review of TRACG for

1 applicability to the AOOs for the operating fleet.
2 What we are looking at for the applicability to ESBWR
3 is an extension of that applicability to incorporate
4 the ESBWR design features that are not part of the
5 operating fleet designs.
6 So we have been reviewing TRACG, and we
7 have been back and forth to the Thermal Hydraulics
8 Subcommittee, and to the full Committee, on three
9 occasions already for TRACG, for the AOOs for the
10 operating fleet, for applicability to LOCA for the
11 operating fleet, and for applicability -- or to the
12 ESBWR, and applicability to the stability for ESBWR.
13 MR. WALLIS: Are there any phenomena in
14 these transients which we haven't already reviewed on
15 the LOCA and stability that we have to worry about?
16 I can see that ATWS has some new features, but are
17 there other transients that have new features?
18 MR. LANDRY: This is looking at the
19 passive features of the design for the transients. We
20 wanted to do a separate review of the applicability to
21 make sure that the code was still applicable to the
22 features of this design.
23 MR. WALLIS: Did you look at the range of
24 variables on the phenomena or something? Are there
25 any new phenomena in these --

1 MR. LANDRY: No, I didn't. Jim Gilmer
2 will be --
3 MR. WALLIS: He is going to say that.
4 MR. LANDRY: -- covering some of this.
5 MR. WALLIS: I would just be surprised if
6 there are many new phenomena that you have to worry
7 about in the transients that you haven't already
8 looked at for LOCA and stability.
9 MR. LANDRY: Well, that's why I said,
10 Graham, that this is really extending that approval
11 from the operating fleet. Now, you have to recall,
12 when we reviewed it for the operating fleet, that was
13 applicable to BWRs 2 through 6. It was not applied
14 for applicability to BWR 1 or ABWR. So we are
15 reviewing it to make sure that it's applicable for the
16 ESBWR.
17 MR. WALLIS: But I was thinking about the
18 -- you've already reviewed for LOCA and stability for
19 the ESBWR. So you've looked at the kind of phenomena
20 that happen during transient.
21 MR. LANDRY: This is another check on
22 that.
23 MR. WALLIS: Okay. So it just seems to me
24 it shouldn't be that big a job, right?
25 MR. LANDRY: Right.

1 MEMBER BANERJEE: You don't want to put
2 words in his mouth.
3 MR. LANDRY: We always have additional --
4 MR. WALLIS: Yes, I know. I know.
5 MR. LANDRY: -- things we want to look at.
6 MR. WALLIS: I was wondering about what we
7 have to worry about. We have to worry about much --
8 MR. LANDRY: You just have to believe us.
9 MR. WALLIS: Okay.
10 (Laughter.)
11 CHAIRMAN CORRADINI: You look very
12 believable today.
13 MR. LANDRY: Thank you.
14 MEMBER BANERJEE: Especially since you
15 have moved to NRO, right?
16 MR. LANDRY: Moving right along, I'd like
17 to briefly summarize the regulations that apply to the
18 reviews that we have for presentation this afternoon.
19 Overriding for the LOCA, 10 CFRs 50.34 and
20 50.46, of course, and standard review plan Section
21 6.3, emergency core cooling, 15.65, and 15.02.
22 With that, I'd like to turn the discussion
23 over to Dr. Wang to discuss LOCA and LOCA
24 applicability with you.
25 DR. WANG: Good afternoon. My name is

1 Weidong Wang, and I am going to talk about the
2 applicability for LOCA, which Ralph has already
3 discussed -- I mean, mentioned that we had received a
4 topical report in the past, and we have approved in
5 the preapplication stage for LOCA application. And at
6 that time, we had an SER and we listed 20 confirmatory
7 items which basically these items should be addressed
8 during this DCD application.
9 And my presentation here is try to give a
10 few points of interest for these confirmatory items,
11 which later GE submitted to us.
12 Next slide, please.
13 The first item is phenomenon
14 identification ranking table for long-term cooling,
15 and GE has submitted through the II report -- report
16 letter basically for -- they divided this phenomena
17 into catalogs for the LOCA. One is --
18 MR. WALLIS: I thought you were reviewing
19 TRACG, not PIRT.
20 DR. WANG: That's right.
21 MR. WALLIS: Is PIRT also part of the
22 review, then?
23 DR. WANG: Well, PIRT, basically for the
24 TRACG code, we needed to simulate for the --
25 MR. WALLIS: That's what you put into

1 TRACG?

2 DR. WANG: Okay. The purpose of PIRT here

3 is we want to identify the phenomena. And that

4 phenomena, the TRACG has the capability to model this

5 phenomena. That's the purpose of being mentioned

6 here.

7 And these confirmatory items was listed in

8 the past ISE, and basically for this evaluation we

9 tried to go through all of these confirmatory items,

10 even though today I only selected a few to discuss

11 here.

12 CHAIRMAN CORRADINI: May I ask -- I think

13 I see where you're going with this.

14 MR. LANDRY: Let me see if I can help

15 Weidong out on that. This might help you, too, Mike.

16 When we did the TRACG applicability for LOCA review,

17 before the DCD was submitted, that material did not

18 take TRACG for LOCA into the long term. The part that

19 was submitted was only a short-term PIRT. It was not

20 a PIRT into the long-term applicability or long-term

21 phenomenon applicability.

22 That's why when we did the TRACG SER we

23 listed as one of the confirmatory items that when you

24 come in with a DCD you have to provide a PIRT for

25 long-term. And that's what Weidong is talking about.

1 MEMBER BANERJEE: Right. And a lot of
2 your evaluation, then, related to the integral test
3 for the PCCS and how they agreed with that.
4 MR. LANDRY: Did that help you, Mike?
5 CHAIRMAN CORRADINI: Yes. I had a
6 different question, though. In the long term, the
7 ratio of the machine to what you put the machine in
8 the building matters. So what is the effect of the
9 12.5 percent uprate from 4,000 megawatts thermal to
10 4,500, when all of the other pieces of the building
11 stay the same size? Is that reflected in the concern
12 over -- because in the long term, time scales don't
13 matter. It's a matter of energy balances of what I
14 have and what I heat up. Has that been considered, or
15 is that part of the --
16 DR. WANG: There is another open item
17 later I will discuss. Basically, we would like to
18 verify or check any new -- especially in the core for
19 this, say, void fraction generation, the TRACG code
20 capability. Basically, we have an II on that I think
21 I will cover in the later slides.
22 For the long-term core cooling -- and we
23 basically checked GEH supplement for the phenomena for
24 the high break locations, like a main steam line break
25 and feedwater line break. And the interesting

1 phenomena here is the capacity relative to RPV volume,
2 and also PCCS capacity relative to decay heat. The
3 PCCS is basically for heat removal for this whole
4 system in the long-term cooling.
5 And for low elevation breaks, the lower
6 drywell volume with this elevation, basically since
7 the break is low you needed to have something --
8 volume to hold the water. And also, break flow
9 pressure drop -- break flows and the pressure drops
10 through the DPVs, because for the lower -- lower part
11 of this break, the break is more considered a small
12 break for the bottom drain line break. So
13 pressurization is slow, and this ADS system, like DPV,
14 is -- for break flow is important.
15 And the staff will evaluate this long-term
16 core cooling, and we found it acceptable.
17 MEMBER BANERJEE: You also reviewed the
18 scaling analysis and everything that --
19 DR. WANG: We do and --
20 MEMBER BANERJEE: -- top down?
21 DR. WANG: Do you have any specific
22 questions which Mohammed --
23 MEMBER BANERJEE: No. I'm just asking the
24 scope of the review.
25 DR. WANG: Yes.

1 MEMBER BANERJEE: What --

2 MR. LANDRY: Sanjoy, we did review the
3 scaling analysis and reviewed the testing program when
4 we reviewed TRACG for LOCA applicability before the
5 DCD. After the DCD came in, because, as Mike pointed
6 out, it was at a higher power level, we went back and
7 looked at what we had reviewed for the testing and for
8 the scaling to see that there was nothing in this
9 power uprate that -- or the changes that we saw that
10 would negate our calling to question any of the
11 positions that we had taken in acceptance of the
12 testing and scaling program.

13 So, yes, we did review it, and we went
14 back and checked it and looked at it again after the
15 DCD came in.

16 VICE CHAIRMAN ABDEL-KHALIK: Let me just
17 ask a slightly different question. The implication,
18 of course, when you're talking about long-term cooling
19 is that you understand everything about short-term
20 cooling. And we hear a great deal about non-
21 condensable gas accumulation in ECCS systems for
22 current reactors. Is there any mechanism by which a
23 non-condensable gas can accumulate in the gravity-
24 driven system that would prevent them from operating
25 in the short term?

1 MR. LANDRY: We did not see in the short
2 term anything that would -- any way that you would
3 have sufficient non-condensable accumulation to
4 prevent this system from operating. But we --
5 VICE CHAIRMAN ABDEL-KHALIK: Do you have
6 any idea about the detailed piping arrangement of the
7 gravity-driven system?
8 MR. LANDRY: We reviewed --
9 VICE CHAIRMAN ABDEL-KHALIK: Whereby
10 pockets of gas may actually accumulate during startup?
11 MR. LANDRY: We have to -- I guess we
12 would have to see the real details. If the piping
13 arrangement was different than our understanding of it
14 when we did the LOCA TRACG report, or if it was
15 different than our understanding of the system today
16 -- let me call on Andre Drozd from the staff, who did
17 part of the containment review.
18 MR. DROZD: This is Andre Drozd from
19 Containment Issue -- Containment Branch. There is a
20 chance of collecting non-condensables in the PCCS.
21 However, it helps to resolve the issue if you remember
22 that PCCS can work in two modes. One mode is a
23 condensing mode, where you condense in the tube, you
24 suck in -- suck in steam from the drywell. the second
25 mode is delta P mode. That is, if by any chance you

1 degrade your heat transfer in the PCCS, drywell
2 pressure goes up, and delta P between drywell and wet
3 well increases in such a way that it flushes through.
4 So it works kind of in a forced flow. The
5 delta P that potentially can be created forces flow
6 through PCCS, and, therefore, reestablishing the
7 condensing mode of operation.
8 CHAIRMAN CORRADINI: But that -- if I just
9 might make sure I understand. That leads to Graham's
10 point, which is after you get through the initial
11 transient, then you're back to whatever that delta P
12 set, and that will set -- that delta P will slowly
13 rise, rise, rise, as you --
14 MEMBER BANERJEE: I don't think that was
15 Said's point.
16 VICE CHAIRMAN ABDEL-KHALIK: Perhaps GE
17 should answer my question.
18 MEMBER BANERJEE: Yes.
19 MR. UPTON: This is Hugh Upton with GEH.
20 We have a reference routing for the GDCS lines
21 injecting into the RPV. It's sloped back to the
22 pools, so if there's any accumulation of nitrogen in
23 the line it will bubble up to the pools and up to the
24 drywell air space.
25 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

1 problem to simulate this phenomena.

2 VICE CHAIRMAN ABDEL-KHALIK: And you say

3 that based on what, your own personal experience?

4 You've done calculations of this type?

5 DR. WANG: Not really personally used the

6 TRACG. But I was -- developed it by FIRE code and

7 TRACE code, and I was involved in this kind of

8 calculation. In my personal experience, I don't think

9 TRACG should have this problem, even though I never

10 really learned TRACG myself.

11 VICE CHAIRMAN ABDEL-KHALIK: Okay. Now,

12 back to the isometrics that will be provided by GE,

13 will the staff review that to make sure that this

14 problem is indeed impossible?

15 MS. CUBBAGE: We have received PNIDs. You

16 know, I think if they set a design criteria that there

17 is going to be a certain sloping, then when they build

18 the plant they are required to build it the way they

19 said they would.

20 MR. UPTON: That's correct. We have a

21 requirement that we slope the lines away from the RPV

22 at I think one inch -- 1 to 100. I think that's the

23 average slope.

24 MR. WALLIS: I think the problem would

25 come about if you put the check valve in the wrong

1 place, so that there was air trapped below the check
2 valve. You wouldn't get enough delta P to open it.
3 You would put the check valve in the right place in
4 this line, so that you don't trap -- possibly trap
5 non-condensables below the check valve, and then they
6 won't open because there isn't enough delta P to open
7 it. So I assume that you put the check valve in the
8 right place.
9 MR. UPTON: Again, we have looked at that.
10 MR. WALLIS: The long pipe with the check
11 valve in it, and there's air underneath it. It won't
12 open if it doesn't have enough pressure to push it
13 open. But you're not going to put the check valve at
14 the top of the pipe, presumably.
15 MR. UPTON: That's correct.
16 MR. WALLIS: I hope not.
17 MEMBER BANERJEE: Well, these non-
18 condensables in EEC lines is an issue that we've had
19 to deal with in the past. So --
20 PARTICIPANT: We still are.
21 MEMBER BANERJEE: We still are. So it has
22 to be -- make sure that we know something about it.
23 MR. WALLIS: Be sure that some architect-
24 engineer doesn't go and route the pipe up and over a
25 wall or something.

