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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MEETING OF THE SUBCOMMITTEE ON
THERMAL-HYDRAULIC PHENOMENA

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TUESDAY,
JULY 8, 2003

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The meeting was convened in Room T-2B3 of
Two White Flint North, 11545 Rockville Pike,
Rockville, Maryland, at 8:30 a.m., Dr. Graham B.
Wallis, Chairman, presiding.

COMMITTEE MEMBERS:

- GRAHAM B. WALLIS, Chairman
- F. PETER FORD, Member
- THOMAS S. KRESS, Member
- DANA A. POWERS, Member
- VICTOR H. RANSOM, Member
- JOHN D. SIEBER, Member

1 ACRS STAFF PRESENT:

2 RALPH CARUSO, ACRS Staff, Designated Government
3 Official

4 SANJOY BANERJEE, ACRS Consultant

5 VIRGIL E. SCHROCK, ACRS Consultant

6 ALSO PRESENT:

7 YEE K. CHEUNG, General Electric

8 ROBERT GAMBLE, General Electric

9 ATAMBIR RAO, General Electric

10 BHARAT SHIRALKAR, General Electric

11 PATRICK BARANOSWSKY, RES

12 AMY CUBBAGE, NRR/DRIP/NRL

13 JAMES HAN, RES/DSARE/SMSAB

14 DON HELTON, RES/DSARE/SMSAB

15 JOHN V. KAUFFMAN, RES/DSARE/REAHFB

16 WILLIAM KROTIUK, RES/DSARE/SMSAB

17 RALPH LANDRY, NRR/DSSA/SRXB

18 SHANLAI LU, NRR/DSSA/SRXB

19 MUHAMMAD M. RAZZAQUE, NRR/SRXB

20 JACK ROSENTHAL, RES

21 JOSEPH STAUDEMEIER, RES/DSARE/SMSAB

22 GEORGE THOMAS, NRR/DSSA/SRXB

23 EDWARD D. THROM, NRR/DSSA/SPSB

24 JERRY WILSON, NRR/DRIP

25 MARCOS ORTIZ, ISL

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

(8:31 a.m.)

CHAIRMAN WALLIS: This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Thermal Hydraulic Phenomena.

I'm Graham Wallis, the Chairman of the Subcommittee. Subcommittee members in attendance are Tom Kress, Victor Ransom, Peter Ford and Dana Powers, and I think Jack Sieber may come, too.

Consultants in attendance are Sanjoy Banerjee and Virgil Schrock.

The purpose of this meeting is to discuss the application of the TRACG code to the economic and simplified boiling water reactor, ESBWR -- at last we know what its name is -- and the ESBWR scaling analysis.

The Subcommittee will hold discussions with representatives of the NRC staff, General Electric Nuclear Energy, and other interested persons regarding this measure. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

Ralph Caruso is the Designated Federal Official for this meeting.

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1 The rules for participation in today's
2 meeting have been announced as part of the notice of
3 this meeting previously published in the Federal
4 Register on June 25th, 2003.

5 Portions of this meeting will be closed
6 for the discussion of proprietary information.

7 A transcript is being kept and will be
8 made available as stated in the Federal Register
9 notice. It is requested that speakers first identify
10 themselves and speak with sufficient clarity and
11 volume so that they can be readily heard.

12 We have not received any requests from
13 members of the public to make oral statements or
14 written comments.

15 We will now proceed with the meeting, and
16 I call upon Ms. Amy Cubbage of the Office of Nuclear
17 Regulation to begin, please.

18 MR. CARUSO: One more comment. Dr. Peter
19 Ford.

20 MEMBER FORD: I have a conflict of
21 interest since I'm a G.E. retiree.

22 CHAIRMAN WALLIS: Okay. Thank you.

23 MR. CARUSO: Amy.

24 MS. CUBBAGE: Thank you.

25 On behalf of the staff, late this

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1 afternoon we'll be making presentations to the
2 Committee. This morning we're going to begin with
3 General Electric. Mr. Atam Rao is the project manager
4 for the ESBWR project. He'll be providing an overview
5 of the project.

6 CHAIRMAN WALLIS: Atam, it's always a
7 pleasure to hear from you, and I'm glad we finally got
8 you here to talk about this impressive machine of
9 yours.

10 MR. RAO: Thank you for giving us the
11 time.

12 We wanted to give you an update on where
13 the design is and where the technology closure is
14 going on this project.

15 One of our objectives of this pre-
16 application review is shown in Chart No. 3, and I'll
17 get to that, and that is to obtain closure on the
18 technology program that's been ongoing for the last 15
19 years. I'll give you an overview of the design and
20 the program. I'll give you an overview of the
21 submittals we've made since I made a brief
22 presentation to the ACRS last year and summarize where
23 we are going in the overall project.

24 I know you had mentioned that you're glad
25 that we finally announced what the ESB stands for. We

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1 were waiting for a utility, Entergy or Exelon, so
2 that we'd name the E after them, but I guess that
3 hasn't happened yet. The E stands for economic. We
4 finally decided that in the early part of this year
5 the --

6 CHAIRMAN WALLIS: Are you going to
7 demonstrate that this is economic for us?

8 MR. RAO: Not for you.

9 (Laughter.)

10 MR. RAO: We save that for the utilities.
11 We focused on the safety part. That's what the S
12 stands for. The middle initial was S, safety.

13 Okay. No, simplified, and that --

14 MR. SCHROCK: Was it formerly something
15 else, Atam?

16 MR. RAO: Pardon?

17 MR. SCHROCK: Was it some other name
18 previously?

19 MR. RAO: There has been a lot of
20 confusion on what the E stood for. It might have been
21 European in the earlier days when we started off about
22 ten or 11 years ago.

23 CHAIRMAN WALLIS: It's not "excellent," is
24 it?

25 MR. RAO: Even simpler than the SBWR, ES.

1 Okay.

2 (Laughter.)

3 MR. RAO: The goals for the technology
4 closure are listed out here. Basically two basic
5 goals that we have for the technology closure program.
6 One is approval of the TRACG code for analysis, and
7 the second is confirmation of the adequacy of TRACG.

8 Let me just describe what those two goals
9 mean specifically. Basically we're looking for the
10 approval of TRACG for the vessel response to pipe
11 breaks, which is the loss of coolant accident,
12 sometimes called the DBA and sometimes called
13 ECCS/LOCA.

14 I wanted to put down the definition of
15 terms here because we'll be using that in the
16 presentations all the way through. So ECCS/LOCA
17 refers to the vessel response to the pipe break.
18 That's what you will be hearing in all of the
19 different presentations.

20 And the containment response to the pipe
21 break will be referred to as containment/LOCA, and
22 then we'll be talking about the vessel response to
23 anticipated operational occurrences, sometimes called
24 transience. People will be using that terminology
25 interchangeable, and sometimes it's called AOO.

1 The fourth one, which is the plant
2 response to ATWS and normal operation stability is not
3 currently part of the technology program and we will
4 be coming back shortly on that. It was more a
5 question of time rather than that this is not what --
6 it had nothing to do with the adequacy of the TRAC
7 code or whatever. It was just --

8 CHAIRMAN WALLIS: There are still some
9 very interesting issues for us, I think, those two.

10 MR. RAO: Yes, but we just ran short of
11 time. What the overall goal here is to show that.
12 I'll come back in the take-away at the end.

13 The second major goal, which is actually
14 a subpart of the approval of the TRACG code is a
15 confirmation of the adequacy of TRACG, which means
16 that the qualification base that we're taking is
17 adequate. We've done enough testing. There's enough
18 qualification of the uncertainties and all of those
19 issues that go into the qualification of TRACG.

20 So as I started off earlier, what we've
21 done here is a 15-year plus year comprehensive
22 technology program, and it's using essentially the
23 same thermal hydraulic technology that is used in most
24 BWRs, and is that enough?

25 And it is an important question because

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1 ultimately I wasn't going to talk about economics or
2 all the rest of it; ultimately industry has to know
3 whether or not we have done enough and whether we need
4 to spend more money, and the sponsors will view that
5 as incomplete if we don't get closure on some of these
6 issues, and that there's no way to get closure.

7 So that's why we've coined the term
8 "technology closure." The official terminology is
9 pre-application review.

10 This goes into a little bit more detail on
11 what the steps are for the technology closure plan.
12 Basically we're looking for safety evaluation report
13 for the TRACG application for ECCS/LOCA, the same for
14 containment/LOCA, and for application for AOOs.
15 That's in the first phase of the technology closure
16 program.

17 That would be based on the different
18 submittals that have been made. The TAPD is the
19 technology and analysis program description. That
20 gives the road map for what has been done, what are
21 the important parameters, what qualification is needed
22 for those important parameters, and the different
23 phases of the transience.

24 You will hear a detailed presentation by
25 Dr. Shiralkar on that. So one --

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1 CHAIRMAN WALLIS: Let me interject here.
2 I mean, you've got four approvals of application of
3 TRACG for something.

4 MR. RAO: Right.

5 CHAIRMAN WALLIS: So we're back to where
6 we usually are with these codes. We know the codes
7 have assumptions and shortcuts and so on in them, and
8 yet they get approved for a particular application
9 rather than sort of approving the code as being
10 perfect in itself, which it never is.

11 MR. RAO: Right.

12 CHAIRMAN WALLIS: The approach always is
13 to look at how it compares with data for a particular
14 application; say for that application it's okay.

15 MR. RAO: Right.

16 CHAIRMAN WALLIS: That's where we usually
17 are. I'm just sort of reiterating where we are. We
18 always find ourselves with codes when we sort of
19 approve them for applications rather than some generic
20 way.

21 MR. RAO: That's what we're asking for,
22 for a specific application.

23 CHAIRMAN WALLIS: In a way, this is a way
24 of getting around what we might say were not
25 necessarily shortcomings, but shortcuts in the code by

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1 just looking at the specific applications. So we
2 never face up to going back to the code and saying,
3 "Let's fix the whole thing so we don't have to keep
4 looking at application."

5 MR. RAO: And the TRACG application for
6 ATWS, we have not yet submitted an application
7 methodology. That's why it's too early to ask for the
8 approval of that.

9 And for stability, we were going to use
10 ODYSY as the basis for the evaluations there and some
11 TRACG calculations. Again, we haven't submitted the
12 application methodology for that. So we will come
13 back and be working with the staff to define a
14 schedule for doing that.

15 So this gives the overall picture for what
16 are the -- oops. I keep pressing the wrong buttons.

17 MR. SCHROCK: Your statement about LOCA is
18 kind of general, and don't you distinguish between the
19 large break LOCA and the small break LOCAs?

20 MR. RAO: No, we don't.

21 MR. SCHROCK: In what you're doing to
22 improve the technology?

23 As I read some of the reports I had the
24 impression that the large break LOCA was being claimed
25 to be covered by previous technology, nothing new to

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1 deal with as a result of the design of ESBWR. Is that
2 wrong?