1 DR. WANG: I just wanted to clarify what
2 my statement I said for this TRACG have the capability
3 to -- you know, this I assume, okay, because TRACG is
4 too free to model, which is similar to the TRACE code,
5 and also RELAP 5 is too free to model.
6 What I tried to say is for this you have
7 liquid and you have non-condensable gas for this flow
8 to be able to simulate. However, for condensation in
9 the PCCS, that's a different issue. I tried to make
10 a point -- you know, if you have some trapped in it,
11 if you have liquid, you should be able to simulate.
12 That's my point.
13 CHAIRMAN CORRADINI: thank you.
14 DR. WANG: And next preliminary item I
15 would like to bring up is, since TRACG, up to that
16 time for the preapplication, that was version
17 TRACG 02, and later for the DCD phase --
18 MR. SHUAIBI: Let me just go back to the
19 question that was raised. Let us take that back as a
20 lookup and come back maybe between now and the
21 Subcommittee, maybe at -- between now and the full
22 Committee, and maybe at the full Committee we'll have
23 an answer for you as to how we're considering that or
24 what we need to do to consider it.
25 I think I understand the question is your

1 concern is like looped seals and things like that in
2 the system that could maybe prevent or cause some
3 problems. We understand the question, so let us take
4 that back and we'll get back to you.
5 VICE CHAIRMAN ABDEL-KHALIK: Thank you.
6 DR. WANG: So staff would like to -- GE
7 basically provided a confirmatory -- confirms the new
8 models, and if they are applicable to the ES design --
9 ESBWR design, and I have listed a few model
10 improvements here, which will impact the ESBWR
11 calculation. But we think these models will include
12 ESBWR calculations.
13 First is entrainment model and --
14 PARTICIPANT: What's that?
15 DR. WANG: Entrainment model.
16 Basically --
17 PARTICIPANT: You're not going to add
18 another field.
19 DR. WANG: No, we didn't do that.
20 MR. WALLIS: Which kind of entrainment are
21 you talking about? Are you talking about entrainment
22 in something like annular flow, or are you talking
23 about entrainment from a pool when you're above --
24 DR. WANG: Annular flow. That's what --
25 MR. WALLIS: Annular flow. So it's a --

1 CHAIRMAN CORRADINI: So you mean to
2 improve the model.
3 DR. WANG: Right, you improve the model,
4 yes.
5 MR. WALLIS: There's not entrainment from
6 a pool where you've got bubbles coming out of it.
7 It's not that kind of entrainment.
8 DR. WANG: Not for that one. And here is
9 basically -- we have increased the power, and we are
10 basically -- GEH made this improvement, and staff made
11 the judgment evaluation what they have done. And
12 entrainment model they use the ECM/ECC model, and the
13 improvement is basically they consider that as when
14 it's dried out -- they consider a partial dryout and
15 partial -- but just kind of -- basically, they
16 improved the prediction for the low pressure data.
17 At the time, in the preapplication, the
18 model is mainly for high pressure.
19 MR. WALLIS: Can I ask you something,
20 though, to follow up on Said's question? This GDCS
21 pool draining into the reactor, is the opening that
22 goes into the vessel always below the water level? Or
23 is there a possibility that it's opening and then
24 spilling out like an open drain? Does it pour out
25 like -- if it pours out like an open drain, you have

1 to ask: do the non-condensables go back up the pipe
2 or not? And does that change the hydrostatic head in
3 the pipe?
4 DR. WANG: Even if it vortexes --
5 MR. WALLIS: Yes. But, I mean, the
6 simplest thing: does it run full or not? Because
7 that changes the hydrostatic head. It's like when you
8 empty the sink in your hotel room or something, you
9 know, if there's a bubble in the pipe, if often
10 doesn't drain very fast until that bubble is gone.
11 The bubble comes up the pipe into the sink. It
12 doesn't go the other way. So there's a bubble coming
13 back up the GDCS line, is that what you mean?
14 DR. WANG: Yes, I understand your
15 question, but I --
16 MR. WALLIS: Does that ever happen or not?
17 CHAIRMAN CORRADINI: GE is going to have
18 to answer that one, yes?
19 MR. MARQUINO: Okay. I want to be clear.
20 Are you asking about the GDCS line going into the
21 vessel?
22 MR. WALLIS: Going into the vessel from
23 the GDCS line. Does the end of that pipe ever -- is
24 it ever not submerged? Because if it's not submerged,
25 then you have to ask: does the gas go back up the

1 pipe countercurrent flow or not?

2 MR. MARQUINO: I think that's like nine

3 meters. Do you remember the --

4 MS. CUBBAGE: Graham, just to make sure,

5 are you talking about if the GDCS has been actuated or

6 during normal operation?

7 MR. WALLIS: At any time.

8 MS. CUBBAGE: At any time.

9 MR. MARQUINO: When it's actuating.

10 DR. CHEUNG: This is Chester Cheung from

11 GEH.

12 MR. WALLIS: After it has been activated,

13 but, you know, after it has been activated there's

14 less flow in --

15 MS. CUBBAGE: Yes. That's what I -- yes.

16 DR. CHEUNG: This is Chester Cheung from

17 GEH. The GDCS pool surface level is somewhere around

18 22 meters or 20-some meters. The elevation for the

19 connection to an RPV is 10.5 meters. So you are

20 talking about 13 meters of water head.

21 MR. WALLIS: I know. But that is not

22 always available if the pipe has got gas in it.

23 CHAIRMAN CORRADINI: I think what they are

24 asking you is: where is the inlet line compared to

25 where the level is where you initiate injection?

1 MR. WALLIS: And during injection, does
2 that level ever come down and expose the end of the
3 injection line, so that gas could go back up the pipe?
4 That's what I'm asking.
5 MR. MARQUINO: Dr. Wallis --
6 MEMBER BANERJEE: Where it meets the RPV.
7 DR. CHEUNG: Meet the RPV at 10.5 meters.
8 MR. WALLIS: I think that the level in the
9 vessel sometimes is below, because your minimum
10 collapsed level is sometimes eight or nine meters.
11 DR. CHEUNG: The level may be dropped
12 below the connection point, but --
13 MR. WALLIS: When that happens, does gas
14 go back up the GDCS line?
15 DR. CHEUNG: No. The --
16 MR. WALLIS: Do you have a high enough --
17 DR. CHEUNG: No, let me finish. There is
18 trouble in the line. If the pressure in RPV on the
19 other side of it is lower --
20 MR. WALLIS: No, it's not a question of
21 pressure. It's a question of having enough flow to
22 prevent gas going back up.
23 DR. CHEUNG: It has something to do with
24 the pressure. If the pressure is lower --
25 MR. WALLIS: That's not --

1 DR. CHEUNG: The pressure is higher --

2 MR. WALLIS: That's not the issue.

3 MEMBER SIEBER: It could be stagnant.

4 CHAIRMAN CORRADINI: Let's try it this

5 way. You said it's 10.5 meters to the pipe from the

6 core?

7 DR. CHEUNG: From the bottom of the RPV.

8 CHAIRMAN CORRADINI: From the bottom of

9 the RPV. Where is the setpoint where you initiate

10 GDCS injection? What is that setpoint in terms of

11 level?

12 DR. CHEUNG: In terms of level, it is

13 11.5.

14 PARTICIPANT: A little bit above --

15 DR. CHEUNG: A little bit above --

16 PARTICIPANT: -- the collapsed level.

17 DR. CHEUNG: -- the collapsed level.

18 PARTICIPANT: Okay.

19 VICE CHAIRMAN ABDEL-KHALIK: During

20 transient, it is possible that after you have actuated

21 this gravity-driven system, the water level in the

22 vessel would drop below the point --

23 DR. CHEUNG: Yes.

24 VICE CHAIRMAN ABDEL-KHALIK: -- where the

25 line connects with the vessel.

1 DR. CHEUNG: Yes.

2 VICE CHAIRMAN ABDEL-KHALIK: So there may

3 be countercurrent flow of gas up that pipe.

4 CHAIRMAN CORRADINI: Where would the gas

5 come from, though? That would be --

6 DR. CHEUNG: Well, that is what the --

7 MEMBER BANERJEE: I think what he was

8 saying is that TRACG should be capable of modeling

9 that countercurrent flow if it occurs. Now, that's a

10 capability --

11 MR. WALLIS: Does it model concurrent flow

12 in horizontal pipes?

13 DR. CHEUNG: Yes, we model -- let me try

14 again. The RPV pressure, if higher, it won't stop any

15 flow from it going back.

16 MR. WALLIS: No, it doesn't stop gas going

17 the other way. You can have liquid running one way

18 and gas going the other way.

19 DR. CHEUNG: It doesn't.

20 MEMBER BANERJEE: It really doesn't, so

21 don't argue that...

22 DR. CHEUNG: No. The --

23 CHAIRMAN CORRADINI: I think he's starting

24 higher up. He's just trying to talk you through that

25 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?

1 So if you do have gas, it's going to go back up there
2 into the pool and bubble --
3 MR. WALLIS: The thing is, if there is
4 that, it will change the hydrostatic head. It will
5 change the flow rate. That's the whole thing. It
6 will affect the flow rate of GDCS flow.
7 MEMBER BANERJEE: I guess the issue here
8 is if TRACG is above the capture this type of
9 phenomena --
10 MR. WALLIS: Then it's okay.
11 MEMBER BANERJEE: -- then it's okay,
12 because it will be automatically captured. On the
13 other hand, the point that Graham is making is that
14 one has to be sure that TRACG can count -- capture
15 countercurrent flow in a horizontal pipe. If it can
16 do that, then it should be part of -- automatically
17 part of the calculation.
18 DR. CHEUNG: Do you want to make a
19 comment?
20 CHAIRMAN CORRADINI: Can I just make sure
21 I understand your question? Where Said started was he
22 was concerned about having non-condensables. Okay.
23 Now you are talking about steam flow going back up the
24 pipe that rather -- going up all that area this way.
25 I don't think steam wants to go the hard way. Why

1 doesn't it want to just go straight back up?

2 MEMBER BANERJEE: That's the calculation

3 of --

4 MR. WALLIS: That's the whole continuum.

5 It sees the gravitational head in the pipe, and it

6 sees a crude number, and it will go back up the pipe.

7 MEMBER BANERJEE: Well, whichever, but

8 that should be calculatable. That should come out of

9 your --

10 MR. WALLIS: I'm not sure that TRAC can

11 handle it. It's not that easy a problem to --

12 MEMBER BANERJEE: Yes. The issue that has

13 been raised I think is whether you can handle

14 countercurrent horizontal flow, which is not all that

15 straightforward, because you get waves, you get

16 flooding. It's a different behavior -- horizontal

17 countercurrent flow. So maybe you could just answer

18 that question. Did you look at that specific issue?

19 MR. WALLIS: I don't think they did. I

20 think it's an open item for me. And even if you got

21 steam, the steam will run in to condense on the cold

22 water, and it will then pile up whatever non-

23 condensables are in the pipe.

24 And then, the question is: are they going

25 to go up the pipe, or are they going to come back out

1 into the vessel?

2 DR. CHEUNG: Let me answer the other way.

3 Okay. TRACG has the option to turn on the

4 countercurrent flow, since it's happening in any --

5 MR. WALLIS: Well, I guess what I'd have

6 to do is look at the velocities you're calculating in

7 the pipe and figure out if I think that gas would go

8 up the pipe or not.

9 DR. CHEUNG: I think it's a hand --

10 MR. WALLIS: Rather than asking what TRAC

11 does, I want to see the numbers and --

12 MEMBER BANERJEE: If the pipe doesn't

13 fill, it you don't have the velocity to fill it --

14 MR. WALLIS: Then it would change the

15 draining rate.

16 MEMBER BANERJEE: Yes.

17 CHAIRMAN CORRADINI: So I'm still back at

18 the beginning. You initiated 11-1/2 meters, and the

19 pipe is coming into the downcomer at 10 meters. And

20 in one of your limiting sequences you uncover that

21 pipe?

22 DR. CHEUNG: Yes.

23 CHAIRMAN CORRADINI: Okay. And that's the

24 main steam line break?

25 MR. WALLIS: And gas could go up the pipe.

1 Now, if you think about your hotel room drain, you
2 know, if there's gas in the pipe, the drain pipe from
3 your sink, then the only head that is draining the
4 water in is the little head near the plug, the hole.
5 When that gas comes out, if you get enough water to
6 fill that pipe, you get, you know, six feet of water
7 sucking water out and it goes zipping down there. It
8 makes a big difference what's in that pipe. It takes
9 a certain amount of velocity to clear the pipe.
10 CHAIRMAN CORRADINI: Yes. But you're
11 talking a non-condensable versus steam in cold water.
12 So I'm not sure that's exactly the analogy.
13 MR. WALLIS: Yes. But if they're non-
14 condensable, if the steam --
15 MEMBER BANERJEE: Over a period of time,
16 the steam will condense and --
17 MR. WALLIS: So I think it is a viable
18 question, an issue. That's the kind of thing I think
19 we ought to be focusing on. And we go through all
20 this stuff here. We think, well, what could possibly
21 not be properly modeled by this kind of analysis?
22 That's what we should be focusing on.
23 MEMBER BANERJEE: TRACG has a non-
24 condensable field in the steam, right?
25 PARTICIPANT: Yes.