3 MR. RAO: No, that's not true.

4 MR. SCHROCK: Okay.

5 MR. RAO: What we're saying, the first
6 one, ECCS/LOCA or containment/LOCA covers the full
7 spectrum of break sizes. Okay? So we are covering
8 small to large break. There may be some --

9 MR. SCHROCK: But there is such a
10 statement in the reports that the large break LOCA is
11 basically the same as before.

12 MR. RAO: I'm not aware of that. There
13 are --

14 MR. SCHROCK: Well, I'll find it.

15 MR. RAO: Okay. The ESBWR is basically an
16 evolution within a small range which basically
17 minimizes operational risks. What you'll see is
18 there's been just -- you know, when you go back to the
19 earlier plant designs, they were almost in the 3,300
20 megawatt range, and the ESBWR is up to 4,000 megawatts
21 thermal.

22 There's not a huge increase in the range
23 of power that we have a lot of years of experience.
24 We don't want to lose the 40, 50 years of experience
25 with BWRs that we've had over the last 40 or 50 years.

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1 Even the component sizes aren't that much
2 larger. What you see is it's the same vessel diameter
3 as the ABWR, 7.1 meters. In fact, that's how we sort
4 of set the power level. We said we'd keep the same
5 vessel diameter and see what's the maximum power we
6 can get from it.

7 CHAIRMAN WALLIS: Now, do these take
8 account of the recent power uprates, these numbers?

9 MR. RAO: These do not take account of the
10 recent uprates. These were the original power.

11 CHAIRMAN WALLIS: Okay. With the power
12 uprate we're already in the range of ESBWR.

13 MR. RAO: Right. When we look at the
14 power densities and all, the numbers that are shown
15 here are with the original designs. The power
16 uprates, there are some that have gone to 62 kilowatts
17 per liter. Okay?

18 So this is with the original design.
19 That's where we got the years of experience.

20 The number of fuel bundles also --

21 CHAIRMAN WALLIS: Is this the same fuel as
22 --

23 MR. RAO: Yes.

24 CHAIRMAN WALLIS: It's the same fuel as
25 you're going to use?

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1 MR. RAO: It's the same standard fuel,
2 except that it's a little bit shorter, three meters
3 compared to 3.7 meters. Otherwise it's the same fuel
4 design.

5 Again, the concept being that more from an
6 economic and commercialization point of view, you
7 don't want to design a new fuel where you've got to
8 build new factories. People would order a plant one
9 at a time so that we -- we've got to make sure that
10 the first one is economic and you've got the factories
11 in place.

12 We are not relying on a six pack order to
13 make this commercially viable.

14 So the power density as you notice out
15 here is in the range of where we've got lots of
16 experience with the power uprates. I think the life
17 service of the BWR-6 is up at what, 62 kilowatts per
18 liter?

19 No recirculation pumps.

20 The type of control rod drives, we've gone
21 to the control rod drives that are in the ABWR, the
22 fine motion drive as opposed to the locking piston
23 drives.

24 This is where the simplification has come
25 about. So what you can see is in the normal operation

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1 it's just like a BWR, except that it doesn't have
2 recirculation pumps. Where the simplification has
3 come is in the safety system area. This shows some of
4 the large pumps. We've gotten rid of them. Mostly a
5 few diesel generators. This --

6 CHAIRMAN WALLIS: Now, in a way you're
7 replaced a pump, which is a mechanical device, by a
8 natural circulation pump driven by a condenser or
9 something. So in a sense it's a pump. It's not with
10 the conventional mechanical moving parts.

11 MR. RAO: Yes.

12 CHAIRMAN WALLIS: And it is a functioning
13 pump in a sense.

14 MR. RAO: In some senses, yes, when I get
15 into those, but this is more from a body count point
16 of view, from the economics. This is all I was going
17 to say about the economics basically. It's shown out
18 here.

19 One of the interesting things when you see
20 the evolution of designs over a period of time, the
21 core damage frequencies have come down as we went from
22 BWR-4s, 5s.

23 CHAIRMAN WALLIS: Now, why did they come
24 down?

25 MR. RAO: They came down because we added

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1 more divisions. We went from two divisions to three
2 divisions. This was two divisions. This was two and
3 a half divisions.

4 CHAIRMAN WALLIS: Divisions?

5 MR. RAO: Divisions of safety systems.

6 CHAIRMAN WALLIS: And the redundancies?

7 MR. RAO: The redundancies. We've added
8 more redundancy. Okay? Now, this is a full three
9 division system, the ABWR. So there's two, two and a
10 half, three -- I'm just giving you sort of a --

11 CHAIRMAN WALLIS: No, I think it's useful
12 because in a factor of 100, the question is how did
13 you get a factor of 100. You can adjust from these
14 divisions?

15 MR. RAO: Just from the divisions, and
16 there were other factors that apply into that. One is
17 that we've reduced the number of pipes. The number of
18 large pipes below the core has gone down. Okay? In
19 the ABWR there are no --

20 CHAIRMAN WALLIS: The fewer things to go
21 wrong. Is that it?

22 MR. RAO: Redundancy does give you more
23 things that can go wrong. Okay? But what's happened
24 here is we had learned from the PRAs basically. PRAs
25 went into the design of the ABWR. Okay? I think the

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1 BWR-6 was more before the days of the PRA.

2 MEMBER KRESS: But the dominant sequences
3 in BWR-6 are ATWS and station blackout?

4 MR. RAO: Station blackout is the dominant
5 sequence in all of them.

6 MEMBER KRESS: Station blackout is
7 dominant in all of them?

8 MR. RAO: In all of them, and that's --

9 MEMBER KRESS: And how does that relate to
10 zero safety diesels?

11 MR. RAO: Okay. Now what we've done out
12 here, so that's exactly what I was going to explain to
13 you, is when we went to the ESBWR, we've pretty much
14 four times ten to the minus seven is about as low as
15 you're going to get. To just put it in perspective,
16 the vessel rupture is ten times minus eight, okay? So
17 you've reached about as good as you're going to get,
18 and what we've done out here is basically gone in with
19 passive systems which have allowed us to reduce the
20 complexity of the design, and that shows up out here
21 in the safety building volume, which is expressed in
22 units of cubic meters per megawatt electric.

23 So you've got about half the size. This
24 is the containment and the reactor building and all of
25 those buildings. They're about half the size of the

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1 ABWR and you get about the same core damage frequency.

2 Okay. So the reason for going with
3 passive systems besides the soft feeling, you know,
4 it's not quantifiable that passive system are better
5 than active systems. I'm not here to tell you that.

6 CHAIRMAN WALLIS: No, because we thought
7 that for a while. Then we realized that maybe having
8 a pump is forcing water in is better than letting
9 nature do it because letting nature do it depends on
10 your predictions being right about what nature is
11 going to do.

12 So it's not always clear that passive is
13 better.

14 MR. RAO: Yeah, we are not advocating one
15 is better than the other. In fact, when you see the
16 design, what you'll see is in the boiling water
17 reactor, direct cycle plant actually, any direct
18 cycle plant, you have lots of pumps. You heard the
19 multiple pump story for the boiling water reactor.

20 We still retained all of those pumps. All
21 of those systems are still there. So for those who
22 like pumps, the pumps are still there. They are just
23 not safety grade anymore.

24 So we've got the balance in the design
25 between the passive systems and the active system. I

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1 don't know whether I answered your question.

2 Basically what we've done, I'll show you
3 what we've done in the safety systems is basically
4 simplified them, and that gives about the same core
5 damage frequency. I think the actual number is a
6 little lower, but it's not significant.

7 CHAIRMAN WALLIS: Probably when we see a
8 number for a reactor that doesn't exist we should
9 always add a factor of something or other to that
10 number of ten to the minus seven.

11 MR. RAO: Well, yes and no, but you've got
12 to look at, you know, we're using components that we
13 have good experience with, you know. The main issue
14 really is initiating frequencies, you know, and we
15 have a lot of experience with BWRs, and so we are
16 using the same basic design.

17 I like to call the ESBWR BWR Lite, same
18 megawatts, just less calories.

19 We've gone with natural circulation, and
20 basically because it gives us simplification without
21 performance loss. One of the interesting issues in
22 the design of the plant has been people always ask us
23 why did you give up poor circulation.

24 There are several reasons for doing that.
25 When you combine passive safety systems and natural

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1 circulations, for both of those you need a large
2 vessel, and if you get into one or the other, you
3 still retain the larger vessel. So if you put one or
4 the other and you add the second one, you get it for
5 free. Okay?

6 So we don't have the penalty associated
7 with the large vessel that would come with natural
8 circulation as long as we stay with passive safety
9 systems.

10 MEMBER SIEBER: So the six meters
11 additional height is just do to provide the driving
12 head?

13 MR. RAO: That is primarily for the
14 driving head, but as you'll see in the presentation,
15 the basic design of this plant is you put a lot of
16 water in the vessel. The vessel is bigger, and that's
17 your first line of defense. You've got more water in
18 there, and you've actually got more steam in there.
19 So what that does is it makes the loss of coolant
20 accident response a lot better and makes the transient
21 response a lot better because when you get a
22 reactorized solution, since you've got a lot more
23 steam, the pressure goes up at a much slower rate.

24 And you do need the taller vessel to get
25 the improved natural circulation flow. We get a

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1 significant reduction in the components, both pumps,
2 motors, controls, heat exchangers. This is an actual
3 drawing out of the ABWR reactor internal pump system.
4 It's not just pumps. There's a lot of controlled
5 piping and heat exchangers and all of the rest of it.
6 So we got rid of all of that stuff, and we --

7 MEMBER KRESS: Do your control rods still
8 come in through the bottom?

9 MR. RAO: The control rods still come in
10 through the bottom. We had looked at other options,
11 and again, we wanted to stay with what was proven and
12 works, and that does work.

13 And the things that we simplified were
14 basically driven by let's reduce the component count.
15 We'll reduce the material quantities, and --

16 CHAIRMAN WALLIS: Now, you're reducing the
17 flow resistance in the downcomer.

18 MR. RAO: Right.

19 CHAIRMAN WALLIS: In fact, you probably
20 want to reduce a lot of flow resistance. So this
21 looks like something which could have a tendency to
22 oscillate. Natural circulation oscillations occur in
23 many boiler systems and have to be dealt with.

24 MR. RAO: Right. You've got to take a few
25 things, I remind, just because boilers with pumps and

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1 natural circulation oscillate. This is a boiler
2 without pumps.

3 CHAIRMAN WALLIS: They oscillate more when
4 they're without pumps.

5 MR. RAO: Which we weren't going to cover
6 that in this presentation, but there's just a little
7 bit out here on the right-hand corner for you to feel
8 comfortable about that. We didn't have a detailed
9 presentation on that. We weren't going to cover it.

10 CHAIRMAN WALLIS: But you have analyzed
11 the stability. You have analyzed the natural
12 circulation.

13 MR. RAO: Yes, yes.

14 MR. SCHROCK: So we don't get to talk
15 about that one today?

16 MR. RAO: No, stability wasn't on the
17 agenda. We're just going to focus on ECCS/LOCA.

18 MEMBER KRESS: We'll cover it at some
19 time.

20 MR. RAO: You'll get a chance, but I don't
21 want to duck the question. Let me just give a one
22 minute answer on that.

23 What we've done is we've reduce the flow
24 restriction and increased the driving head. We have
25 reduced the restrictions in the separators. We've got

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1 a shorter core, reducing the two phase pressure drop,
2 and the biggest improvement is getting rid of the
3 pumps.

4 You got into an operating BWR and you weld
5 out the pumps, if you want to do that. You would
6 increase the natural circulation flow by a factor of
7 two basically.

8 This shows the power flow map out here.
9 It's really hard to read out here. We've presented it
10 in the average flow per bundle, average power per
11 bundle rather than the standard power flow mat, and
12 this is what you're concerned about out here. This a
13 jet pump plant. I mean, this is for a BWR-5, the red
14 line. This is for the ABWR, and as you can see out
15 here, in fact, when we went from the jet pump plant to
16 the ABWR, the natural circulation flow actually went
17 down, and that's because the internal pumps provide a
18 major flow restriction in the downcomer out here.

19 So what we've done in this plant is
20 basically removed that flow restriction. Another way
21 to look at it is what the pump does is it puts in a
22 restriction, and then it has to work and do a lot of
23 extra work to just overcome that initial restriction,
24 and you get only about a 50 percent benefit of that,
25 you know, a little additional extra flow.

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1 So what you see out here is the flow for
2 the ESBWR, and when we look at the power to flow ratio
3 at the 100 percent operation point, it's hard to see
4 all of the detail in that small chart. They are about
5 in the same range as that for a forced circulation
6 plant.

7 So you've got less power per bundle, and
8 you've got a little less flow per bundle, but the
9 power to flow ratio is about the same range, and you
10 can see we've got about four or five times as much
11 flow compared to the forced circulation plants.

12 CHAIRMAN WALLIS: Which comes up to the
13 MELLA line on one of those things at the top?

14 MR. RAO: Right. This is the MELLA line.

15 CHAIRMAN WALLIS: -- instability in this?
16 You're showing it for the ESBWR.

17 MR. RAO: Yeah, we've analyzed the
18 stability for the ESBWR. We aren't presenting
19 anything on that today, but the decay ratios are in
20 the range of .2. Okay. So it's much lower than
21 anything, you know.

22 You've got instability out there, and in
23 this case we are very far away from that point.

24 MR. CARUSO: Because you're using natural
25 circulation, you're going to have to change your fuel

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1 management strategies quite a bit for this reactor,
2 won't you?

3 MR. RAO: Yeah.

4 MR. CARUSO: Do you feel confident that
5 the methods will still be valid since you haven't done
6 natural circulation fuel management in 40 years?

7 MR. RAO: I don't think the fuel
8 management depends on whether you use natural
9 circulation or forced circulation. They just rely on,
10 you know, what are the flow inlets to the bundle.
11 Okay? So, yes, the answer is yes.

12 DR. BANERJEE: How high is the chimney?

13 MR. RAO: The chimney is five meters.

14 PARTICIPANT: Eight, point, five meters.

15 MR. RAO: Eight, point, five meters.

16 DR. BANERJEE: So the six meter increase
17 is due to --

18 MR. RAO: The chimney.

19 DR. BANERJEE: -- mainly the chimney.

20 MR. RAO: Mainly the chimney. The core is
21 a meter charter and 8.5 ball park.

22 DR. BANERJEE: And the chimney you
23 subdivide inside?

24 MR. RAO: Yeah, it's a meter by meter
25 subchannels.

1 DR. BANERJEE: So 8.5 meters, meters by
2 meters, and do you have evidence of what goes on in
3 these large --

4 MR. RAO: Yeah, yeah. In some of the
5 presentations you'll hear where we've qualified the
6 TRACG computer code. In fact, it was done in Ontario
7 Hydro (phonetic). Was it in Montreal or was it
8 Ontario -- I mean Toronto? Somewhere in there. It
9 was actually --

10 CHAIRMAN WALLIS: Did you look at the flow
11 distribution across the chimney in a 3D sense?

12 MR. RAO: It's a channel, you know.
13 That's an open --

14 CHAIRMAN WALLIS: But is that channel so
15 tied to the core so that you can't get a
16 redistribution of flow between channels and the
17 chimney?

18 MR. RAO: Why don't you save those
19 questions until Bharat?

20 CHAIRMAN WALLIS: Bharat will explain
21 everything?

22 MR. RAO: He will give you all, and then
23 when he gets up he'll say that Chester will explain
24 everything and then we'll --

25 (Laughter.)

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1 CHAIRMAN WALLIS: And we will remember.

2 DR. BANERJEE: And the velocities are
3 about the same roughly as in a forced circulation
4 plant?

5 MR. RAO: Yeah. Chester can give you the
6 exact numbers when he comes up. He will give you
7 the exact numbers. I don't remember all of the
8 numbers.

9 Okay. One of the areas, even though it's
10 a simplified plant, it ends up taking a lot more to
11 explain it, and I am notorious for exceeding my time.
12 So I will try to get through all of the charts here.

13 One of the ways we got simplification is
14 eliminate systems like you saw in the previous case.
15 We basically got rid of the recirculation system.
16 Another way -- this is just an example -- of where we
17 got simplification was eliminating a total system. We
18 got rid of the shutdown cooling system or the residual
19 heat removal system. There is no RHR system or a
20 separate shutdown cooling system.

21 What we did in this plant was for normal
22 shutdown -- for accident conditions, there's a
23 separate one and I'll get into that for the safety
24 grade decay heat removal -- but for normal shutdown,
25 there is no RHR system, and we basically combine the

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1 reactor water clean-up system. It now has a double
2 function, that it can also operate as a shutdown
3 cooling system.

4 A really neat innovation out here. This
5 is actually a standard BWR shutdown reactor water
6 clean-up system. Okay? It looks just like that if
7 you go to any of the plants. The only difference, the
8 only two differences are here.

9 One is in the region rate of heat
10 exchangers. This is how the shutdown cooling system
11 works. It takes suction from the vessel and goes to
12 the regen. heat exchangers, and then it goes to the
13 nonregenerative heat exchangers. Here's a pump. Here
14 is the demineralizers, and it puts the water back into
15 the vessel.

16 Okay. So what we did on this was it has
17 pumps and heat exchangers. For those of you who like
18 pumps and heat exchangers, they are there, plenty of
19 them.

20 In a shutdown cooling mode, we basically
21 bypass the regenerative heat exchangers, and we remove
22 the decay heat from using the nonregenerative heat
23 exchangers.

24 These in a traditional reactor water
25 clean-up system are a little smaller than what will be

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1 needed for shutdown cooling. So by increasing the
2 size of these heat exchangers, why, basically increase
3 the area by a factor of four, we have eliminated an
4 entire system, the shutdown cooling system.

5 So these heat exchangers are a surface
6 area of a factor of four, and actually they don't take
7 up much more space, and we had to make a few changes
8 on the pumps on this side out here.

9 MEMBER KRESS: And you have to make the
10 pipes bigger also?

11 MR. RAO: No, the pipes are the same size.

12 MEMBER KRESS: The pipes are the same
13 size?

14 MR. RAO: The pipes are the same size.
15 The only other thing that we changed was we put in a
16 second pump because the flow rates are a little
17 different. Okay?

18 So for the high flow and the low flow
19 conditions. So that's the only additional thing.
20 this pump here, and of course you bypass the filter
21 demineralizers dealing shutdown cooling, and you
22 reduce the number of pipes, the amount of maintenance
23 and all of the rest of it.

24 And you get an advantage. You get a
25 performance advantage. Now you have a full pressure

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1 shutdown cooling system. A traditional boiling water
2 reactor --

3 MEMBER KRESS: Do you have to manually
4 operate that bypass valves?

5 MR. RAO: Yeah, yeah. There are two
6 chains of these, by the way.

7 In a traditional boiling water reactor to
8 get to shutdown cooling, the shutdown cooling system,
9 the RHR system can only operate at about 400 psi or
10 thereabouts. My numbers are going to be approximate.
11 Okay?

12 This one can kick in at full pressure. So
13 in that sense you've improved the operability and the
14 safety of the design.

15 DR. BANERJEE: Is this because natural
16 circulation is just easier? What is the qualitative
17 difference --

18 MR. RAO: Between this plant --

19 DR. BANERJEE: -- that allows you to do
20 this and --

21 MR. RAO: Okay. Because --

22 DR. BANERJEE: -- you can't do it in
23 another plant?

24 MR. RAO: No. In the active plant, you
25 have to have an active decay heat removal system. So

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1 you use that for normal shutdown also. Okay? You use
2 the same system. This is for just normal shutdown.
3 This is when you're going into refueling. Okay?

4 So you use the same system cool down
5 during a refueling outage. So since you don't have --
6 passive systems you've got to remember do not get you
7 to ambient conditions. They always keep you at above
8 ambient conditions. Okay? So with a passive system
9 for normal shutdown during refueling, you'd need pumps
10 and heat exchangers to get down to below ambient
11 conditions. So that's the reason you can do this
12 here.

13 MEMBER FORD: You mentioned earlier on
14 that your pumps were not safety grade. That doesn't
15 apply to these?

16 MR. RAO: This doesn't apply. This is
17 just for normal shutdown, not for accident conditions.

18 MR. CARUSO: How long after shutdown are
19 the heat exchangers sized for? I mean decay heat
20 drops versus time. At what point were you planning on
21 this system being able to remove decay heat?

22 MR. RAO: I don't remember the number
23 offhand.

24 MR. CARUSO: One hour or 12 hours?

25 MR. RAO: No, I'm sure it's in the -- I

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1 don't know. We can get back to you on that one. It's
2 fairly because, you know, we're trying to meet some
3 fairly aggressive refueling outage times.

4 My guess, I would have said one hour, but
5 you know, I don't remember the number offhand.

6 Did I answer your question, Sanjoy? Yeah?

7 DR. BANERJEE: Yeah.

8 MR. RAO: Okay. This is the plant
9 basically.

10 Let me go back to the previous chart.
11 Just remember the most complicated systems and plants
12 are all of these water systems, you know. Everyone
13 talks about the safety systems, but the water systems
14 have heat exchangers, pumps, controls. They need
15 electrical supplies, and they go all over the plant.

16 So by eliminating a full water system, you
17 end up with a major simplification. The passive
18 safety system in this plant are basically all shown
19 out here, and this looks like a traditional boiling
20 water reactor vessel. This is the reactor vessel.
21 The control rod drives still come in at the bottom,
22 shown out here.

23 You've got four steam lines. These are
24 then two steam lines here and two steam lines here.
25 These are the feedwater lines out here.

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1 When we went from the SBWR to the ESBWR,
2 one of the really neat things about a direct cycle
3 plant is we didn't have to to add another set of steam
4 generators to make them bigger. We added two more
5 steam lines. Okay? That's pretty much all that we
6 are doing to add more fuel also.