1 MEMBER BANERJEE: So if there was non-
2 condensables going in, they would accumulate in this
3 line and you --
4 MR. WALLIS: How does it figure out which
5 way they go once they're in there? That's the
6 question.
7 MEMBER BANERJEE: That's the issue, yes.
8 Because probably if you don't get the interfacial drag
9 quite right, you might just sweep this out, whereas in
10 fact this might sort of migrate, as Graham says, up
11 against -- if the flow rate is not high enough. So
12 that has to be probably looked at.
13 VICE CHAIRMAN ABDEL-KHALIK: So as far as
14 we know, there is no calculation that the staff knows
15 of that shows that this issue is a non-issue. Is that
16 correct?
17 MEMBER BANERJEE: That's correct. But
18 basically --
19 VICE CHAIRMAN ABDEL-KHALIK: So rather
20 than sort of relying on intuition, and so on, is it
21 reasonable to expect that the applicant would do a
22 mechanistic calculation to show that this is indeed a
23 non-issue, or it is calculable by the existing code?
24 And this question was directed at both GE and the NRC.
25 MR. DONOGHUE: I think the answer is, yes,

1 we should think about this -- first of all, the
2 phenomenon, and get some understanding of it somehow,
3 but then exercise the code, our confirmatory
4 calculations to see what happens.
5 MR. WALLIS: And if it doesn't predict
6 what looks physically reasonable, then you have to
7 question it.
8 MR. DONOGHUE: Yes.
9 CHAIRMAN CORRADINI: What is the current
10 calculation assuming in this regard? Do you guys
11 know?
12 MR. MARQUINO: The current calculation --
13 number one, the vessel is not filled with non-
14 condensables during operation. It's full of steam.
15 CHAIRMAN CORRADINI: That's Graham's
16 point. Graham's point or concern is is that -- is
17 that you've got this competing effect. So I guess a
18 question to ask is: are you allowing this to occur,
19 or are you essentially assuming it's just water flow
20 in?
21 MR. MARQUINO: No. We're allowing it to
22 occur, and the code has the capability to model
23 countercurrent flow in the --
24 CHAIRMAN CORRADINI: What NEDO do we look
25 at to make ourselves feel better?

1 VICE CHAIRMAN ABDEL-KHALIK: I'm sorry.
2 Does your calculation have enough resolution to answer
3 this question?
4 MEMBER BANERJEE: Yes. In the line
5 between the GDCS and the RPV, do you have enough --
6 MR. WALLIS: I think it assumes single-
7 phase flow probably.
8 MR. MARQUINO: No. There is no switch in
9 the code that will cause it to say it's only single-
10 phase flow.
11 VICE CHAIRMAN ABDEL-KHALIK: But would it
12 have enough resolution to predict a free surface
13 inside that pipe?
14 MR. MARQUINO: The nodalization will have
15 some impact on where it tracks free surfaces.
16 MR. WALLIS: Does it have a criterion that
17 lets or does not let steam go back into the pipe? I
18 don't show that --
19 MR. MARQUINO: So I think what would be
20 appropriate is you asked if -- isn't it reasonable
21 that the applicant -- we should get back to you and
22 describe the capabilities of the code, our
23 nodalization, the piping slopes, so that we can
24 justify to you that this countercurrent flow phenomena
25 is not significant in the LOCA.

1 MR. WALLIS: Does it show that there's a
2 big enough crude number that it will sweep out
3 anything that goes in there, and so --
4 MR. MARQUINO: And agree that it might be
5 -- the hand calculation could validate the code in
6 this regard.
7 MEMBER BANERJEE: There are regimes, I
8 imagine, where the flow is fairly small, right,
9 through that line?
10 MR. WALLIS: We just don't know. I just
11 don't know how --
12 MEMBER BANERJEE: So one way around this
13 would be if you have the capability in the code, and
14 if you nodalize that finely enough, and just make --
15 yes, just show that you are capable of capturing that
16 phenomena, then it should be automatically --
17 MR. WALLIS: Well, it depends how much
18 pressure there is from the vessel. It may be that the
19 flow into this GDCS line is simply driven by gravity,
20 and there is really essentially no pressure difference
21 from the outside world. You can go around through the
22 core and all the way back to the pool. There is still
23 very little pressure there.
24 CHAIRMAN CORRADINI: Dr. Wallis?
25 MR. WALLIS: There will be -- you've got

1 so much header water that the velocity is so big it
2 shoots everything out. But if there's a back pressure
3 from the core, then you could reduce the flow rate to
4 the point where you get steam going back up the line.
5 I just don't know.
6 CHAIRMAN CORRADINI: Dr. Wallis?
7 I guess the one thing I'd ask GEH, as you
8 thinking about all of this, at least point us to the
9 right topical, so we can look to see what you've done
10 to date.
11 MR. MARQUINO: Okay.
12 PARTICIPANT: That would be helpful, a
13 good starting point.
14 MR. WALLIS: Well, don't make me search in
15 somewhere to find it.
16 (Laughter.)
17 MR. MARQUINO: You want a page number and
18 like a three-digit section number.
19 MEMBER BANERJEE: Yes. Does it handle
20 condensation in horizontal --
21 MR. WALLIS: I think you are all right,
22 but I think we ought to be asking if, from a safety
23 point of view, what kind of things could happen which
24 might somehow change the scenario in a way which isn't
25 predicted.

1 MEMBER BANERJEE: Right.

2 MR. SHUAIBI: And I guess today we're not
3 going to be able to satisfy you, and, you know, we'll
4 take this one back and we'll take a look at it, and
5 we'll come back. And if additional analyses need to
6 be done, that's -- that's part of the reason why we're
7 here is to get your input.

8 MR. WALLIS: the staff didn't ask this
9 question before?

10 MR. SHUAIBI: If we had, I think we would
11 have been up answering your question. It appears to
12 me like this is something that you've identified that
13 we need to go back and look at. So we appreciate
14 that.

15 MR. WALLIS: And I think we ought to look
16 at the PCCS arrangement. We've got some sort of
17 sketches about how the condensate and the non-
18 condensables get vented this way and that way, and
19 there's a fan. But until you see the piping, you
20 can't really tell what's happening there.

21 So we can't tell, is the fan going to
22 ingest water, or is the water going to get -- prevent
23 the non-condensables? Until you see the details of
24 the design you can't really tell whether some of these
25 things will work, and that's what bothers me about

1 this kind of rather superficial review --

2 MS. CUBBAGE: Right. Well, I --

3 MR. WALLIS: -- if TRACs predict something

4 and you accept it, you know.

5 MS. CUBBAGE: Well, I think we already

6 decided yesterday we'd be coming back with more

7 details on containment, and we have not yet seen the

8 details of this fan arrangement.

9 MR. WALLIS: Right. Okay.

10 MR. SHUAIBI: I just want to make sure --

11 I don't think it's fair that we're doing a superficial

12 review. I think we've done a lot of work.

13 MR. WALLIS: I'm sorry. I mean, the TRAC,

14 when you just look at TRAC, without looking at the

15 details of the fittings, and so on, I mean, maybe

16 "superficial" is the wrong word, but, I mean, just a

17 code type analysis, where you don't look at the

18 details of what happens at some of those nodes. That

19 could be called "superficial." I'm not saying it in

20 the derogatory sense. I mean, it's at a high level,

21 surface.

22 MR. SHUAIBI: Just let me add one comment

23 to that is that even if you have detailed design

24 drawings and you build everything, as you are well

25 aware, you will find that in operating plants there

1 could be still be a problem. So plants are going to
2 have to have programs to still make sure there is no
3 gas buildup in there, in the GDCS system.
4 MEMBER BANERJEE: But it's very hard to
5 find that, as we know.
6 MR. SHUAIBI: Yes.
7 MEMBER BANERJEE: Because we have faced
8 this, as you know, before. It is very hard to find
9 out if there is gas or not, and we are facing this
10 with the operating reactors right now.
11 MR. SHUAIBI: Right.
12 DR. WANG: Okay.
13 MEMBER BANERJEE: Before you jump from the
14 entrainment model, I wanted to ask you about the flow
15 regime.
16 DR. WANG: Basically, what -- GE have
17 improved the flow regime to annular flow, and I only
18 can give you, you know, high-level summary on that for
19 here.
20 Basically, they look at that -- the
21 mechanism for the change to annular, and they said
22 that was the philosophy for the change regime and
23 annular regime is equal, and then try to solve the
24 void fraction and use that void fraction as the base
25 for flow regime transition.

1 MEMBER BANERJEE: So now, because of this
2 somewhat increasing power, you are probably close to
3 the transition between turbulent and annular flows.
4 DR. WANG: Right.
5 MEMBER BANERJEE: And in these rather
6 large pipes, and like the chimneys, what sort of
7 database is there for that? I mean, I'm sure there is
8 some in the oil-gas industry, but there isn't a huge
9 amount that I know of in any other.
10 DR. WANG: I believe we went through an
11 audit, and they look at data like at Toshiba they have
12 done some low pressure data, and basically I believe
13 GE has validated this model against those data. So
14 the point here is improvement is -- in the past is
15 mainly focused on the high pressure, and here is
16 focusing on the low pressure system.
17 MR. WALLIS: The real question isn't, what
18 is -- isn't really, what is the flow regime, but does
19 the correlating scheme predict the data? Because you
20 can have the wrong flow regime in terms of looking at
21 it, but the fudge factors in the model will predict
22 the data very well. And that's okay.
23 MEMBER BANERJEE: That's not okay.
24 MR. WALLIS: So Dick Finlay doesn't
25 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

1 this region to find out important it could be?

2 MR. WALLIS: Did Ontario Hydro try

3 different distribution methods?

4 MEMBER BANERJEE: No, did not. As far as

5 I -- there is another issue which is even more

6 important, which is whether you really get static head

7 fluctuations which are large. And we asked this

8 question about the chimney about two years ago, and it

9 was answered by doing some fine nodalization runs with

10 TRACG.

11 But, again, there was the issue of: how

12 well does the fine nodalization runs capture the real

13 effects if you are using a static flow regime map

14 anyway, you know?

15 DR. WANG: That's why GE is proposing for

16 the interfacial --

17 MEMBER BANERJEE: Right, right. So that's

18 not there yet.

19 DR. WANG: Right.

20 MEMBER BANERJEE: Okay.

21 DR. WANG: But I think for the question

22 you raised, as far as I think for -- it's too

23 difficult a question basically to address here.

24 MEMBER BANERJEE: But there are -- there

25 could be some experiments which would clarify the

1 issues. If you get large static head fluctuations in
2 these chimneys with a certain frequency, then we are
3 worried about how it couples, you know, to the core.
4 So we are looking at -- even though we are not
5 addressing stability with TRACG here, nonetheless,
6 that has been a concern.
7 MR. WALLIS: You're thinking of an
8 experiment where you take a chimney element and you
9 take your 16 different channels, and you put in
10 different regimes in the channels, and you see what
11 happens and measure with real conditions, that sort of
12 thing?
13 MEMBER BANERJEE: Well, if not real
14 conditions, perhaps with freon or something, you know.
15 I don't know.
16 MR. WALLIS: Well, ideally, with full
17 scale and full pressure.
18 DR. WANG: I don't have an answer for you
19 on this.
20 MR. WALLIS: GE traditionally has a very
21 good philosophy of doing, when they can, full scale,
22 full condition experiments. That's what they do with
23 the fuel. Very good job. Test the fuels, real
24 conditions. The chimney -- that doesn't seem to have
25 happened, so we're relying on TRAC or something else

1 to predict what happens in the chimney.

2 So these sorts of questions can always be

3 raised, and I just don't know how you answer them,

4 except by some kind of engineering judgment, unless

5 you've got some evidence.

6 MR. MARQUINO: We've heard your concern,

7 and we will work to address it.

8 MEMBER BANERJEE: Somebody mentioned that

9 the Dodewaard experience might be looked at in

10 relation to this problem. And that might be helpful

11 to bring it in and --

12 MR. WALLIS: Did they have chimneys like

13 this?

14 MR. MARQUINO: They had chimneys. Yes,

15 they had four by four super channels.

16 MEMBER BANERJEE: And --

17 MR. MARQUINO: Or, excuse me, two by two

18 super channels. It was somewhat shorter than ours.

19 MEMBER BANERJEE: And you've used TRACG,

20 of course, against that.

21 MR. MARQUINO: Yes.

22 MEMBER BANERJEE: Okay.

23 CHAIRMAN CORRADINI: Did we miss that? Is

24 that analysis in another NEDO that I don't -- I can't

25 remember where it went?

1 MR. MARQUINO: I think it's in the 32177
2 report, the TRACG qualification report.
3 CHAIRMAN CORRADINI: And then, just for
4 the sake of -- and then, you will also give us some
5 advice on that one as well as the one where you said
6 there is already a calculation for us to look at as
7 you consider the countercurrent in the piping. Thank
8 you.
9 MEMBER BANERJEE: Perhaps some scaling
10 analysis or something to indicate the applicability of
11 that data, has that already been done, or have I
12 missed that?
13 MR. MARQUINO: We did submit a scaling
14 analysis for --
15 MEMBER BANERJEE: I know that. But the
16 applicability of this Dodewaard data, I mean, in terms
17 of the range of parameters and the other non-
18 dimensional groups, is it within the range of what we
19 are looking at TRACG here for?
20 MR. MARQUINO: Do you want to comment on
21 the Dodewaard scaling or --
22 MEMBER BANERJEE: No. I mean, does it
23 actually have the same range of, let's say, these pie
24 groups or whatever we talk about?
25 DR. SAHA: Okay. This is Pradip Saha from

1 GEH. The scaling analysis that we did, and then it
2 was upgraded for 4,500 megawatts, I think was geared
3 towards the LOCA.
4 So basically we looked into GIST and
5 GIRAFFE SIET experiments. And then, we showed that
6 even though the power has been raised by 12.5 percent,
7 so decay heat goes up, but primarily dominant
8 phenomena during LOCA was that ADS or the enthalpy --
9 mass and enthalpy going out predominantly in the most
10 dominant term was ADS. And the decay heat portion was
11 much smaller. So that is why we concluded -- and I
12 think staff has agreed with that -- that the earlier
13 experiments are applicable to 4,500 megawatt also.
14 Now, for Dodewaard, I don't think there
15 was anything related to --
16 MEMBER BANERJEE: No. That would be more
17 towards normal operation.
18 DR. SAHA: Right. No, it was not part of
19 that study.
20 MEMBER BANERJEE: I know it's a separate
21 issue --
22 DR. SAHA: Yes.
23 MEMBER BANERJEE: -- but let me ask this
24 for information, then. For the applicability of TRACG
25 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

1 that.

2 MEMBER BANERJEE: Obviously, because there

3 is no LOCA test done.

4 DR. SAHA: Right. I know that what Mr.

5 Marquino mentioned in the TRACG qualification report

6 and Rev 3, I think 32177 probably, the number, I think

7 there is a simulation of Dodewaard with TRACG. But I

8 do not recall whether there is any scaling analysis.

9 MEMBER BANERJEE: Yes, because that would

10 show whether the conditions which are important were

11 similar or not or within the range of interest. I

12 think that's the real issue.

13 DR. SAHA: We understand.

14 MEMBER BANERJEE: Okay.

15 DR. SAHA: And I'm sure Wayne is taking

16 notes of that.

17 MEMBER BANERJEE: Great. Thank you.

18 DR. WANG: Continue?

19 CHAIRMAN CORRADINI: Yes.

20 DR. WANG: Okay.

21 CHAIRMAN CORRADINI: Please.

22 DR. WANG: For the thermal conductivity,

23 actually yesterday we talked about it for the LOCA

24 part. And there is other models. TRACG has updated

25 the models, and these models are actually for the LOCA

1 -- it is not important. I just basically list it here
2 for -- to illustrate what kind of models TRACG has
3 went through from version 2 and through version 4.
4 MR. WALLIS: So you don't use the quench
5 run model for this --
6 DR. WANG: Because no dryout for the LOCA.
7 MR. WALLIS: -- for this source term? You
8 just take some sort of source term, you don't try to
9 figure out core damage or anything like that?
10 DR. WANG: Because for the LOCA there is
11 no -- I mean --
12 MR. WALLIS: But, I mean, when you're
13 doing the Chapter 15 analysis, you don't try to be
14 realistic in any way about if it does dry out and then
15 you construct this artificial scenario, how does it
16 rewet?
17 MR. LANDRY: Are you talking about for the
18 radiological assessment?
19 MR. WALLIS: Yes.
20 MR. LANDRY: We're talking about strictly
21 for the design basis.
22 MR. WALLIS: Yes, but you don't try to
23 make any bridge whatsoever between reality and the
24 regulations.
25 MR. LANDRY: For the design basis analysis

1 for LOCA, the core does not dry out. So none of these
2 models apply.
3 MEMBER KRESS: They just have to show that
4 the temperature in the hot leg --
5 MR. WALLIS: When you get into Chapter 15,
6 you just make a leap into the source term without
7 asking how it got formed, right?
8 CHAIRMAN CORRADINI: For 15.4, that's what
9 they have to do.
10 MR. WALLIS: All right. So --
11 MEMBER BANERJEE: But for some of the
12 anticipated transient, there is dryout. But then, you
13 don't worry about rewet I guess.
14 MR. MARQUINO: Not for anticipated
15 transients.
16 MEMBER BANERJEE: Sorry. Special -- what
17 did you call --
18 MR. MARQUINO: For ATWS -- for ATWS, there
19 is a dryout-type phenomena.
20 DR. WANG: Okay. Go to the next one?
21 CHAIRMAN CORRADINI: Please.
22 DR. WANG: Okay. This confirmatory item
23 is about -- addresses the power and the results from
24 main steam isolation valve closure. Basically, at the
25 preapplication stage, staff asked GE to confirm about

1 -- say if for the main steam isolation valve closed,
2 what about the power transient, is it going to
3 increase or not? And GE has the response that
4 basically the rod -- I mean, the scrams way earlier
5 occur before this main steam isolation valve closure
6 during the LOCA. So this problem has been closed.
7 And the next one, basically GE is aware
8 from the earlier submission to the later design change
9 being made, and the staff asked GE to confirm the
10 TRACG applicability, say, for the core power since it
11 has changed from 4,000 megawatts to 4,500 megawatts.
12 And staff asked us to confirm the
13 applicability of the TRACG interfacial shield model.
14 This is an open item.
15 And for ICS was for the -- LOCA analysis
16 was not a part of the ECCS, and the latest design is
17 considered as a part of the ECCS, and the staff have
18 a question basically -- ask GE to make a clarification
19 about nodalization, and also justify that the modeling
20 of the IC heat removal capacity in the LOCA is
21 conservative.
22 And other changes -- other design changes,
23 we believe TRACG has the capability to model, so these
24 will not affect TRACG applicability. Many of them are
25 listed here. For example, core shroud size and core

1 lattice. These are not really modeled for this --
2 well, the core lattice is not really modeled.
3 And another example is the number of
4 bundles and the control rod drives. These are also
5 another model for this LOCA analysis.
6 If you have no questions, I'll go to the
7 next one.
8 Other confirmatory item is basically for
9 the containment analysis the TRACG assumed there's a
10 loss of feedwater flow, and staff raised the question
11 is -- if you have additional feedwater goes to the
12 reactor vessel. If you don't, basically assume it's
13 lost, and the additional inventory and energy, and
14 that can eventually go through the containment. And
15 staff raised this question, basically wanted GE to
16 address for this containment system.
17 And next confirmatory item, 11, is similar
18 to this item 10. Basically, staff asked GE to add a
19 detailed modeling of this feedwater system. And I
20 believe GE has submitted this II back, and currently
21 staff is reviewing it.
22 MR. WALLIS: You are talking about some
23 sort of model for these heaters, the actual feedwater
24 heaters, this -- taking bleed steam from the turbine
25 and how they work?

1 DR. WANG: I believe --

2 MR. WALLIS: Do you want to --

3 DR. WANG: I believe it is not really what
4 you have just mentioned. I believe that in the
5 beginning when -- people at NRR at times raised this
6 question, is it related to the item 10, and they
7 wanted to have more realistic modeling of this
8 inventory amount goes to the reactor vessel and also
9 go through containment.

10 It's not anything, you know, for the
11 current feedwater operation domain. But GE did answer
12 -- they have added some model for the feedwater, so we
13 are looking at it.

14 Any clarification here?

15 DR. CHEUNG: This is Chester Cheung.
16 Three years ago when we modeled the feedwater line,
17 only modeled the -- half of it. And at that point in
18 time, the GDCS volume compared with the lower drywell
19 volume and then the feedwater line volume is kind of
20 mixed. And there was a concern that you have the
21 whole line of feedwater volume was water inventory
22 going into the drywell, and then what happened.

23 And now we model exactly all of this
24 volume into it, and in case of feedwater line break
25 all of the volume in the feedwater line, it did go

1 into the lower drywell and pressurize the drywell that
2 way. So at that point in time, it was a volume
3 concern, the volume between the different locations.
4 DR. WANG: Does that answer your question,
5 Dr. Wallis?
6 MR. WALLIS: I'm not sure. Why do you say
7 feedwater heater modeling?
8 DR. WANG: Because the heater modeling
9 will affect the amount of their -- this whole system
10 in the -- for the feedwater drain, there is many
11 stages of the heaters.
12 MR. WALLIS: Right.
13 DR. WANG: And if you model the system --
14 MR. WALLIS: Well, the vessel actually has
15 quite a bit of water in it before the heat -- water
16 heaters, doesn't it?
17 DR. WANG: Yes, there's quite a bit of
18 water.
19 MR. WALLIS: So you want to know where the
20 water goes, is that what you're modeling, then?
21 DR. WANG: We model it, and then the water
22 eventually will go in the lower drywell.
23 MR. WALLIS: I see.
24 DR. WANG: Until the isolation valve or
25 the feedwater line actually closes.

1 And there is an uncertainty analysis we
2 discussed yesterday about, you know, basically this is
3 not a technical issue but a laboratory issue, and you
4 needed to answer -- address how --
5 MR. WALLIS: How uncertain they are about
6 2,200 degrees?
7 DR. WANG: Right. And they claim this
8 coil is always covered, so there is no issue. But we
9 needed to ask GE to address this.
10 CHAIRMAN CORRADINI: I'm not sure what
11 you're asking them. You're asking them to come up
12 with some sort of uncertainty analysis?
13 DR. WANG: Basically, have to address this
14 laboratory guide, but what --
15 MEMBER BANERJEE: You are looking at what
16 the level above the core or something.
17 CHAIRMAN CORRADINI: No, that's what
18 they're suggesting. I'm trying to understand your
19 question. Are you saying that you haven't evaluated
20 their response based on level? Is that --
21 MR. LANDRY: The regulation, 50.46, says
22 you can do either a realistic analysis with a
23 determination of uncertainty, or you can do an
24 Appendix K analysis. What General Electric-Hitachi
25 has submitted is a realistic analysis.

1 MR. WALLIS: Well, you can't do an
2 Appendix K analysis of this --
3 MR. LANDRY: They have not done any form
4 of an uncertainty analysis, and what we are simply
5 saying is they don't uncover the core. This is not a
6 safety issue, it's not a technical issue, it is a
7 compliance issue. The regulation doesn't say a
8 realistic analysis, and if you don't uncover, okay.
9 It says you do this or you do this, and they have not
10 done --
11 MR. WALLIS: I think they have. They have
12 essentially said it doesn't uncover, so their
13 uncertainty is zero.
14 MR. LANDRY: Yes. But they have to do
15 some sort of -- we discussed this over and over with
16 them.
17 MEMBER BANERJEE: I guess it's uncertainty
18 of uncovery that -- by the --
19 MR. LANDRY: They have to do some sort of
20 uncertainty analysis.
21 MR. WALLIS: Of uncovery.
22 MS. CUBBAGE: And we have asked this to
23 GEH in an RAI. We're waiting for their response.
24 MR. WALLIS: Okay. Well, I'm sure they'll
25 respond.

1 MR. LANDRY: This is not a safety issue.
2 It is a compliance issue with the exact statement of
3 the regulation.
4 CHAIRMAN CORRADINI: Got it. Thank you.
5 MR. WALLIS: But they asked for
6 uncertainty analysis of these 2,200 degrees and things
7 like that.
8 MR. LANDRY: No. No, it says with a
9 determination of uncertainty.
10 MR. WALLIS: So a blanket uncertainty.
11 MR. LANDRY: It just says a determination
12 of uncertainty.
13 MR. WALLIS: Okay.
14 MEMBER BANERJEE: So you can define that
15 uncertainty the way you like. It can be done --
16 certainty involved in that core uncovery calculation.
17 MR. LANDRY: And that's what we've said.
18 Do some sort of uncertainty determination.
19 MEMBER BANERJEE: I think that's fair.
20 MR. LANDRY: Yes.
21 MR. WALLIS: And you might find there's a
22 certain probability of uncovery. You might. You
23 might. Okay.
24 MR. WILLIAMS: Jim Gilmer got turned over
25 from Veronica the transient portion of the 33083P, and

1 he is going to discuss his -- discuss the review of
2 that.
3 CHAIRMAN CORRADINI: Okay.
4 MR. GILMER: We made a decision early on
5 to take out ATWS to allow Ben Parks more time to
6 discuss the key issues of core injection, which he
7 talked about this morning.
8 MEMBER SIEBER: Take a break.
9 MR. GILMER: Some of the things that we
10 are going to talk about in the AOO and infrequent
11 events also apply to the ATWS.
12 CHAIRMAN CORRADINI: Would you be hurt if
13 we took a break now? I'm starting to look at members
14 that are looking at bit weary. So can we take a 15-
15 minute break and come back to you? Would that be
16 okay?
17 MR. GILMER: Sure.
18 (Whereupon, the proceedings in the
19 foregoing matter went off the record at
20 3:02 p.m. and went back on the record at
21 3:17 p.m.)
22 CHAIRMAN CORRADINI: All right. Let's get
23 started. Let's go.
24 MR. GILMER: I wanted to say that the key
25 ATWS concern was the ability of TRACG to model the

1 boron injection which Ben Parks talked about this
2 morning. There are a few items that I'll mention here
3 also, if there's time.
4 CHAIRMAN CORRADINI: That's fine.
5 MR. GILMER: We do have a couple of key
6 open items that I want to summarize.
7 Next slide.
8 The SRP 1502, Shawn had an earlier slide,
9 so that's all I'll say there. But there are some
10 additional key references on transient and background
11 analysis methods. And NUREG/CR-5229, which is the
12 CSAU method for LOCA was also used for the --
13 MEMBER BANERJEE: But in these anticipated
14 transients, TRACG presumably is coupled to some sort
15 of neutronic field, right?
16 MR. GILMER: That's correct.
17 MEMBER BANERJEE: And they were separately
18 approved I guess, right?
19 MR. GILMER: Well, that's still ongoing.
20 I'll let Dr. Yarsky --
21 MEMBER BANERJEE: Okay.
22 MR. GILMER: -- address the neutronics.
23 He's our expert on that.
24 DR. YARSKY: This is Peter Yarsky
25 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.