7 So the vessel diameter went up about a
8 meter compared to the old SBWR design, and the vessel
9 height is, I think, a meter, a couple of meters
10 higher.

11 CHAIRMAN WALLIS: It's a very interesting
12 vessel because there's no way to open it.

13 MR. RAO: Runs forever. No. This is just
14 a cartoon to show you the --

15 MEMBER POWERS: Maybe the people working
16 in safeguards and security can come up with a way of
17 opening it.

18 MR. RAO: We wanted to improve the
19 security of the design, right.

20 Okay. The other couple of things to
21 notice is like a standard boiling water reactor, there
22 is a suppression system. This is what's called the
23 drywell. This is the wetwell. This is the pool of
24 water. It's the same size as the ABWR. It's similar
25 to the ABWR in the sense that you've got the -- this

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1 is the connection from the drywell to the wetwell.
2 These are the horizontal discharges, three sets of
3 what we call main vents (phonetic). You'll hear that
4 in the presentations as we go through.

5 So this is the wetwell airspace out here,
6 okay, and this part out here is where you find the
7 steamline piping, the safety relief valves, and some
8 of them have quenchers going into the suppression pool
9 just like standard boiling water reactors.

10 There are depressurization valves which
11 come off the steam lines, and some of them have
12 separate nozzles of their own. They do not have
13 quenchers. They open straight into the wetwell.

14 There isn't much other equipment shown out
15 here. Of the three pools of water, this is what has
16 replaced all of the safety systems, the water make-up
17 systems. It's a combination of the water in the
18 reactor vessel itself and about 1,000 cubic meters of
19 water make-up to provide slow injection into the
20 vessel following a loss of coolant accident.

21 As you'll see the responses, they'll show
22 you that you don't really need high make-up systems
23 for this.

24 CHAIRMAN WALLIS: What's that great
25 lattice work of red piping there?

1 MR. RAO: That's all supports.

2 CHAIRMAN WALLIS: Oh, supports. That's
3 structure. That's not pipes.

4 MR. RAO: No, that's structures.

5 CHAIRMAN WALLIS: It's a jungle gym sort
6 of thing.

7 MR. RAO: It is jungle gym, but we've also
8 looked at it from maintenance point of view, and we've
9 moved each one of those valves. There isn't much
10 equipment in this building, except there are valves.
11 There are pipes and valves. That is all that is left
12 out there.

13 MEMBER KRESS: When you evaluate LOCAs for
14 this plant, do you have a drain line in the bottom?

15 MR. RAO: Yes.

16 MEMBER KRESS: And you have the control
17 rods. Are those part of the LOCA?

18 MR. RAO: Yes. We analyze the LOCA except
19 for one drain line also, yes.

20 MEMBER KRESS: Okay.

21 MR. RAO: Yes.

22 CHAIRMAN WALLIS: You can also break the
23 shutdown cooling system in the bottom.

24 MR. RAO: Pardon?

25 CHAIRMAN WALLIS: You can break the

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1 shutdown cooling system.

2 MR. RAO: Yeah. There are actually not
3 one drain lines. There are four drain lines in the
4 bottom, but they are two inch nozzles, only two inch
5 nozzles. They're very small, and we do analyze that.

6 Yes?

7 MEMBER POWERS: What has to happen to keep
8 from depressurizing this vessel?

9 MR. RAO: As you'll see the transient
10 response, you'll see that we don't open the relief
11 valves for falling reactor isolation. So it's a very
12 forgiving machine. Because it has got a bigger
13 vessel, okay, the initial transient response for the
14 first 30 seconds without any system operating,
15 basically you don't open any relief valves and then
16 the isolation condensers come in and take care of the
17 decay heat.

18 MEMBER POWERS: That's not the question I
19 asked.

20 MR. RAO: Okay.

21 MEMBER POWERS: The question I asked is
22 what has to happen to make it impossible to
23 depressurize this vessel.

24 MR. RAO: What has to happen to make it
25 impossible to depressurize?

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1 MEMBER POWERS: Un-huh. Hypothesize a
2 station blackout as a going in thing. Now, what can
3 keep me from being able to depressurize?

4 MR. RAO: If you have just a station
5 blackout and no pipe break --

6 MEMBER POWERS: Naw. Don't assume that.

7 MR. RAO: I'm just trying to understand
8 what your assumptions are. If you have a pipe break,
9 you are going to depressurize. But if you just have
10 a station blackout, okay, and that has been the
11 dominant sequence for the operating plants, is a
12 station blackout.

13 In that case, when you just have a station
14 blackout, you don't depressurize the plant, and I'll
15 show you what the response is.

16 If you have a station blackout combined
17 with a break, then you will depressurize the plant.

18 MEMBER POWERS: I'm still not getting an
19 answer to my question.

20 MR. RAO: I must be missing something.

21 MEMBER POWERS: I'm asking you what keeps
22 your from depressurizing this plant. What has to
23 happen so that you cannot depressurize?

24 CHAIRMAN WALLIS: Under what conditions?

25 MR. RAO: Under what conditions? As long

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1 as there's no pipe break -- I'm still -- are you
2 saying what do we have to do to the design to prevent
3 it from depressurizing during a pipe break?

4 Someone can help me in the back.

5 CHAIRMAN WALLIS: How can you get into a
6 situation where you're unable to depressurize.

7 MR. RAO: Where you are not able to
8 depressurize?

9 MEMBER POWERS: Even with a pipe break.

10 MR. RAO: Even with a pipe break. Well,
11 if you get failure of both the areas, there are two
12 area systems. We've added the wilsadee (phonetic) and
13 the depressurization system. We've got the standard
14 safety relief valves, and we've added another system
15 called the DPVs, the depressurization valves.

16 So if both of those fail, then you fail to
17 depressurize.

18 MEMBER POWERS: Okay. What causes both of
19 those to fail?

20 MR. RAO: What would cause both of those
21 to fail? Anyone in the back ready to answer that?

22 CHESTER: All of the valves, they use
23 different --

24 PARTICIPANT: Could you give us --

25 CHESTER: I'm Chester (unintelligible).

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1 The ADS valve and the DPV valve, they have
2 diversified single systems that are very hard to have
3 fail all the signals. You're talking about multiple
4 failure of all the signals.

5 MEMBER POWERS: I'm not really interested
6 -- I mean, I am very interested in what makes it
7 difficult to depressurize or what makes it easy to
8 depressurize. What I very much want to understand is
9 what combination of things make it so that you cannot
10 activate these ADS systems.

11 Now, obviously if I get no signal to do
12 so, that will do it.

13 MR. RAO: Yeah, yeah.

14 MEMBER POWERS: So the question is: what
15 makes it so you can't get a signal to them?

16 MR. RAO: Well, you've got to, I guess,
17 have a common cause failure. We've got four
18 divisionals in the control and instrumentation. So
19 you have to have a common cause failure in control and
20 instrumentation.

21 CHAIRMAN WALLIS: But if you had a fire,
22 say, which incapacitated all of the system?

23 MR. RAO: Well, that's where you have the
24 four division system. So you do the separation to
25 handle -- you handle that. Okay? It is an anergic

1 containment. So there's not going to be a fire inside
2 the containment. The external, you handle that by
3 division and standard separation.

4 So if there is a common cause failure, you
5 know, an undefined common cause failure of the
6 instrumentation, that will give you a failure to
7 depressurize.

8 MEMBER POWERS: Is there anything else
9 that will give you a failure to depressurize?

10 If you have no electrical power
11 whatsoever?

12 MR. RAO: We rely on batteries for that,
13 but even if you lose the batteries in addition to the
14 station blackout, then you'd lose instrumentation.

15 MEMBER POWERS: And that will cause a
16 failure of the ADS?

17 MR. RAO: Yes.

18 MEMBER POWERS: So a total station
19 blackout is still --

20 MR. RAO: Total loss of batteries, failure
21 of all the signals.

22 MEMBER POWERS: That will do it.

23 MR. RAO: Yeah.

24 MEMBER POWERS: So there's still a TC
25 sequence here someplace.

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1 MR. RAO: Yeah.

2 MEMBER POWERS: Okay.

3 CHAIRMAN WALLIS: I'm a bit worried about
4 failure to complete this presentation on time.

5 (Laughter.)

6 CHAIRMAN WALLIS: Okay. The --

7 DR. BANERJEE: Before you go on, what is
8 different between this and the SBWR? Is there
9 anything in the wetwell/drywell connection design?

10 MR. RAO: Well, we just got two more steam
11 lines. We got a slightly bigger vessel. This, the
12 top part, the GDCS, these are the pools of water.
13 Those are all the same. This is all the same. The
14 only difference, okay, that's different, and it's hard
15 to show that kind of detail in this cartoon, is in the
16 SBWR. These pools were open at the top out here. The
17 roof of the drywell is out here. Okay? The top part
18 was open to the drywell.

19 In the ESBWR this wall goes up to the roof
20 of the drywell, and this pool of water is now part of
21 the wetwell.

22 So all that we did was we extended this
23 wall up to the roof. It was about a foot opening, I
24 think, in the SBWR. So we've extended it up to the
25 top and put a connection between this airspace and

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1 this, the wetwell airspace.

2 MR. SCHROCK: Is that permanently open or
3 --

4 MR. RAO: Yeah, all those are permanently
5 open. No valves.

6 So otherwise it looks just like the ESBWR.

7 MR. SCHROCK: Why did you do that?

8 MR. RAO: You'll see that basically what
9 it does is remember the containment pressure is
10 dependent on the wetwell volume, airspace volume.
11 Okay? So this was, again, taking advantage of the
12 passive system.

13 When this water drains out, okay, then it
14 opens up more airspace. So it loads the containment
15 pressure. Okay? So there's an advantage.

16 CHAIRMAN WALLIS: Well, there's a
17 conservation of airspace. If you lose it in one place
18 you gain it in another.

19 MR. RAO: Right. No, but you want more
20 airspace in the wetwell. That keeps your containment
21 pressure lower. So we actually did lower the
22 containment design pressure compared to the SBWR.
23 That doesn't show on a chart like this. We came down
24 ten psi. That's, again, an economic benefit, but we
25 kept essentially the same margins by making that

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1 change.

2 MEMBER POWERS: Can you give me some idea
3 of the what the magnitude of the economic benefit is
4 to get ten psi reduction in your design pressure?

5 MR. RAO: No, I don't have a number for
6 that, and we never did calculate one. As a matter of
7 fact, again, one of the reasons for doing that was it
8 brought us down to the same level as the ABWR. Okay?
9 So there was a lot of experience with that, you know,
10 a lot of the testing on serial accident failures.

11 So there was that soft benefit of making
12 the same as ABWR.

13 CHAIRMAN WALLIS: I'm not sure you gained
14 because you actually put water in the drywell. Your
15 total airspace stays the same inside containment if
16 you include the whole works.

17 MR. RAO: There are two issues here. One
18 is the volume of the building, and the other is the
19 design pressure of the building. Okay? So Dana's
20 question is related to the design pressure. It does
21 end up in giving you less rebar requirements. We've
22 actually --

23 MEMBER POWERS: That's the cheapest deal
24 in America is rebar.

25 MR. RAO: No, rebar itself is cheap, but

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1 putting it together, constructing it. We have
2 actually gone down to even lower than the ABWR and our
3 structural designers told us it wasn't any additional
4 benefit. So we came back to --

5 MEMBER POWERS: I'll bet you run out of
6 benefit really quickly on rebar and concrete.

7 MEMBER RANSOM: Are vacuum vapor valves
8 still included in this design?

9 MR. RAO: Yes, there are three vacuum
10 breakers between the -- they're on the floor out here
11 between the drywell and the diaphragm floor.

12 MEMBER POWERS: Remind me again what your
13 containment volume is.

14 MR. RAO: Sorry, I don't. Does anyone
15 have the number off the top of their head?

16 PARTICIPANT: The drywell is about 6,000
17 kilometers. The wetwell is about 4,500.

18 MR. RAO: That's the airspace.

19 PARTICIPANT: The airspace.

20 CHAIRMAN WALLIS: You should really count
21 the whole thing. What's the whole containment?

22 MR. RAO: The whole containment volume,
23 you don't have the answer?

24 PARTICIPANT: I don't have it. I don't
25 know.

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1 CHAIRMAN WALLIS: Well, you have about
2 five minutes more now in presentation time.

3 MR. RAO: Okay.

4 CHAIRMAN WALLIS: So you're about a
5 quarter of the way through. Maybe we should plan on
6 you taking up all the time until the break. Is that
7 more realistic?

8 MR. RAO: No. When we sort of planned it,
9 we sort of anticipated that I'd run over a little, but
10 not --

11 CHAIRMAN WALLIS: A little bit.

12 MR. RAO: -- not all the way to lunchtime.
13 You want to hear the other things.

14 CHAIRMAN WALLIS: Lunchtime? No, no, no,
15 no, no.

16 MR. RAO: You want to hear from some of my
17 colleagues. You get all of your answers from
18 Shiralkar and Gamble and Cheung there.

19 Okay. This shows all of the safety
20 systems put together, including all of the valves, and
21 the thing that's -- let me go through all of this.
22 This is the reactor vessel. You can see the core. The
23 core is lower down in the vessel in this plant than in
24 the standard BWR. There's a shorter core. So you
25 need less space at the bottom, lower plenum for the

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1 control rod --

2 CHAIRMAN WALLIS: That's really to scale?

3 MR. RAO: Pardon?

4 CHAIRMAN WALLIS: Is that really to scale,
5 that tiny core?

6 MR. RAO: No. This is just to show how
7 the --

8 CHAIRMAN WALLIS: You should draw these
9 things to scale so it doesn't give some illusion.

10 MR. RAO: This was more to show you how
11 the lines connect up. Okay. We will try to fix that
12 in the next one. This is the isolation condenser out
13 here. This operates like some of the isolation
14 condensers on operating plants.

15 When you get to reactor isolation, these
16 valves are normally open. The valve is out here. The
17 condensate drain valves open, a signal to open. Steam
18 condensers in there and condensate is returned to the
19 vessel. So you've got a closed loop following reactor
20 isolation. You don't open any relief valves. You
21 don't lose any water to the containment. You don't
22 heat the containment. You don't need any of the
23 reactor coolant isolation condenser type of systems to
24 operate or you don't need any cooling system to
25 operate.

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1 The energy is removed to the spool of
2 water which is sitting outside the containment, and
3 the energy is release to the atmosphere.

4 DR. BANERJEE: It's still downflow
5 condensation.

6 MR. RAO: Yes.

7 DR. BANERJEE: And somebody will tell us
8 about the non-condensables.

9 MR. RAO: This is reactor isolation.
10 There should be no non-condensables.

11 CHAIRMAN WALLIS: There's a vent line for
12 that.

13 DR. BANERJEE: Oh, okay.

14 MR. RAO: Okay. But if you operate it for
15 72 hours, okay, this is designed to operate for 72
16 hours. Okay? It can. Then you'll get some
17 radialysis (phonetic) which will produce hydrogen, and
18 then you'll get non-condensables.

19 In that case, there is a vent line out
20 here. It will open and release the non-condensables.

21 CHAIRMAN WALLIS: And all of this has been
22 tested at full scale?

23 MR. RAO: Yes, yes.

24 CHAIRMAN WALLIS: In Japan or somewhere?

25 MR. RAO: In Italy.

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1 CHAIRMAN WALLIS: Italy. That's the Italy
2 one.

3 MR. RAO: Okay. So this is the isolation
4 condenser. This is considering they let the plant sit
5 there for 72 hours, which it probably likely wouldn't.
6 The gravity driven cooling system pools are shown out
7 here. This is that pipe that I mentioned. This is
8 the change from the SBWR where we went all the way to
9 -- came to this wall up to the top, and we added this
10 connection between that air space and the wetwell
11 airspace.

12 What it does is it makes this airspace
13 available long term when that pool drains. So it
14 lowers the long-term containment pressure.

15 MEMBER KRESS: How big is that pipe?

16 MR. RAO: How big is that pipe?

17 CHESTER: Half a meter.

18 MEMBER KRESS: It's a big pipe.

19 MR. RAO: Yes.

20 MEMBER SIEBER: You have to use the
21 microphone.

22 MR. RAO: You have to stand near the mic.

23 CHESTER: It's a big pipe.

24 MEMBER KRESS: Yeah, okay.

25 CHESTER: There are three pipes for each

1 of the pools.

2 MEMBER KRESS: Okay. Because the
3 effectiveness of that as an airspace depends on the
4 size.

5 MR. RAO: Yeah.

6 CHAIRMAN WALLIS: You mean the pressure in
7 that wetwell is somehow different from the overall
8 pressure in the building?

9 Because if you look at the entire
10 containment, the total amount of air in there is
11 constant. You can tree it off between the drywell and
12 the wetwell. You haven't really gained airspace.

13 MR. RAO: You have. What controls the
14 containment pressure, okay, is you take all the non-
15 condensables from the drywell and shove them into the
16 wetwell.

17 CHAIRMAN WALLIS: And you pressurize the
18 wetwell referentially to the --

19 MR. RAO: No, that's how the suppression
20 system works, is this is where your source of energy
21 is. This is where the brakes and the steams will come
22 out. So it will push all of the non-condensables into
23 this airspace.

24 So the bigger this airspace and the
25 smaller this airspace, the lower your containment

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1 pressure. Okay? So you want to minimize that
2 airspace and maximize this airspace.

3 And so by shifting it between the two you
4 will maximize the wetwell --

5 CHAIRMAN WALLIS: You mean your wetwell
6 gets higher pressure than the drywell?

7 MR. RAO: Yeah.

8 CHAIRMAN WALLIS: Then you should vent it
9 back into the drywell.

10 MR. RAO: No, because you've got to
11 remember the reason it gets higher is because
12 everything is being pushed through two flow paths.

13 CHAIRMAN WALLIS: How does it get pushed
14 if the pressure is higher in the wetwell than in the
15 drywell?

16 MR. RAO: You guys want to go through
17 that? Okay.

18 CHAIRMAN WALLIS: Well, I don't know.
19 Maybe we'll wait and hear about that.

20 MR. RAO: We'll wait while we get the
21 presentations. Okay?

22 CHAIRMAN WALLIS: Okay.

23 MR. RAO: The containment pressure is
24 determined by the wetwell pressure. Okay.

25 CHAIRMAN WALLIS: Well, it can't be.

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1 We'll get back to that because the whole thing is one
2 unit, isn't it? And the containment has to contain
3 both the drywell and the wetwell.

4 MR. RAO: Yes.

5 CHAIRMAN WALLIS: So let's get back to
6 that when the time comes.

7 MR. RAO: You'll hear detailed
8 presentations on that, okay, shortly.

9 This is the GDCS pool. This is the
10 suppression pool. These are the safety relief valves
11 that have quenchers blowing down into the suppression
12 pool.

13 This is the depressurization valve, the
14 alternate depressurization system which opens out into
15 the drywell.

16 CHAIRMAN WALLIS: That's called the Dana
17 Power's valve. That's DPV because that's the one he's
18 concerned about.

19 MR. RAO: We added the diversity because
20 we knew Dana was going to ask that question to make it
21 more reliable.

22 The ADS system in the BWR generally is
23 deemed to be fairly reliable, but we've gone to a
24 diverse system also. It's a screw actuated (phonetic)
25 valve. So it has different motor flows to open it.

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1 What's shown out here is the passive decay
2 heat removal system, which is called the passive
3 containment cooling system. No valves for it to
4 operate. Okay?

5 CHAIRMAN WALLIS: I presume an explosive
6 valve requires very little electrical energy to set it
7 off, whereas actually operating a large motor operated
8 valve would require a lot more power.

9 MR. RAO: A lot more energy, yes.

10 So we do have batteries to as --

11 CHAIRMAN WALLIS: So you could take your
12 flashlight and set off the explosive valve.

13 MR. RAO: Yes. That's why we believe it's
14 a very reliable system.

15 The passive containment cooling system --

16 MEMBER POWERS: What is the reliability of
17 screw actuated valves?

18 MR. RAO: Pardon?

19 MEMBER POWERS: What is the historical
20 reliability of screw actuative valves?

21 MR. RAO: Don't have the number on that,
22 but we can get back.

23 MEMBER POWERS: I think we found it
24 surprisingly unreliable.

25 MR. RAO: We'll give you a number.

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1 Do you have the number, Bob? No. Okay.

2 The passive containment cooling condenser,
3 basically steam goes up through here, and just like
4 the isolation condenser, steam gets condensed there,
5 and condensate is returned back to the vessel.

6 This is one other change relative to the
7 SBWR. We've added this system. In the SBWR this
8 condensate would return to the gravity driven cooling
9 system pool, but now since the GDCS pool is part of
10 the wetwell, we had to bring the drain back into the
11 drywell.

12 So initially in some of our earlier
13 designs we actually didn't even have this drain tank
14 and it would just flow back into the bottom of the
15 drywell.

16 We added this drain tank because we felt
17 that it would be better to have it drain back into the
18 vessel. If this valve does not open, the
19 functionality of the ECCS is not impacted.
20 Functionality of the system is not impacted. Water
21 does drain back into the vessel -- I mean into the
22 lower drywell, and you still have a closed loop.

23 So the steam is condensed out there. The
24 energy is removed to the PCCS pool, and steam is
25 vented out of the containment. That is the ultimate

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1 heat sink out there.

2 DR. BANERJEE: So if that valve doesn't
3 open, then you get water going in. Where does it go?

4 MR. RAO: It goes into the lower drywell.
5 Okay? Then you have a closed loop. The closed loop
6 is through here. These are what are called spillover
7 holes here. It flows into the suppression pool.
8 There's a line connecting the suppression pool back to
9 the vessel, the screw valve. So you have a closed
10 loop.

11 So we have looked at all of the different
12 possibilities, not enough time to go into each one of
13 the combinations out here, but you have a closed loop
14 and the water can go back through the vessel.