1 MEMBER BANERJEE: Yes, temperatures are
2 changing. Does that change various things in the
3 code, the cross-sections or how you collapse them and
4 feed back?
5 DR. YARSKY: I'm not sure if I --
6 MEMBER BANERJEE: The interaction between
7 the two.
8 DR. YARSKY: Yes. I'm not sure if I can
9 answer that in sufficient detail in open session.
10 MEMBER BANERJEE: Oh, okay. But there is
11 an answer to that, right?
12 DR. YARSKY: Yes.
13 MEMBER BANERJEE: Okay.
14 CHAIRMAN CORRADINI: But just to be clear,
15 so you're in the midst of the review as of now. So
16 we'll probably hear back from staff when you guys are
17 at a point.
18 MR. SHUAIBI: Let me make sure what Peter
19 said I guess clear. He can't answer it in an open
20 session, because we're in open session. I guess if we
21 go to a closed session, he may be able to get into
22 more detail, a little bit more detail.
23 CHAIRMAN CORRADINI: But before we go to
24 that effort, I just want to make sure I understand.
25 You still are in the middle of the review? Because

1 you have not issued the SER yet on this part of this.
2 DR. YARSKY: This is being reviewed as
3 part of Chapter 4, but the actual review is for the
4 topical report, the nuclear design topical report,
5 which is the -- which in it contains the qualification
6 of the methods.
7 CHAIRMAN CORRADINI: Right.
8 DR. YARSKY: So that's going to be an SER
9 that is issued for the proprietary topical report.
10 CHAIRMAN CORRADINI: Which we eventually
11 will get to look at.
12 MS. CUBBAGE: Yes.
13 DR. YARSKY: Yes.
14 CHAIRMAN CORRADINI: Okay.
15 MEMBER BANERJEE: He wants to move on, so
16 -- he doesn't want to --
17 (Laughter.)
18 CHAIRMAN CORRADINI: I don't want to go
19 into closed session right now for that one question.
20 MEMBER BANERJEE: So all we're saying is
21 we will address this issue in a -- later on.
22 CHAIRMAN CORRADINI: I guess there is one
23 thing -- and maybe I missed it -- we got some of the
24 topicals in a CD that we have. There's others that
25 people are mentioning that are still either in transit

1 or have arrived and staff is looking at them. Is
2 there like a master list that I've missed?
3 MS. CUBBAGE: A master list. There is a
4 list of topical reports in DCD Chapter 1, I believe.
5 There is a list of all of the references, some of
6 which are old and long since been approved, some of
7 which are supporting the DCD and the SER we're writing
8 for the certification. Some of them we're going to
9 have separate SERs we're writing -- for example, in
10 the fuel, we've written a separate SER on TRACG for
11 stability. We have given you a number of those on the
12 CD.
13 CHAIRMAN CORRADINI: But the DCD Version 3
14 has at that time what that list is in Chapter 1. Are
15 there additions to that?
16 MS. CUBBAGE: Yes. There have been some
17 recently submitted topical reports, two of which I
18 gave to Gary at lunch time. That's the feedwater
19 topical, and I think he has already given you CDs.
20 Feedwater topical and initial core transients, you
21 have in your hand. And maybe I can get with Gary at
22 some point offline, and we can kind of do an inventory
23 of what you have and maybe what you need.
24 CHAIRMAN CORRADINI: Okay. That would be
25 very helpful.

1 MEMBER BANERJEE: I think it would be
2 helpful if Gary circulated what you called a master
3 list, at least the current status of --
4 CHAIRMAN CORRADINI: Yes. The current
5 status of what GE has as coming or has come and what
6 you guys have reviewed, and so that we can -- because
7 in some sense I'm becoming a bit lost.
8 MS. CUBBAGE: Right. We have received --
9 with the exception of perhaps one topical, we have
10 received at least the Rev 0 version of every topical
11 we are expecting to get ---
12 CHAIRMAN CORRADINI: Okay.
13 MS. CUBBAGE: -- at this point. As the
14 review continues, there will be revs of various ones
15 that are -- that you have already received.
16 CHAIRMAN CORRADINI: Sure. Okay. Thank
17 you very much.
18 MR. GILMER: Okay?
19 CHAIRMAN CORRADINI: Sorry. Thank you.
20 MR. GILMER: The staff's recent review is
21 based on the preapplication -- the approval topical
22 33083. The transient revision was Section 4, which is
23 the subject of this transient safety evaluation.
24 Like the LOCA, GEH's method was the
25 CSAU 14 stuff, and our evaluation concludes that the

1 product appropriately -- is appropriate for this.

2 MEMBER BANERJEE: So are you going to tell

3 us sometime about these independent calculations done

4 with TRACE and PARCS to --

5 MR. GILMER: Yes.

6 CHAIRMAN CORRADINI: But I don't have a

7 feeling you're going to do it today, though.

8 MR. GILMER: That's correct.

9 MEMBER BANERJEE: When is this time going

10 to be? I mean --

11 MR. GILMER: Well, we have -- Tony Ulses

12 from our Office of Research has done TRACE/PARCS

13 calculations. They're ongoing, not yet completed.

14 MEMBER BANERJEE: Oh, I see. Okay.

15 MR. GILMER: Maybe Tony can at least

16 answer when he expects to --

17 MR. DONOGHUE: Oh, I don't want to put

18 Research on the spot for their schedule here in the

19 ACRS meeting. What I will say is that they have to --

20 they have to run their code, they have to evaluate it

21 before they even release it to us, and then we have to

22 evaluate the results and make sure --

23 CHAIRMAN CORRADINI: Is there an RAI to do

24 for --

25 (Laughter.)

1 Just out of curiosity.

2 MR. DONOGHUE: There is a formal process

3 to ask for work. We are bureaucrats, after all.

4 MEMBER BANERJEE: Work is underway right

5 now. Is that -- the work is underway?

6 MR. DONOGHUE: Yes. Yes.

7 MR. LANDRY: The analyses are underway.

8 Tony has run a number of cases. He has some cases to

9 run yet. But those calculations have not gone through

10 the full checkout procedure here, and sign-out,

11 concurrence, and transfer to the other office.

12 We do a lot of checking, the vendors do

13 checking and QAing before they send material in. We

14 do checking of our material before we send it to

15 others and before we present it in public, because we

16 want to make sure that what we're doing is -- that our

17 calculations are right also.

18 MEMBER BANERJEE: So how many months have

19 been spent up to now on this, Ralph?

20 MR. LANDRY: Bits and pieces of time. I

21 don't know if we could estimate the exact amount of

22 time, because Tony has had other work he has had to

23 do. He has been working on this since last spring in

24 pieces, and then he had other work, and then he'd come

25 back and do some more. So I don't think I can put a

1 handle on exactly how much time, if you put it in a
2 continuous stream of time.
3 We have work going on on AOO calculations.
4 We have work going on on LOCA calculations. We have
5 the ATWS work that we're doing, which you've heard
6 about. So we have a number of areas where we're doing
7 confirmatory calculations using TRACE and using FLUENT
8 and these -- all these tools that are available to us.
9 MEMBER BANERJEE: TRACE and PARCS have
10 been coupled now, right, to the ATWS, so --
11 CHAIRMAN CORRADINI: What does that mean
12 in this regard? Are they communicating online
13 simultaneously? Are they feeding input decks to each
14 other?
15 MR. LANDRY: Let's let Tony explain it.
16 But TRACE has been coupled with PARCS and with TRITON.
17 CHAIRMAN CORRADINI: What is TRITON?
18 MR. LANDRY: It is a cross-section code.
19 CHAIRMAN CORRADINI: Oh. Thank you.
20 MR. ULSES: Hi. This is Tony Ulses, the
21 Office of Research. We basically have the PARCS code
22 is now actually compiled right in with TRACE directly,
23 so there is no -- you know, we're not actually handing
24 information between two separate codes. In other
25 words, you know, I use PARCS to calculate power, and

1 then it's inserted into the TRACE, the fuel
2 structures.
3 It calculates -- then, it calculates a
4 fuel temperature and a moderator density. It hands it
5 back to PARCS. So that's all handled online, and then
6 we feed it a set of cross-sections, which is derived
7 to cover the entire expected space of the analysis in
8 terms of fuel temperature, void conditions within the
9 core, and that is essentially how the code works.
10 MEMBER BANERJEE: Is there a table you
11 fill in or what?
12 MR. ULSES: Well, actually, it works with
13 -- it actually works based on partial derivatives
14 within the model itself. And we've actually used the
15 HELIOS code to generate the cross-sections, although
16 we do have our own internal TRITON code that we're --
17 we actually have cross-sections. I just haven't had
18 time to actually plug them in and run them and see how
19 they work yet so far.
20 CHAIRMAN CORRADINI: Because I was going
21 to say I was under the impression that RELAP and PARCS
22 and HELIOS were coupled, and so when you used another
23 cross-section -- so HELIOS is not used here, it's this
24 other tool that you mentioned.
25 MR. ULSES: We actually have HELIOS cross-

1 sections. And that's what we've used to date.

2 MR. LANDRY: That's what we've used in

3 this case. Another task that Tony wants to do is to

4 use TRITON to generate the cross-sections instead of

5 HELIOS, so that it would be a completely coupled

6 TRACE, PARCS, TRITON.

7 CHAIRMAN CORRADINI: Okay.

8 MR. ULSES: Exactly. Exactly.

9 CHAIRMAN CORRADINI: Thank you.

10 MR. GILMER: Okay. One thing I did not

11 have on the slide is ISL has done their own

12 independent technical evaluation for both ATWS and

13 AOO, and those are attached to the safety evaluations

14 that the members should have, the SERs also.

15 MEMBER BANERJEE: Attached to the --

16 CHAIRMAN CORRADINI: It's attached to --

17 where is it attached? I'm sorry.

18 MR. GILMER: It should be --

19 MEMBER BANERJEE: On 21? Is this an

20 addendum or --

21 CHAIRMAN CORRADINI: No. They're attached

22 to the specific SERs that say SER for ATWS and SER for

23 transients. There was two addendums. They're not

24 attached to the addendums, and they're not attached to

25 Chapter 21.

1 MR. ULSES: They're in the attachments to
2 the particular --
3 MEMBER BANERJEE: Yes. SER for TRACG is
4 applied to ATWS clean, you call it.
5 CHAIRMAN CORRADINI: Okay. All right.
6 MR. GILMER: Okay. The significant open
7 items -- there are a couple on the isolation condenser
8 modeling. One we discussed earlier on the ability of
9 the TRACG to model condensers, so we'll have to
10 resolve that with the -- whatever we've done on the
11 benchmark, other ways, and get back with you on that.
12 The other one was just regarding the test
13 that was done, the range --
14 CHAIRMAN CORRADINI: I think you need to
15 speak louder.
16 MR. GILMER: Okay. The range that GEH
17 looked at did not cover the high pressure that could
18 result from an SRV opening, so there is an open item
19 on that. And some slight disagreement between us and
20 staff and GEH on the ranking of the few PIRT
21 parameters and the high and medium ranked, and the way
22 they are combined to get the uncertainties.
23 CHAIRMAN CORRADINI: The isolation
24 condenser modeling, can you remind me what -- the
25 issue there is just how it's modeled? I don't

1 remember the --

2 MR. GILMER: Veronica would like to chip

3 it on that one.

4 MS. WILSON: Just for a second. This is

5 Veronica Wilson. We had several issues with the

6 isolation condenser modeling that GE had. Now, you've

7 got to remember that GE uses it for LOCA and AOOs.

8 And for LOCA specifically, we had questions about the

9 non-condensable gas, because they don't have non-

10 condensable gases in AOOs. So that was specifically

11 the LOCA. The treatment of that, the data, was a

12 little non-representative, and so we just asked GE to

13 justify --

14 MR. WALLIS: Where do those gases go in

15 the isolation condenser?

16 MS. WILSON: There is a vent line to the

17 suppression pool.

18 MR. WALLIS: There's a vent line to the

19 suppression pool.

20 MS. WILSON: Yes. And so --

21 CHAIRMAN CORRADINI: So the treatment

22 there is different than in the PCCS? It's the same

23 model as far as I thought, as far as I understood.

24 And they're using the Berkeley and the MIT test as

25 their basis to at least show they -- so what's the

1 issue?

2 MS. WILSON: I think it was the PANTHERS

3 data that actually did full-scale isolation

4 condensers.

5 CHAIRMAN CORRADINI: Yes.

6 MS. WILSON: Now, these are not

7 representative -- that was what we were told, that

8 they're not representative of ESBWR. But when they

9 had injected some non-condensable gases and then they

10 modeled that with TRACG, they completely missed like

11 a lot of the timing and some of the pressures.

12 I think it was a pressurization -- timing

13 was missed, and so it kind of showed that in the

14 presence of non-condensables the model that they were

15 using with TRACG, not exactly working out. And so

16 when we asked GE some questions. It's an open item.

17 We're discussing it right now with GE. It just kind

18 of is not clear that with the presence of non-

19 condensables that the TRACG model is working out so

20 well.

21 CHAIRMAN CORRADINI: Well, I mean, this

22 concerns me more for the PCCS, since it really -- it

23 really needs to work well there. So is it -- so let

24 me just ask one more time. Is it at high steam mass

25 fracture that there seems to be a problem, or at any

1 steam mass fracture?

2 Because there tends to be an ability to

3 err on condensation and heat transfer coefficient very

4 easily at small amounts of non-condensable gas. At

5 high amounts of non-condensable gas, everything tends

6 to be relatively insensitive once I'm out there. So

7 is it a function of the proportion, or is it they

8 missed it over a wide range of regimes? That's what

9 -- I'm looking back.

10 MS. WILSON: I can't answer your question

11 completely. We were told by GE was that the tests

12 that they showed us that showed this mistiming was not

13 actually representative of any way -- in the way that

14 the ECCP valve would be operated. And so I'm not

15 really sure that there was ever a range done.

16 The description says that they merely did

17 the test to show that the vents would work. When they

18 were testing the PANTHERS, they were testing the IC,

19 and that the isolation -- I mean, the non-condensables

20 would certainly go to the suppression pool. And that,

21 they said, was the purpose of the test. They weren't

22 really trying to set up realistic conditions to model

23 that, and so --

24 CHAIRMAN CORRADINI: Can I ask GE to kind

25 of illuminate us?