15 CHAIRMAN WALLIS: So most of the water in
16 this containment building is available to cool the
17 core.

18 MR. RAO: Yes, to cool the core. You
19 know, we've got an expression pool also connected to
20 the vessel. We've got GDCS pools connected to the
21 vessel.

22 One thing that's different than standard
23 BWRs is the suppression pool is raised to the core.
24 Most suppression pools are on the base mat out here.
25 This one is higher than the core. So you can get the

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1 flow from the suppression pool into the vessel.

2 CHAIRMAN WALLIS: Even when the core is
3 drawn properly, it's still higher?

4 MR. RAO: Yes, still lands it on top.

5 DR. BANERJEE: And the PCC vent line is at
6 the bottom there, right?

7 MR. RAO: Yes, yes.

8 DR. BANERJEE: Is that assuming that non-
9 condensables get driven into that?

10 MR. RAO: No. Now, non-condensables are
11 important in the operation of the PCC because you've
12 got non-condensables in the drywell. Okay? So the
13 condensation, the steam flow is similar to the
14 isolation condenser, but it's a condensation driven
15 system.

16 Okay, and that brings in non-condensables
17 with it. The major innovation in this design is
18 removing the non-condensables, and the non-
19 condensables are driven out from there by the pressure
20 difference between the drywell and the wetwell. The
21 drywell is at a higher pressure than the wetwell. I
22 think I said it the other way around.

23 Okay. The drywell is at a higher pressure
24 than the wetwell, and that drives the non-condensables
25 out through that non-condensable vent line.

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1 There will be several more presentations
2 that will cover all of that. That's been tested.
3 That's how it works. I'm just giving you an overview.

4 And what determines the ultimate
5 containment pressure is the modern non-condensables.
6 You put them in the wetwell airspace. That is the
7 major component of the containment design pressure
8 following the LOCA. All of that air gets pushed over,
9 and there is some vapor pressure because there's a
10 slight heating up of the suppression pool. The
11 suppression pool in this plant only heats up because
12 of blow-down energy. Okay?

13 In a traditional boiling water reactor,
14 what you do is the first part of the transient is the
15 same. All the air following a pipe break gets pushed
16 over into the wetwell airspace. That gives you a
17 certain pressure.

18 And then what happens is the energy from
19 the drywell gets transferred to the suppression pool.
20 The suppression pool heats up. It gives you an
21 increase in the vapor pressure which causes the
22 condensed pressure to heat up.

23 The active RHR system removes the energy
24 from the suppression pool. It is only effective at a
25 certain delta T. So you've got to heat up the pool to

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1 remove this energy. In this plant the difference is
2 we remove the energy before it gets to the suppression
3 pool through these heat exchangers.

4 Just to give you some ball park numbers,
5 in a operating plant the suppression pool has to get
6 up to 212, 220 before the RHR system is effective in
7 removing the decay from the containment.

8 Following an initial blow-down, assuming
9 that the suppression pool starts at 110 degrees, the
10 initial blow-down gives you about a 30 or 40 degree
11 increase in the suppression pool temperature. You get
12 a similar increase, slightly less increase in this
13 line, because some of the energy actually goes out
14 through the heat exchanger.

15 CHAIRMAN WALLIS: Does the pressure pool
16 get to, say, 220 Fahrenheit?

17 MR. RAO: No, not in this plant, not in
18 this plant. In operating plants, it will get up --
19 for the RHR system to be effective in operating
20 plants, you'll have to get the suppression pool up in
21 temperature. That's how the system works. For the
22 delta T, you need a higher delta T to remove that
23 energy.

24 Okay. In this plant it's primarily the
25 blow-down energy that heats up the suppression pool.

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1 So that's a 30 to 40 degree increase in temperature
2 from the initial starting temperature. If you go with
3 the tech spec, I believe it's 120. One, twenty?

4 CHESTER: One, twenty.

5 MR. RAO: One, twenty. So you get a 30 to
6 40 degree increase in temperature by the initial blow-
7 down, and then for a short time period these heat
8 exchangers cannot remove all of the energy, and you
9 get a slight increase in temperature beyond the
10 initial blow-down. Okay? And that gives you a vapor
11 pressure that gets up to 180, 190 at this plant.

12 In the operating plant, you get up to 220
13 degrees, beyond that.

14 Okay. So what determines the containment
15 pressure in this plant is primarily the drywell
16 volume. Take all of that air and shove it into that
17 space. Do that on the back of an envelope, and about
18 a five to eight psi vapor pressure from the heating up
19 of the suppression pool.

20 So it's a fairly simple calculation as
21 long as these heat exchangers are properly sized, and
22 as you will see in the presentations, these are
23 properly sized.

24 This is the 13 pump story. For those of
25 you who don't like passive systems, you can see that

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1 what we have for core cooling is we've done several
2 things in the design to improve the plant response.
3 We've increased the inventory in the vessel. You'll
4 see a chart that shows that we've got two and a half
5 times as much water.

6 We've increased the amount of subcooled
7 water. Chester will go into a lot of details on how
8 the plant behaves and where the water is.

9 We've eliminated large pipes from below
10 the core. We've minimized the other pipe sizes. Like
11 I mentioned, the only pipes that are connected at the
12 core, near the core elevation are two inch nozzles.
13 So we've kept them down to very small sizes.

14 Well, we provide inventory makeup. We
15 don't need a fast makeup system. Okay? The makeup
16 rate is very low, as you'll see the plots out here.
17 You don't reach the minimum water level until at least
18 600 seconds into the transience. That's when you
19 depressurize the vessel, and all that you have to do
20 is make up the water that's lost by boil-off.

21 So you don't need any accumulator driven
22 system. You don't need any high pressure injection
23 systems because the plant actually reacts fairly
24 slowly.

25 Now, because you don't have any high

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1 pressure systems, any accumulators or other core
2 makeup tanks or any of the other issues that you might
3 see on other plants or high pressure coolant injection
4 systems, like on BWRs, you see fewer system
5 interactions. The only high pressure system that
6 exists on this plant is the isolation condenser, and
7 we don't take credit for that in the loss of coolant
8 accident analysis.

9 CHAIRMAN WALLIS: If this is such a
10 wonderful system, how come it has taken 15 years
11 before anyone is seriously looking at it?

12 MR. RAO: Well, when you look at the
13 market, there hasn't been a plant --

14 CHAIRMAN WALLIS: The market has been
15 lousy.

16 MR. RAO: And the other thing that's
17 different out here is we are now using an integrated
18 analysis. You know, when I first joined General
19 Electric, I worked out here, and I defended using all
20 the different codes, you know. We had to use
21 LAMB/SCAT, SAFE, SAFER, CHASTE, and all of those
22 things for doing all of the calculations.

23 Now we have got an integrated core. What
24 you asked us to do -- all of you weren't on the
25 committee then -- was to develop an integrated core.

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1 We've got one now. It's there. It doesn't do
2 everything. It doesn't do windows, but it does do an
3 excellent job of doing the calculation.

4 In the interest of time I will skip
5 through a few of the charts.

6 On the decay heat removal system,
7 basically what we do is remove decay heat from the
8 vessel. What's new in this plant is we've now got a
9 full pressure, novel shutdown cooling system. We rely
10 on isolation condensers. In some of these cases
11 they're old. We've gone back to features that were in
12 the older BWRs.

13 We can remove SLV through relief valve
14 opening. I mean you can open the relief valve. You
15 do have a non-safety grade suppression pool cooling
16 system. So you can do that also. So for those who
17 like some of the old features, they're still there.

18 And of course, if needed, if you get a
19 pipe break, we basically remove heat from the
20 containment through the ECCS heat exchangers, which
21 are new. I'll discuss those in some time.

22 Of course, we do have a suppression pool
23 cooling system in this plant also, but it's a non-
24 safety system. So the pumps and heat exchangers that
25 we had in the old plants are still there.

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1 Decay heat removal, how it works. I
2 discussed this briefly in some of the earlier charts.
3 You get the blow down energy, which flows to the
4 suppression pool, traditional pressure suppression
5 system.

6 Longer term, the decay heat flows through
7 the heat exchanger similar to an isolation condenser,
8 and heat is transferred outside the containment.
9 You've got tube heat exchangers. The non-condensables
10 are removed by the pressure difference between the
11 drywell and the wetwell. Like I mentioned earlier and
12 corrected myself, the drywell is at a higher pressure
13 than the wetwell, but the drywell pressure --

14 CHAIRMAN WALLIS: It's always at a higher
15 pressure than the wetwell?

16 MR. RAO: Except for a short time period,
17 and I'll show you the transience when that happens.
18 When you condense the steam in the drywell, you know,
19 after the initial blow-down and you condense the
20 steam, when the water from the gravity driven cooling
21 system flows in, it condenses the steam. So the
22 pressure in the drywell will come down for a little
23 while, and then you pull the non-condensables back.

24 CHAIRMAN WALLIS: That's right. You suck
25 it, suck up out of the suppression pool.

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1 MR. RAO: I was wrong when I made my
2 earlier statements. I guess maybe I'm getting old and
3 forgetting some of these things as we go along.

4 No, but that's how it works. You'll see
5 details on that.

6 MEMBER POWERS: Will we discuss the
7 capabilities of the plant during shutdown refueling?

8 MR. RAO: We were not planning to discuss
9 that, but I can address that right now. Basically,
10 the same system is still available for that, except
11 for the water makeup system. The gravity driven
12 cooling system is still available. Okay?

13 You've got the vessel that's full of
14 water. The one thing that's --

15 MEMBER POWERS: I mean that's the question
16 that came to my mind. You've got a core very low and
17 a very tall vessel, and I was wondering how low do you
18 have to drop that water for your refueling process and
19 service all of these systems that come in above the
20 core.

21 MR. RAO: The vessel is actually full of
22 water at that time, during the refueling. So just to
23 give you a feel for some of the numbers, let me go
24 back to --

25 MEMBER POWERS: I mean, what comes to mind

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1 is -- this is a good one.

2 MR. RAO: Okay. Let me give you a feel
3 for some of the numbers. The vessel volume is about
4 500 cubic meters. Okay? This lower drywell is 700
5 cubic meters. Okay?

6 One of the neat things about this design
7 is this pool of water is 1,000 cubic meters. Okay?
8 And the vessel is full of water. Okay. During the --

9 MEMBER POWERS: But is it full of water if
10 I am servicing my squib valves?

11 MR. RAO: Yeah, there are check valves,
12 and there are block valves all along the line.

13 MEMBER POWERS: The system. So you don't
14 have to take the water level down before --

15 MR. RAO: No, you don't have to take the
16 water level down during an outage.

17 MEMBER POWERS: And you don't have
18 anything like an operational mode five here then where
19 you have low inventories and safety systems taken out.

20 MR. RAO: No.

21 MEMBER POWERS: Okay.

22 MR. RAO: Okay, but the thing that's
23 different is that this lower drywell volume is about
24 700 cubic meters. It's a lot smaller than that for
25 the operating plants, okay, and so it doesn't take

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1 that much water to fill that up. That solves the
2 simplistic way of looking at it.