1 MR. MARQUINO: Yes, thank you. The test
2 didn't simulate a transient, a specific transient
3 event, or a LOCA event. It was -- the heat exchanger
4 is the same headers as ESBWR, so in that sense it's
5 completely representative of ESBWR. But in that
6 PANTHERS test of non-condensable gas, they fed the
7 heat exchanger non-condensable gas. We watched its
8 performance degrade, and then they opened the vent
9 valve and they saw it purge itself and pick up heat
10 capacity again. So --
11 CHAIRMAN CORRADINI: So it's a LOCA TRAC
12 analysis of the test.
13 MR. MARQUINO: I think we did do a TRAC
14 analysis of the test, and I think the statement that
15 it wasn't representative of ESBWR must be it's not
16 exactly ATWS boundary conditions applied during the
17 test. Does that -- Veronica, do you want to clarify?
18 MS. WILSON: We weren't really concerned
19 about ATWS to begin with, because like the time
20 scales, as you had pointed out -- which we agree with
21 -- were not really long enough to create the
22 radiolytic gas decomposition. So it was more for the
23 LOCA, because we knew that you guys actually modeled
24 that.
25 And I think some of the details might be

1 proprietary, but we know that the non-condensables are
2 modeled in the LOCA due to the long-term nature of the
3 vent, and so --
4 CHAIRMAN CORRADINI: Can I ask GEH to give
5 me a -- you don't -- any one of your numbers?
6 MR. UPTON: Yes, I found the open item.
7 I was trying to get back to what the staff said in the
8 SER, but I guess I don't remember the test. I'm
9 sorry.
10 CHAIRMAN CORRADINI: The PANTHERS, is that
11 32177, or is that one in the ESBWR?
12 DR. CHEUNG: I cannot get it off my head.
13 CHAIRMAN CORRADINI: We have that one. Or
14 no --
15 MS. WILSON: 32725?
16 CHAIRMAN CORRADINI: Is there a 76 --
17 PARTICIPANT: 377.
18 MR. MARQUINO: 32177 is the TRACG
19 qualification --
20 CHAIRMAN CORRADINI: Okay, thank you.
21 MR. MARQUINO: -- LTR.
22 CHAIRMAN CORRADINI: Thank you.
23 MR. WALLIS: Now, this isolation
24 condenser, is it the vessel pressure, isn't it? So
25 there's a tremendous pressure difference between it

1 and the suppression pool.

2 MR. MARQUINO: Yes.

3 MR. WALLIS: So what controls the flow

4 rate to the suppression pool?

5 MR. MARQUINO: The vent. It's got a

6 little vent line, and if it --

7 MR. WALLIS: Is the race to be -- condense

8 the steam enough so that it doesn't all get sucked to

9 to the suppression pool down the vent line?

10 MR. MARQUINO: No, it's -- if there is

11 radiolytic acid, the vent line would be --

12 MR. WALLIS: But even if there's no non-

13 condensables, there's going to be tremendous suction

14 in that vent line, isn't there?

15 MR. MARQUINO: No, but the vent line is

16 closed.

17 MR. WALLIS: It's closed.

18 MR. MARQUINO: So if there's no non-

19 condensables in it, the vent line is closed.

20 MR. WALLIS: When does it open?

21 MR. MARQUINO: It opens automatically on

22 high pressure.

23 MR. WALLIS: On pressure. On pressure.

24 CHAIRMAN CORRADINI: And how would the

25 pressure be any different than the RCS? What do you

1 mean by high pressure? A differential pressure from
2 the vessel?
3 MR. WALLIS: In the RCS, or what?
4 MR. MARQUINO: No. Absolute gauge
5 pressure. So if the -- it's an orifice vent line. If
6 the pressure is higher than the setpoint for some
7 duration, the vent line opens, it purges itself,
8 pressure comes back down again.
9 MR. WALLIS: But that setpoint must depend
10 on the pressure in the vessel, or it is determined by
11 the pressure in the vessel.
12 MR. MARQUINO: It's --
13 CHAIRMAN CORRADINI: So let me just make
14 sure -- and then, we'll have to go look and do our
15 homework. But what you're saying, if I understand it
16 correctly, is is that with the isolation condenser as
17 the ultimate heat sink in this mode, pressure would
18 rise within the system to some setpoint, you would
19 have a vent clearing orifice, and that would
20 supposedly clear it and then bring the pressure back
21 down? Am I understanding correctly?
22 MR. MARQUINO: Yes. The symptom is the
23 pressure -- the pressure is too high. If the IC is
24 functioning, it will depressurize the reactor. So if
25 the pressure is high for a long duration, the ICs

1 become radiolytic gas built up and --

2 MR. WALLIS: The microscopic thing, it

3 says the thing isn't working, because the pressure is

4 staying up. So we'd better open a vent film.

5 MR. MARQUINO: Yes. Vent line, yes.

6 CHAIRMAN CORRADINI: With a small amount

7 of leakage, which that supposedly vents --

8 MR. WALLIS: With a small amount of

9 leakage.

10 CHAIRMAN CORRADINI: It will vent both

11 steam and gas and should clear it and start the

12 process.

13 MR. WALLIS: And then it closes again, is

14 that right?

15 MR. MARQUINO: Yes.

16 DR. CHEUNG: This is Chester Cheung from

17 GEH. I want to add one more comment. In the LOCA

18 analysis, the IC heat transfer credit was not taken

19 into consideration. So the only criteria is the IC

20 drain line water volume.

21 CHAIRMAN CORRADINI: Well, we should go to

22 332 or 32177 to check this out further.

23 DR. CHEUNG: That is describing the DCD

24 revision.

25 CHAIRMAN CORRADINI: Okay. Thank you for

1 the reference.

2 Go ahead.

3 MR. GILMER: Okay. One final item we --

4 MS. WILSON: Wait. I'm sorry, I was going

5 to clarify. We have the reference for you for the IC

6 -- if you want the exact like accession number, and

7 what information would be useful? The NEDC number?

8 CHAIRMAN CORRADINI: Ye.

9 MS. WILSON: Okay. It's NEDC -- well,

10 it's -- okay. Here's the title of the document.

11 Update of ESBWR TRACG Qualification for NEDC 32725P

12 and NEDC 33083P.

13 CHAIRMAN CORRADINI: Can you go slower,

14 please?

15 (Laughter.)

16 You're way too fast for --

17 MS. CUBBAGE: We are going to get it to

18 Gary, because --

19 CHAIRMAN CORRADINI: Good. Thank you.

20 MS. CUBBAGE: -- it's not really an LTR,

21 right?

22 CHAIRMAN CORRADINI: Oh, it is not.

23 MS. CUBBAGE: It's a submittal.

24 CHAIRMAN CORRADINI: Okay. Thank you.

25 MS. WILSON: Yes. And so --

1 CHAIRMAN CORRADINI: If you get it to
2 Gary, then we can do our homework.
3 MS. CUBBAGE: It's reference 27 in the
4 Chapter 21 SER.
5 MS. WILSON: Yes. And we had separate
6 issues with the IC for the AOO modeling, and that had
7 to do with nodalization and heat transfer
8 correlations, without going into any proprietary
9 detail. They were just kind of inconsistent with what
10 GE chose to demonstrate in the qualification, so we
11 asked them to justify what they used in the actual
12 TRACG model.
13 CHAIRMAN CORRADINI: Thank you. Thank you
14 very much.
15 MEMBER BANERJEE: Yo you mean they didn't
16 measure any heat transfer coefficients and couldn't in
17 the IC test, right? Or am I getting confused about
18 something?
19 MS. WILSON: I'm sorry. Will you repeat
20 that?
21 MEMBER BANERJEE: They could not measure
22 any heat transfer coefficients, could they?
23 CHAIRMAN CORRADINI: They just measured
24 total heat removed, I thought, essentially heat
25 exchanger performance.

1 MS. WILSON: Right. But they used a heat
2 transfer correlation in TRACG --
3 MEMBER BANERJEE: Based on single --
4 MS. WILSON: Yes. From what he was saying
5 from the Berkeley and the -- I think the name of it is
6 actually proprietary -- that other model that they
7 had, and that is what they used --
8 CHAIRMAN CORRADINI: It's published in the
9 open literature. I think we can say it.
10 MS. WILSON: Okay. Yes, the Kuhn-Schrock-
11 Peterson one, and that was what they had used to try
12 to match the data. They didn't actually measure like
13 a heat transfer correlation, but then they didn't
14 proceed to use some of the same -- but it wasn't for
15 the internal condensation. I think it was the
16 external -- not insights, because that is what they
17 use inside the tubes. It was the heat transfer
18 correlation on the outside of the tubes.
19 MR. WALLIS: Governed by the outside. I
20 mean, the condensation coefficient is so high it's
21 governed by the convection coefficient on the outside?
22 No?
23 MS. WILSON: The point is they use
24 something different than what they used to validate
25 the TRACG in ESBWR, and so we just asked to justify

1 that.

2 MEMBER BANERJEE: I haven't looked in

3 this.

4 CHAIRMAN CORRADINI: Okay. Thank you very

5 much.

6 MR. GILMER: Okay. The last item is the

7 capability to model lower plenum cold water mixing.

8 There's an open item on that.

9 CHAIRMAN CORRADINI: Can you -- since this

10 is one of the three final ones, can you remind me

11 about that one again? I'm sorry. In terms of just

12 the plenum mixing.

13 MR. GILMER: Yes.

14 CHAIRMAN CORRADINI: Distribution of

15 temperatures?

16 MR. GILMER: Well, the main concern was,

17 what is the effect on the minimum CPR? They presented

18 a three-region model, and the RAI response only gave

19 the inner and central rings. We don't have the

20 periphery.

21 CHAIRMAN CORRADINI: Oh, okay. Okay.

22 MR. GILMER: So that's the issue.

23 CHAIRMAN CORRADINI: Informational.

24 MR. WILLIAMS: That's it for our

25 presentation for Chapter 21.6, unless there are any

1 further questions.

2 MR. WALLIS: Does the cold water mixing --

3 you don't know how they're going to resolve that. So

4 we don't know either.

5 CHAIRMAN CORRADINI: I guess I took it the

6 way you explained it is informational. You had some

7 of the information, but not all of the information.

8 MR. GILMER: That's correct.

9 MR. WALLIS: The concern is that different

10 temperatures go into different regions of the core,

11 and this changes the CPR?

12 MS. WILSON: Well, we didn't have enough

13 information from what GE gave to -- since it's a very

14 coarse, nodalized -- you know, TRACG is these big,

15 large cells -- that there would -- if there was actual

16 stratification in the lower plenum, that that would be

17 adequately represented by TRACG.

18 So we asked GE to kind of investigate this

19 and show us, because we're worried that you could get

20 maybe some concentration of cold water and, like you

21 said, might have more significant MCPR.

22 MR. WALLIS: Even the nodalization for

23 TRACG?

24 MS. WILSON: We have, but it's very coarse

25 in comparison to like a real live plant.

1 MR. WALLIS: It doesn't really represent
2 stratification, does it?
3 MS. WILSON: Exactly. And so that's why
4 we wanted to make sure that if there was, that that
5 would either be adequately representative or maybe
6 that there just is not.
7 CHAIRMAN CORRADINI: So let's go around
8 this way this time and get the members' comments.
9 MR. WALLIS: I was going to take the
10 overview and say I think the staff is doing the right
11 thing. They've asked a lot of questions. They've
12 asked the kind of questions that we would ask in many
13 ways. And we really need to see how they're answered.
14 I think our role is to make this list of
15 things that we're concerned about, which may not have
16 been raised enough by the staff, or, if they have, we
17 don't know that. And to try to sort of supplement in
18 some intelligent way these questions, which I say are
19 very comprehensive already, but there may be some
20 which haven't been asked.
21 I think that's our job, and I'll give this
22 to the Chairman, which he can then present to the
23 staff. And, otherwise, I think we're doing the right
24 thing here. I think both the staff and the applicant
25 have been responsive to any questions we have raised.

1 I really want to go into the details of
2 what these technical questions are, but I'll send you
3 a list.
4 CHAIRMAN CORRADINI: That's fine.
5 MEMBER BANERJEE: Yes. I think in many
6 ways I have the same sense of things as Graham that
7 there are many technical issues which we'd like to see
8 a lot more of. And I'll send you a list of these as
9 well. I've been compiling them, and they are
10 actually --
11 MR. WALLIS: How many pages are there?
12 MEMBER BANERJEE: Several pages. But I am
13 going to actually boil it down to one page --
14 CHAIRMAN CORRADINI: That would be
15 wonderful. Thank you.
16 MEMBER BANERJEE: -- for you. But
17 otherwise, I think it's going all right.
18 MEMBER BLEY: It seems like it's going
19 right. The questioning seems good. One issue came up
20 today that isn't strictly a thermal hydraulic one that
21 I thought I'd mention. You were talking about the
22 control rod withdrawal, and I know you're pursuing
23 that during -- based on the events that happened
24 during refueling in Japan.
25 I just looked at -- sneaked ahead and

1 peeked at the PRA, because some of these kinds of
2 issues I thought would be fine if they are dealt with
3 in the PRA. That one specifically blocked out of the
4 PRA, and that the whole shutdown PRA assumes the rods
5 are in place the whole time. So there are no
6 reactivity issues. So that will come up with the PRA
7 as well as here.
8 MEMBER ARMIJO: I don't have anything to
9 add. I agree with Graham's and Sanjoy's comments.
10 CHAIRMAN CORRADINI: Dr. Shack?
11 MEMBER SHACK: I just had a question for
12 GE. I'm very interested in this Dodewaard data,
13 because it seems to me that it's the only thing around
14 that is going to address Said's question. I don't
15 think you are going to go off and run a full-scale
16 test at this point.
17 And it's not 32177, as far as I can find.
18 Can you tell me where it really is?
19 MR. MARQUINO: I will have to get the --
20 there is these two qualification reports, one for
21 TRACG in general and one for ESBWR. If it's in 32177,
22 it must be in the other one. We'll research and get
23 back to you.
24 CHAIRMAN CORRADINI: If you could pass it
25 to Amy, they can just bundle it and send it to us.

1 That would be good. I'd appreciate it.

2 MR. MARQUINO: Okay.

3 VICE CHAIRMAN ABDEL-KHALIK: I mean, like

4 everyone else, I mean, we have a list of issues that

5 have been raised. We'll provide that list to you, so

6 that the staff and GE can come back and provide

7 answers to those. I must say I was somewhat dismayed

8 when I saw the statement about the -- that the

9 Chapter 15 review was significantly affected by that,

10 the new proposed reactor power controlled by varying

11 the feedwater temperature.

12 But we appreciate getting the topical.

13 We'll review it, and we'll do our homework, and

14 hopefully we'll see more details on that.

15 Thank you.

16 CHAIRMAN CORRADINI: Thank you.

17 MEMBER MAYNARD: Well, I think that -- I

18 agree the staff is asking a lot of good questions, and

19 I think that we're getting in a lot -- overall, I

20 think this seems to be a good design. I think these

21 issues are going to get resolved. I do think that the

22 questions are good and need to be dug into thoroughly.

23 A couple of things we forget sometimes.

24 We're dealing primarily with what they're taking

25 credit for. There are still other mechanisms. There

1 is still a lot of defense in depth of active systems
2 and other things that are available to get water moved
3 around and stuff. So there is some defense in depth,
4 although we're not allowed to take credit for that for
5 the design basis stuff and for 72 hours.
6 I think that probably the biggest -- the
7 key thing to me in the questions is the treatment of
8 the non-condensable gases and, you know, what are the
9 real flows through these systems. I think there is
10 probably plenty of conservativism in the analyses, as
11 long as the non-condensable gases do what is assumed
12 in the analysis. And that's where I think probably
13 the key effort needs to be is in really taking a hard
14 look at that, because that is so important to the
15 success of the passive cooling systems and stuff
16 there.
17 So I think we're on the right track, but
18 there are still a lot of unanswered questions to deal
19 with there.
20 One other thing -- I think we do need to
21 be careful that -- you know, our job is to review the
22 adequacy of their design rather than us try to tell
23 them how to design things. And we may all have
24 different ways that we would like to see things
25 handled, and our job is really to take a look at what

1 they are proposing as to the adequacy of that.

2 That's all I've got. Designed by

3 Committee doesn't always end up with a better design,

4 so --

5 CHAIRMAN CORRADINI: Tom?

6 MEMBER KRESS: I guess I'm going to be the

7 outlier here. I think the design is very good. It's

8 a good reactor, and the staff is doing a good job.

9 I'm very, very concerned about the iodine

10 issue. It looks to me like it's closer to be a

11 showstopper than anything. I don't know how they're

12 going to deal with it. There may be ways to deal

13 with.

14 CHAIRMAN CORRADINI: In terms of a change

15 in the pH, or in terms of just that there will

16 continually be the recycle and transport?

17 MEMBER KRESS: You've got to -- I've got

18 to see this analysis by the Sandia people, but it's an

19 extremely difficult thing to determine pH. In most of

20 the cases I've seen where the pH has been determined,

21 not for this reactor but for other reactors, it tends

22 -- unless you've got a highly buffered system, it

23 tends to go negative. I mean, it tends to go acid.

24 CHAIRMAN CORRADINI: It goes acidic.

25 MEMBER KRESS: Yes. And I don't know what

1 it will do in this reactor, but, if it does, you have
2 an iodine pump there that is pumping iodine
3 continuously into the containment. And over the long
4 term it's just going to leak out. It's going to go
5 into -- it's going to establish a steady state. I
6 don't know what that level will be, but it's one that
7 has to be dealt with.
8 If you did -- you know, you're not going
9 to get that iodine. It's one of these things where
10 you have to specify a source term, and a design basis
11 accident. So it's a compliance issue. It's not going
12 to happen. You won't -- I don't think you'll see it
13 in the PRA, but it has to be dealt with because it --
14 MR. WALLIS: That concerned me right from
15 the start. I mean, they've got this wonderful design
16 which cools the core, it's designed to do that. And
17 then, when you look at it from the point of view of --
18 MEMBER KRESS: If you close this off --
19 MR. WALLIS: -- this other thing, it's the
20 iodine pump. So the very fact that it cools the core
21 so well makes it do this other job so badly.
22 MEMBER KRESS: So I'm anxious to see how
23 that one gets resolved, frankly.
24 MEMBER BANERJEE: But with the sodium
25 pentaborate, do you still think it will become acidic?

1 MEMBER KRESS: There's a lot of water in
2 this thing. And, you know, and if you impose this
3 source term, and you've got all of these nitric acid
4 producers and they've got the hydrochloric acid from
5 other things, the cases I've seen in other reactors --
6 not like -- not this reactor, it tends to go acidic.
7 I don't know what will happen. I'm
8 anxious to see what Sandia comes up with.
9 MEMBER SHACK: I mean, that's one of the
10 things that's bad about pure water is it doesn't take
11 much to move a pH around.
12 MEMBER SIEBER: To make it unpure.
13 MEMBER KRESS: That's right. So, you
14 know, I don't know how GE will deal with this. I
15 don't -- I guess we'll wait until we see the results
16 of the calculations and see if it's bad or not.
17 MEMBER BANERJEE: There's a buffer in
18 the --
19 CHAIRMAN CORRADINI: I want to make sure
20 I understand relative to the bad. So the bad is the
21 dose or the -- how it's changing the water chemistry
22 for long-term corrosion?
23 MEMBER KRESS: You have to change the
24 water chemistry to get the dose.
25 CHAIRMAN CORRADINI: right.

1 MEMBER KRESS: But the dose is what's
2 going to be bad, because it's -- an iodine pump pumps
3 it right out of the containment.
4 CHAIRMAN CORRADINI: Jack?
5 MEMBER SIEBER: Well, I agree with Dr.
6 Wallis that we've covered a lot of material. There
7 are some open items. I think the staff is on track,
8 and it seems to me there is more open items today than
9 there was yesterday. And maybe it's because I've
10 struggled with the reassignment in advance of coming
11 here.
12 I don't know if there is a showstopper or
13 not. I think Dr. Kress' point is well made, and I
14 also believe there are solutions to it. But they may
15 not be pretty solutions. We've had this issue before
16 in other plants, and I think it's something that needs
17 to be addressed.
18 I am also particularly impressed with Dr.
19 Abdel-Khalik's comments about non-condensables, which
20 several others have followed up on. And I suspect you
21 can analyze your way out of it, but I think you'd be
22 better off getting isometric drawings and looking at
23 them and having an experienced engineer or two look
24 for the traps to see where they would occur, then
25 that's the time to apply the codes and the mathematics

1 to determine what it takes to overcome those or what
2 impact it has on the ability of gravity-driven cooling
3 systems to operate.
4 So, to me, I think the issues that come
5 out of here is the issue of non-condensables and the
6 iodine, which I think require followup by all of us --
7 General Electric, the staff, and the ACRS. That would
8 be it for me.
9 CHAIRMAN CORRADINI: Well, I've written
10 down -- I think I've written down most of what I've
11 heard. I'm going to get from the members a list, and
12 I'll compile it and send to everybody. I've developed
13 already a summary, but I'll keep on adding to it and
14 just circulating it.
15 MEMBER BANERJEE: How detailed a list do
16 you want? Just some topics, or do you want a --
17 CHAIRMAN CORRADINI: I think major -- I
18 guess I'd break it down into two categories. One
19 category would be major things -- and I'll term it the
20 way Graham said it, which is major things that are
21 gnawing at you about something relative to the design
22 that appears to have been overlooked that could be
23 significant. And take an accident, take how the
24 design may go somewhere that staff may have seen, may
25 have not seen, GEH is kind of addressing, but

1 basically taking it somewhere -- that's your concern.
2 And then, a lot of other things which may
3 be issues, may not be issues. And what I will plan to
4 do is take all of it, hopefully organize it properly
5 send it to Amy, and then the next time we get
6 together, since -- and I guess I'll leave it with you,
7 Amy, on this regard -- my interpretation is we have
8 another batch of chapters which we will look at. That
9 probably won't be for a couple months at least.
10 So in those couple months or more, let her
11 look with her colleagues at the list and say what
12 things fit together. One natural to me is containment
13 response. We could address some of the questions that
14 Tom has relative to DBA calculations that are both
15 source term related as well as containment systems
16 related, and accumulate some of these things and go
17 through a detailed analysis, pick a few accidents and
18 walk through them, so we can understand.
19 MEMBER BANERJEE: So the containment
20 response is going to be very coupled through the --
21 CHAIRMAN CORRADINI: It will be a very
22 coupled -- for example, I mean, if there is
23 information that finally comes out, depending when it
24 comes out, in terms of the STERN lab test data for the
25 GE 14E, get a subcommittee -- or get the Subcommittee

1 together, and then again look at that relative to the
2 CPR. So arrange it so that we can address these
3 issues as the staff is ready to address them with GEH
4 in support.
5 MS. CUBBAGE: Yes, I think that's a good
6 plan.
7 CHAIRMAN CORRADINI: And then, I will just
8 bring it up as it comes out.
9 MR. WALLIS: Don't have too many issues.
10 If we are really going to delve into an issue, it
11 takes time. We've got to look at, you know, proper
12 evidence and reach conclusions. You can't have 50
13 issues on the table when we meet as a Subcommittee.
14 CHAIRMAN CORRADINI: No. My thought is we
15 are going to come down to a handful.
16 MR. WALLIS: Handful of good ones.
17 CHAIRMAN CORRADINI: Yes.
18 MR. WALLIS: Okay.
19 MS. CUBBAGE: Right.
20 CHAIRMAN CORRADINI: So on that note, I
21 wanted to thank GEH and all of the folks that were
22 here, and are still here, that are not rushing to the
23 snow-covered airport.
24 (Laughter.)
25 All right. Thank you for all your help.

1 Thanks to the staff. Amy?

2 MS. CUBBAGE: We did have one -- we wanted

3 to offer just to go to closed just for a couple

4 minutes, because I think Dr. Yarsky would like to

5 maybe try to address one of the remaining issues.

6 CHAIRMAN CORRADINI: Was this the issue

7 relative to the neutronics that Sanjoy asked?

8 MS. CUBBAGE: Yes.

9 CHAIRMAN CORRADINI: Okay.

10 MEMBER BANERJEE: We can get that off the

11 table.

12 MS. CUBBAGE: Yes, we'd like to do that.

13 CHAIRMAN CORRADINI: So I'm supposed to

14 ask anybody that is not supposed to be here to please

15 leave.

16 MS. CUBBAGE: Right.

17 CHAIRMAN CORRADINI: And how will we know

18 that?

19 (Whereupon, at 4:00 p.m., the proceedings

20 in the foregoing matter went into closed

21 session and then subsequently returned to

22 open session.)

23 CHAIRMAN CORRADINI: Okay. Thanks to the

24 staff, and then we'll take a bit -- minute afterwards.

25 Gary reminded me, but I'll remind the members, we have

1 to have -- not have to -- we are expected to provide
2 another interim letter to the staff, but given that
3 we've gone through four chapters in November, and
4 we've gone through these four chapters, there are a
5 number of open items, I think we have to decide what
6 -- I wasn't planning to ask for -- do a letter in
7 February, but to do it in March. But we have to
8 decide what chapters we want to write about.
9 If there's a lot of open items with a very
10 long list, we might want to wait and simply only deal
11 with the information we saw back in November, which
12 was a bit more straightforward and very few open
13 items. Right?
14 MS. CUBBAGE: Right. There are eight
15 chapters on the table.
16 CHAIRMAN CORRADINI: Eight chapters on the
17 table, some of which are a bit unwieldy.
18 DR. YARSKY: Yes.
19 CHAIRMAN CORRADINI: All right? So that
20 is something we have to come to decide. In February,
21 we'll go through a progress report to the full
22 Committee and probably make a decision on what sort of
23 letter we'd write in March.
24 Everybody understand what I just said?
25 MS. CUBBAGE: I didn't. We're coming back

1 in March, right?

2 CHAIRMAN CORRADINI: Right.

3 MS. CUBBAGE: Okay. I just wanted to make

4 sure.

5 CHAIRMAN CORRADINI: For a letter. For a

6 letter. Everything else is internal discussions with

7 us.

8 MEMBER BANERJEE: You may want to be there

9 in February as well.

10 CHAIRMAN CORRADINI: You're welcome to

11 come in February.

12 MS. CUBBAGE: Well, I absolutely can.

13 It's whether we have, you know --

14 CHAIRMAN CORRADINI: No. The answer is we

15 plan to do it in March.

16 MS. CUBBAGE: Thank you.

17 MR. KINSEY: A point of clarification.

18 CHAIRMAN CORRADINI: All right. Thank you

19 so much.

20 MR. KINSEY: So what you are saying is

21 that we will decide between now and --

22 CHAIRMAN CORRADINI: The Committee is

23 going to have to decide what the letter is -- what the

24 scope will be.

25 MR. KINSEY: What the scope of the March

1 meeting will be.

2 CHAIRMAN CORRADINI: What the scope of the

3 March meeting will be and the letter.

4 MR. KINSEY: Eight chapters or something

5 less than that.

6 CHAIRMAN CORRADINI: That's right. And

7 I'll communicate that earlier, much earlier, to

8 everyone. Okay?

9 (Whereupon, at 4:14 p.m., the proceedings

10 in the foregoing matter went off the

11 record.)

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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)

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

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

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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

SER Technical Topics of Interest

- 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)

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

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)

<u>Operation in the FW Temp Operating Domain</u>

- 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

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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).