3 CHAIRMAN WALLIS: When you refuel, do you
4 take out all of the baffle that are in the chimney as
5 well?

6 MR. RAO: Pardon?

7 CHAIRMAN WALLIS: When you refuel, you
8 have to take out all of the baffle you've got in the
9 chimney?

10 MR. RAO: Not in the chimney.

11 CHAIRMAN WALLIS: You leave them in?

12 MR. RAO: We leave them in.

13 MEMBER FORD: Atam, could you go back to
14 that previous graph? Since we're going to have a free
15 flow question period, has there been a materials
16 design review undertaken?

17 MR. RAO: No. We are using the same
18 conditions as that for an operating plant. So we're
19 assuming the best --

20 MEMBER FORD: I ask this question --

21 MEMBER POWERS: If they've been so
22 successful, Peter, why would they possibly want to
23 change?

24 MEMBER FORD: Well, I asked the question
25 a while ago to you, and the answer was that materials

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1 of construction would be essentially those for an
2 ABWR.

3 MR. RAO: Right, exactly.

4 MEMBER FORD: As I look at this design,
5 the difference, of course, is a huge chimney.
6 Everything above the core, and I'm assuming you'd be
7 using hydrogen motor chemistry; everything above the
8 core will be not a very efficient water chemistry.
9 Therefore, everything above the core, regardless of
10 whether it's L grade or not, stainless steels, could
11 crack.

12 Has that been taken into account?
13 Obviously not.

14 And if it did crack, what would the impact
15 be?

16 MR. RAO: Okay. It's been taken into
17 account in the sense of, one, we made sure that all
18 the components inside the vessel are removable easily.
19 They aren't welded anymore. Okay? So we made them
20 replaceable.

21 And so in that sense we have taken that
22 into account. And we've made sure there's enough
23 hatches up in the top. We have a plan to remove the
24 largest components through the refueling floor and out
25 of the containment.

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1 MEMBER FORD: I'm assuming a materials
2 design review will be undertaken.

3 MR. RAO: Yes, definitely.

4 MEMBER FORD: In time so as not to be a
5 rate limiting step if you have to come up with a new
6 material.

7 MR. RAO: Yes, it will be. That will be
8 all done as part of the SAR submittal. Right now
9 remember we are focusing on thermal hydraulic
10 calculations rather than on the actual design.

11 MEMBER FORD: The other question along
12 those lines, I'm assuming it will be nobel metal
13 chemical addition you will be also using in addition
14 to hydrogen water chemistry. Will calculations be
15 done as to how efficient that application will be and
16 whether you can protect all of the wet components?

17 MR. RAO: We expect to do all of that, you
18 know, in time for the SAR submittal.

19 What we have done in this program -- let
20 me step back a little bit -- is by experience with the
21 SBWR was we did technology review, testing, safety
22 analysis report, all in one big package, and
23 everything was going on in parallel.

24 What we've tried to do in this program is
25 let's do it step-wise. Let's get a few things off the

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1 table and see if we can get them off the table.

2 Okay. So the pre-application review is
3 not focusing on the design materials and any of those
4 issues.

5 MEMBER FORD: Even though they may impact
6 on safety?

7 MR. RAO: Yes. There are a lot of design
8 issues that impact the safety and will affect the PRA
9 and all of the rest. What we are trying to do is get
10 closure on the thermal hydraulic spot of the analysis
11 on the completed codes because that in the past has
12 been the biggest uncertainty or whatever for getting
13 these moving forward.

14 If we can't even get this closed out, then
15 you know. You've got to remember that we have not
16 been using any government money for the last ten years
17 to develop. This has been a totally industry effort,
18 and if we can't see the light of day in this tunnel
19 even on this one, then the other ones will be even
20 harder to get to.

21 CHAIRMAN WALLIS: Well, I think it's good
22 to let you take the time until the break.

23 MR. RAO: Okay.

24 CHAIRMAN WALLIS: But I think that's
25 really definitely the ultimate time that you have.

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1 You don't have any longer than that.

2 I think it's good because there are so
3 many questions that it's useful to the Subcommittee,
4 but that is the deadline.

5 MR. RAO: Okay.

6 CHAIRMAN WALLIS: So let's move along.

7 MR. RAO: We will get into how the PCSS
8 works in some of the later presentation, but it's
9 important to understand how they work. Some of the
10 charts have not come out too good on the screen, and
11 I don't know why.

12 It's a standard plant schematic. What you
13 can't see out here -- the pictures are better in your
14 handouts?

15 PARTICIPANTS: Yes.

16 MR. RAO: The thing to notice out here is
17 the major water systems which have the simplification
18 you wanted to hear about the economics is the reactor
19 water clean-up system at the bottom. I think this is
20 the fuel pool cooling system out here shown on the
21 left, and the control rod drive hydraulic system.

22 Those are the only systems left in this
23 design, and that's where the simplification comes
24 from. That's where the economics comes from, is
25 basically in reducing the amount of materials and

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1 quantities that exist out there. All of the safety
2 systems are basically inside the containment or
3 sitting on top of the containment as shown out here
4 for the IC and PCC pools.

5 This shows the evolution of the BWR
6 containments. It's important to understand this as
7 background as we go forward. All except for, I
8 believe, one or two plants was at Big Rock Point and
9 Humbolt Bay, were I think not suppression systems, but
10 we've had suppression systems in Mark Is, Mark IIs,
11 Mark IIIs.

12 Basically the major suppression pool is
13 out here. You've got the drywells and the wetwell
14 airspace. The Mark II, where the drywell was sitting
15 on top of the wetwell, and the Mark IIIs where the
16 drywell was surrounded by the wetwell airspace out
17 here.

18 In all cases the suppression pool was low
19 in the building. That was, again, reasons for because
20 of MPSH considerations for the safety system's pumps,
21 because you needed to take the water from there and
22 put it back in the vessel.

23 The ABWR basically is similar. You've got
24 the precious suppression sitting out on the base mat
25 out here -- the suppression pool, I mean, sitting on

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1 the base mat out here. You've got a T shaped driver
2 because you don't have the recirculation pumps that
3 you have the extent of loops that you have on some of
4 the earlier designs, and the drywell airspace is
5 primarily controlled by the space required on the top
6 by the maintenance of the safety relief valves.

7 So you've got right circular cylinders,
8 concrete containment, covered suppression pool that's
9 noted, and you've got horizontal vents that we
10 developed on the Mark III.

11 The ESBWR took features from both the ABWR
12 and the Mark III. We've got a separate fuel building.
13 You can see in the earlier designs and the ABWR this
14 hash mark out here is not a bar code. That is spent
15 fuel storage. Okay?

16 And like the Mark III, we've put it in a
17 separate fuel building. We've got an inclined fuel
18 transfer system, but, again, we wanted to make
19 improvements.

20 What we have done is, of course, I've
21 mentioned the raised suppression pool off the base mat
22 which provides a means to provide water makeup from
23 multiple source.

24 The inclined fuel transfer, that's what
25 IFTS stands for, the top part of it is not part of

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1 containment like it was in the Mark IIIs. So you can
2 actually move fuel during novel operation. You don't
3 have to open the containment to make sure that that
4 system is functioning and all the rest of it. So that
5 is an improvement over the Mark III.

6 CHAIRMAN WALLIS: Now, this shows an ASBWR
7 vessel has actually a shorter L over D than the Mark
8 II. Is that -- it has a longer L over D, doesn't it?

9 MR. RAO: I know you -- this is more to
10 show some of the features. Okay? this is not
11 necessarily drawn to scale out here, please, and we
12 will try to fix it in the next round.

13 MR. SCHROCK: I would wonder why you
14 didn't include SBWR in this comparison.

15 MR. RAO: It got too complex, and it
16 wasn't adding anything. The key features that I'm
17 trying to show out here, okay, the differences between
18 SBWR and ESBWR are not, as far as containment is
19 concerned, are not that significant. It was just a
20 matter of -- I always run over time. I'm trying to
21 shorten this out here. That was it. No other reason,
22 nothing more complex than that.

23 CHAIRMAN WALLIS: Okay. We're going to
24 move on? Are we going to move on to the next one now?

25 MEMBER SIEBER: Well, the ESBWR is not

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1 innurded (phonetic), right?

2 MR. RAO: It is innurded just like ABWR.
3 All of these things, okay, were adopted by the ESBWR.

4 MEMBER SIEBER: Okay.

5 MR. RAO: Innurded containment, horizontal
6 vents, same as ABWR, covered suppression pool.

7 MEMBER SIEBER: So you actually could not
8 move fuel during operation.

9 MR. RAO: No, no. You can't get into the
10 containment in the operation. You can move fuel up
11 here. You can. This is not innurded. This is not
12 part of containment.

13 MEMBER SIEBER: Okay.

14 MR. RAO: So you can move the fuel up and
15 down, and you see we have a buffer storage up on top.
16 You can actually move it and keep it there ready to -
17 -

18 MEMBER SIEBER: So the upper portion in
19 the fuel building is not subject to containment
20 pressure driven actions.

21 MR. RAO: Right. Both this part --

22 MEMBER SIEBER: Yes.

23 MR. RAO: -- and this part are not subject
24 to containment pressure.

25 MEMBER SIEBER: And so they aren't

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1 designed for containment pressure, right?

2 MR. RAO: They are not designed for
3 containment pressure.

4 MEMBER SIEBER: Thank you.

5 MR. SCHROCK: Do you use the concept of a
6 secondary containment? Is that what that is there?

7 MR. RAO: And that is also what's an
8 undefined external event shield. As the requirements
9 are evolving, we don't want to be the first on that,
10 but we have the space for it. This can take care of
11 anything that might come falling from the skies. It's
12 undefined. We have not designed it structurally yet.
13 We can make it as thin or as thick as we need it.

14 This shows an actual drawing cut-away of
15 the section. You can see that there actually is not
16 much equipment in this building. There's just some
17 equipment down here. The reactor vessel and the
18 piping, and that's what gives it the simplicity.

19 This is the inclined fuel transfer. You
20 can see the spent fuel pool. This is grade elevation
21 here. Okay. It is essentially below grade there.

22 This is the fuel pool cooling system. So
23 all of the water systems are done out here.

24 MEMBER SIEBER: Now, if I look at the core
25 relative to the suppression pool, only about half of

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1 the water in the suppression pool is available for
2 core flooding; is that correct?

3 MR. RAO: Actually, you know, a two
4 dimensional picture is very misleading.

5 MEMBER SIEBER: Yeah. That's the best you
6 can do.

7 MR. RAO: In a two dimensional picture you
8 don't really get the true feel of it. This water
9 level only drops by half a meter or something when you
10 flooded everything in the bottom. Okay?

11 That's about 3,000 cubic meters, and the
12 total volume in the bottom was 700 or some

13 MEMBER SIEBER: But that reactor vessel to
14 some is very large. From the tip of the control rod
15 drives to the top is over 100 feet.