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.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15

Discussion/Committee Questions

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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.

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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.

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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

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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

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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"

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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:

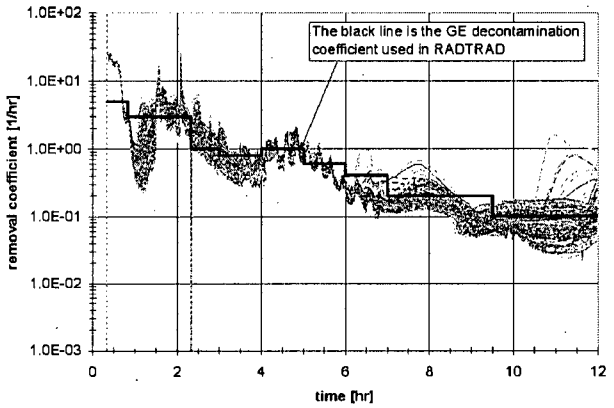
- Fission product natural deposition in containment
- Fission product removal by passive containment cooling system (Open Item)
- Low containment leakage
- Fission product holdup in reactor building (Open Item)
- Control of pH of water in containment pools to prevent iodine re-evolution (Open Item)
- Fission product natural deposition in main steam lines and main condensers (Open Item)

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 15, "Accident Analysis"

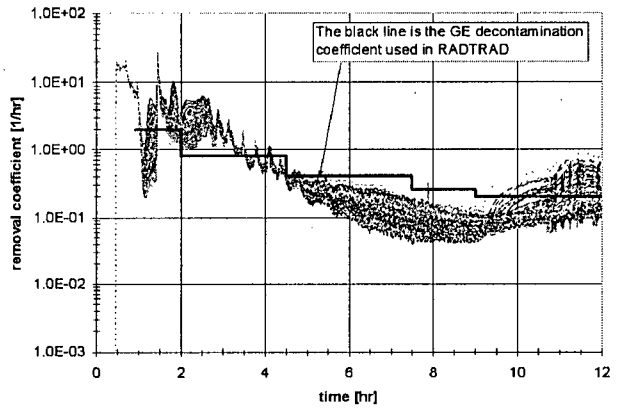
Fission Product Natural Deposition Processes in Containment

- 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)

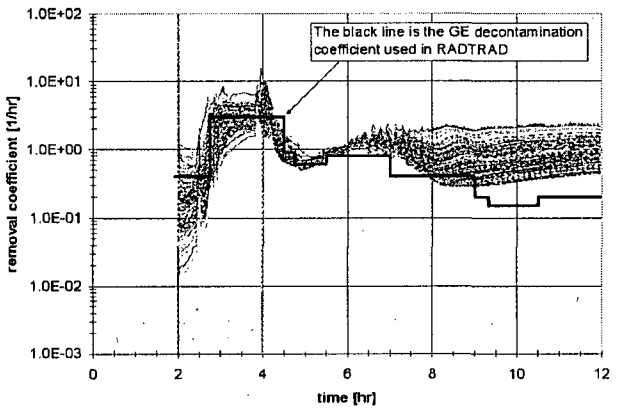
MELCOR Calculated Aerosol Removal Rates for Accident Scenario 1 (RPV Bottom Drain Line Break with Degraded Low Pressure Makeup)



MELCOR Calculated Aerosol Removal Rates for Accident Scenario 2 (RPV Bottom Drain Line Break with Degraded High Pressure Makeup)



MELCOR Calculated Aerosol Removal Rates for Accident Scenario 3 (Loss of Preferred Power)



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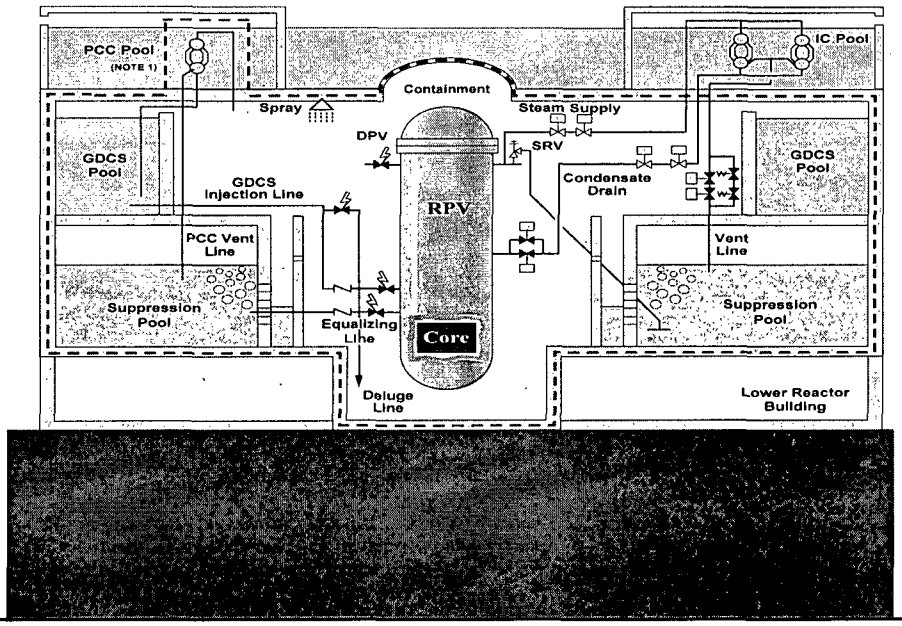
Fission Product Removal by Passive Containment Cooling System (Open Item)

- 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



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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

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Fission Product Holdup in Reactor Building (Open Item)

- 40% mixing efficiency (dilution) in reactor building
- 50% per day leak rate from reactor building

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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

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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

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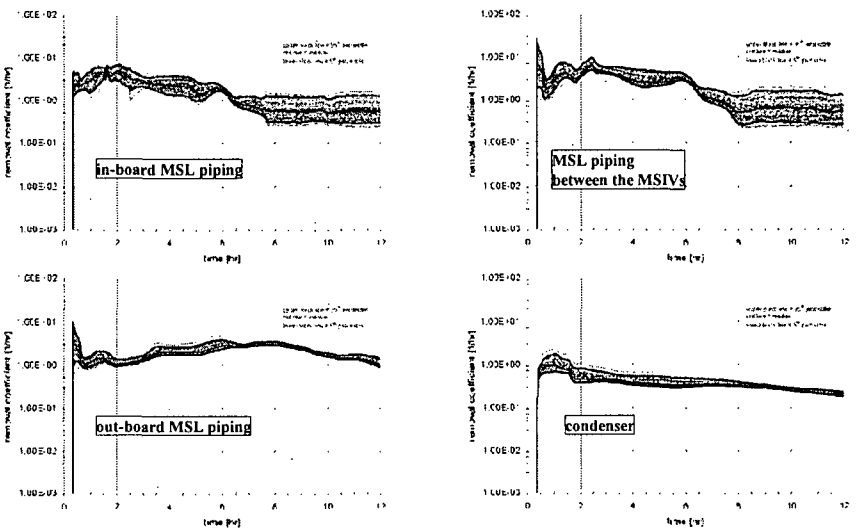
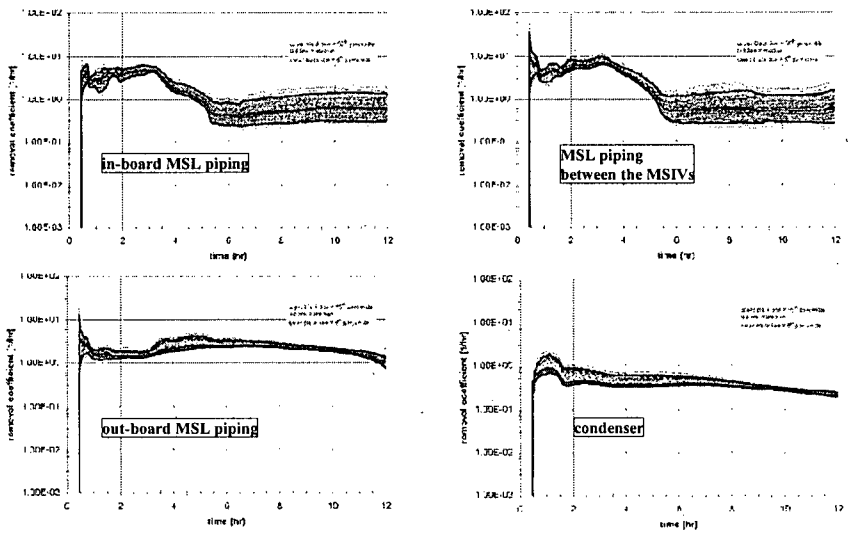
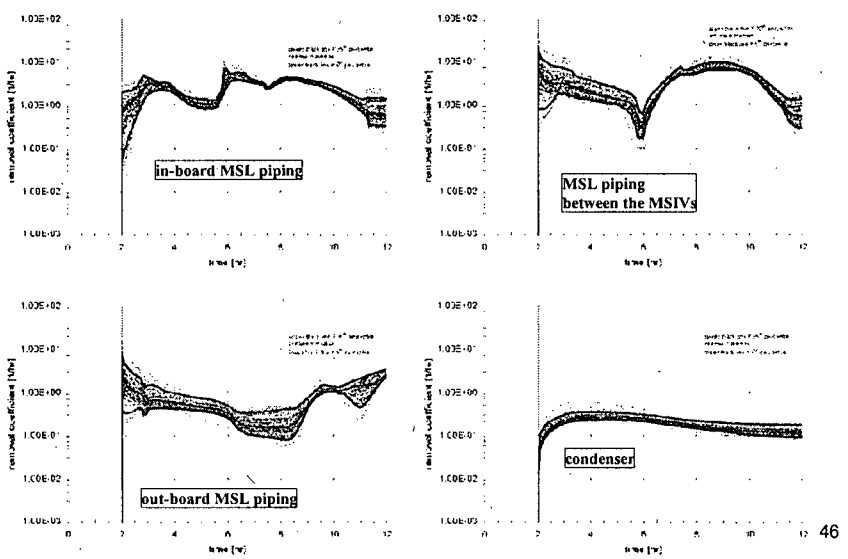
MSL and Condenser Aerosol Removal Rates for Accident Scenario 1



MSL and Condenser Aerosol Removal Rates for Accident Scenario 2



MSL and Condenser Aerosol Removal Rates for Accident Scenario 3



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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

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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

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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

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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

SLCS Injection Shutoff Valve Performance

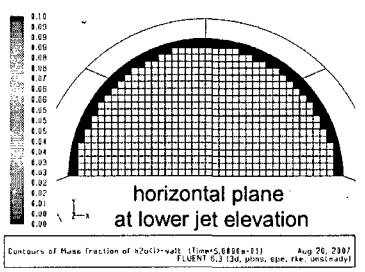
- Shutoff valves are safety related.
- ATWS analysis assumes degraded IC performance (only 3/4 ICs available).
- Shutoff valves are ASME code components subject to inservice inspection program.

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.

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.

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ESBWR Design Certification Review
Chapter 15

Discussion/Committee Questions

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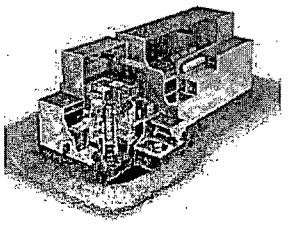
ESBWR DCD Chapter 15 Safety Analyses

Advisory Committee on Reactor Safeguards

Wayne Marquino
Craig Goodson
Pradip Saha, PhD
MD Alamgir, PhD
Erik Kirstein

January 17, 2008



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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

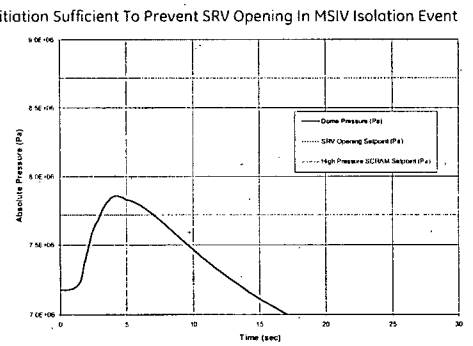
- SRV actuation avoided

Core Water Level

- Core remains covered with no ADS required

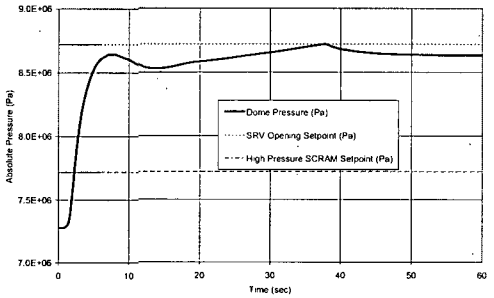
15.2 Increased Steam Volume in RPV Mitigates Pressurization

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

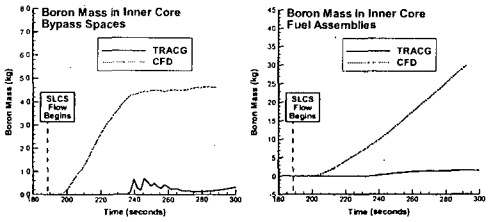
Evaluation of pH in containment pools is being revised for DCD R5 (GEH will consider radioactivity in suppression pool)

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

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>*

Appendices

15A Event frequency calculations for Infrequent Events

15B Radiation Source Term

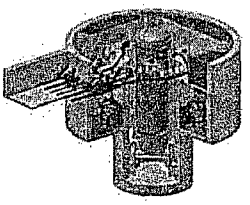
Summary

•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

ESBWR APPLICATION Chapter 21.6 METHODOLOGY for TRACG AOO/IE/SE/ATWS



Wayne Marquino
John Sorensen

January 17, 2008

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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

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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

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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