16 MR. RAO: Yeah, but you don't have to
17 flood that to get the --

18 MEMBER SIEBER: That's right.

19 MR. RAO: You only have to flood the lower
20 part out here. In fact, that is one of the
21 advantages. You've got the core lower than the
22 vessel. You don't have to flood it too much.

23 MEMBER SIEBER: Yeah.

24 MR. RAO: This is the refueling floor.
25 This is what I was mentioning. This is the pool up on

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1 the top. Inclined fuel transfer comes up there. You
2 can store 70 percent of a core up there. Okay? So
3 you can move stuff in and out during novel operations.

4 Again, we were trying to make it easier
5 for the utilities.

6 This one is an important chart. I want
7 you to know because for a couple of reasons. We have
8 greater water inventory, which gives us improved LOCA
9 performance, and we have a larger steam volume in the
10 vessel, the bigger vessel. That's where you start
11 from. You make your vessel bigger. You'll get
12 improved performance of the plan from a safety
13 perspective.

14 So since the focus here is on safety, what
15 you can see is we've got rid of the large pipes below
16 the core, ESBWRs on the left side. We got a shorter
17 core. So the core is actually sitting lower in the
18 vessel. This is the ABWR out here. It's sitting
19 higher because you've got to have the cold space for
20 the control rod drive. So the core is sitting a
21 little higher.

22 The top of reactor fuel above the RPV
23 bottom, you can see is much lower. Okay? So you
24 don't have to fill up the whole vessel, and this is
25 the bottom line. The water volume outside the shroud.

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1 Okay?

2 Chester has color pictures in his
3 presentations. That is what determines the LOCA
4 performance. Okay? You end up with a lot more
5 water that's available for flooding the core, and you
6 don't have to provide it from outside. It's there
7 inside the vessel, and you'll see how the plant
8 behaves.

9 And the other thing is because of the
10 chimney, you've got much larger steam volume. You'll
11 see the pressure rate is about half that of an
12 operating plant off an ABWR, and that's because you've
13 got about twice the steam volume. I mean, you don't
14 need a computer code for that. It's just the simple
15 numbers and the size of the vessel.

16 This shows the plant response, and this is
17 what I was trying to say earlier. If you look at most
18 of the operating plants in the U.S., all of the
19 operating plants in the U.S., jet pump plants, for a
20 couple of them, the water level drops very rapidly
21 below the core, and you have fast pump ejection.
22 That's what makes up the water level.

23 This is the water level following a
24 typical pipe break. ABWR, the water doesn't drop
25 below the top of the fuel because we've eliminated the

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1 large pipes.

2 CHAIRMAN WALLIS: This "typical" means
3 worst?

4 MR. RAO: The actual TRACG plots, this is
5 a simplified plot.

6 CHAIRMAN WALLIS: They're all like this
7 for all pipe breaks?

8 MR. RAO: For the ESBWR, yes. For these
9 plants, they are not. For ESBWR, --

10 CHAIRMAN WALLIS: So for all pipe breaks,
11 the core level is way above the top of the core with
12 ESBWR.

13 MR. RAO: On the ESBWR, you can see the
14 numbers. It's three meters --

15 CHAIRMAN WALLIS: That's the message you
16 want.

17 MR. RAO: It's nine feet above the top of
18 there. No, there's a couple of other messages I want
19 to give to you out here.

20 One is that the minimum water level isn't
21 reached. You don't even start injection --
22 "injection" is the wrong word -- water doesn't start
23 flowing by gravity until about five or 600 seconds
24 into the transience. Things do not have to act very
25 fast. This response here, this first part is just

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1 what's in the vessel. Nothing is going to come
2 outside. This is what's flowing out, okay, and what's
3 available inside the vessel.

4 CHAIRMAN WALLIS: So this is also good
5 from the point of view of operator action?

6 MR. RAO: Yeah.

7 CHAIRMAN WALLIS: Operators don't have to
8 do anything?

9 MR. RAO: No. No operator action is
10 required. It's all in the vessel. Everything is
11 there. Okay? So nothing happens from outside until
12 that time period, 600 seconds. You don't need fast
13 makeup. You don't need any.

14 And then when you see the actual plot, you
15 can delay the injection several hundred seconds or
16 they'll give you some numbers they've drawn.

17 CHAIRMAN WALLIS: I'm tempted to say that
18 the reason this wasn't built 30 years ago was that
19 someone had the crazy idea of putting these things in
20 a submarine so that they couldn't be too tall.

21 MR. RAO: Submarines are 50 years ago, 60
22 years ago.

23 CHAIRMAN WALLIS: Well, an awful long time
24 ago, probably before you were born.

25 MEMBER KRESS: What causes the recovery in

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1 level at 100 seconds?

2 MR. RAO: Oh, okay. This is what happens
3 is you start opening the break transition valves,
4 flashing going on inside the vessel.

5 MEMBER KRESS: Oh, that's the --

6 MR. RAO: That's the depressurization
7 start.

8 MEMBER KRESS: Oh, okay. That's just
9 the --

10 MR. RAO: Just the two phase level.

11 MEMBER KRESS: Two phase level.

12 MR. RAO: You'll see a lot more different
13 plots. This is just to give you somewhat of an
14 overview here.

15 MEMBER RANSOM: What do you mean by the
16 shroud, change in terminology there? Is that the
17 annulus?

18 MR. RAO: Inside this thing this is the
19 shroud. Okay? This --

20 MEMBER RANSOM: So is that a collapsed
21 water level?

22 MR. RAO: This one?

23 MEMBER RANSOM: Well, yes.

24 MR. RAO: This is a two-phased level
25 (phonetic).

1 CHAIRMAN WALLIS: So it's steam above.

2 MEMBER RANSOM: Three phase or collapsed -

3 -

4 MR. RAO: Two phase. You'll see a lot
5 more details on collapsed and two phase and all in the
6 later presentation. This is the two phase level.
7 You'll see a lot more detail as we go along, and you
8 can look at it from collapsed levels. You can look at
9 it from two phased levels. You can look at downcomer
10 levels, shroud levels.

11 The key thing is the water level and the
12 shroud. That's what keeps the floor covered.

13 Okay. This shows the containment
14 pressure, the function of time for the --

15 CHAIRMAN WALLIS: Does it ever come down?

16 MR. RAO: Pardon?

17 CHAIRMAN WALLIS: Does it ever come down?

18 It seems to be creeping up.

19 MR. RAO: A passive system will not get
20 down to ambient conditions.

21 CHAIRMAN WALLIS: So it stays up at .8?

22 MR. RAO: Yeah, it stays up there. That's
23 true. Because remember what keeps the pressure up is
24 the air goes from the drywell to the wetwell. It's
25 not a heating issue. It's not a safety issue. It's

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1 a question of just the air being in the -- from the
2 drywell being pushed into the wetwell. That is really
3 what --

4 CHAIRMAN WALLIS: Then what's in the
5 drywell? Just steam?

6 MR. RAO: Steam.

7 CHAIRMAN WALLIS: Well, eventually that's
8 going to disappear.

9 MR. RAO: Pardon?

10 CHAIRMAN WALLIS: Eventually that will
11 presumably go.

12 MR. RAO: No.

13 CHAIRMAN WALLIS: No?

14 MR. RAO: Decay heat will keep it there.

15 CHAIRMAN WALLIS: Oh, okay.

16 MEMBER POWERS: It depends on the
17 definition of "eventually." Eventually decay heat
18 goes away and then you're all dead.

19 MR. RAO: Eventually you'll have to turn
20 on your pumps. Okay? There's no -- okay. The
21 passive system will never get you to ambient
22 conditions.

23 Okay. There's an extensive test program.
24 I've just given you an overview. We've done component
25 costs. We've done integral tests, different scales,

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1 different countries, a system interaction test. We've
2 even done tests with hydrogen releases. Basically the
3 testing is used to qualify the computer code.

4 And there's been extensive review and
5 participation by the NRC staff in the tests matrix
6 both from the SBWR program, all on the SBWR program,
7 and the running of the actual test.

8 A key point in our presentation is that
9 all of the testing that was done for SBWR we believe
10 is sufficient for the qualification of the TRACG
11 computer code. However, we did additional
12 confirmatory testing for the ESBWR in one of the test
13 facilities, and we'll present results from that also.

14 MEMBER KRESS: I presume you base that on
15 a PIRT and a scaling and pi groups that are --

16 MR. RAO: Right.

17 MEMBER KRESS: -- basically the same?

18 MR. RAO: Right, exactly.

19 CHAIRMAN WALLIS: Actually I think you try
20 to do everything at full scale in the sense that it's
21 full height.

22 MR. RAO: Well, we --

23 CHAIRMAN WALLIS: The only thing that is
24 compromised is the diameter of things.

25 MR. RAO: Well, the component tests were

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1 full scale for the SBWR size.

2 CHAIRMAN WALLIS: As much as possible,
3 right.

4 MR. RAO: We did -- as far as DPVs and
5 vacuum breakers and all, those are full scale
6 components. The only thing that's not full scale for
7 the SBWR and ESBWR is the PCCS heat exchangers.

8 CHAIRMAN WALLIS: Just the system, yeah.

9 MR. RAO: PCCS heat exchangers. Okay?
10 We've made them 35 percent bigger. We just increased
11 the number of tubes. Okay? So that is another
12 difference compared to the --

13 DR. BANERJEE: And the chimney is
14 different, right?

15 MR. RAO: The chimney is the same as the
16 SBWR ones.

17 DR. BANERJEE: They're the same size?

18 MR. RAO: Yeah, the one meter by one meter
19 diameter.

20 DR. BANERJEE: Right, and the length was?

21 MR. RAO: Length may have gone up by about
22 a meter or so.

23 CHESTER: It's just a little bit longer.

24 MR. RAO: Or half a meter. I don't know
25 what the exact number is, but it's up a little bit.

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1 Okay. So we made extensive new
2 submittals. You can see out here we've -- like 7,000
3 additional pages of submittals compared to the SBWR.
4 We are relying a lot on the SBWR. So that was a
5 complete and extensive program.

6 This shows the overall technology program
7 elements. You'll hear on this the testing and
8 analysis program next. It's called TAPD. You'll hear
9 that acronym many times. This gives you what we did
10 on the PIRTs, what was required for qualification.

11 That defines the overall plan. Okay?

12 With regard to the TRAC model description,
13 we got what we called the TRAC base qualification.
14 That was a report that was submitted and approved by
15 the NRC earlier for operating plants' AOOs, as shown
16 out here. So these three on the right had been
17 submitted earlier to the staff.

18 Some of the ones out here with the dashed
19 colors in the blue are some that were submitted for
20 the SBWR. The ones that don't have any color in them
21 are new or unique submittals in support of this ESBWR
22 technology closure.

23 We've got a scaling report. You'll hear
24 about that. You'll hear about the SBWR testing
25 summary. You'll hear about the ESBWR specific tests

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1 that were run. You'll hear more on the TRACG
2 qualification, how we do the model bias and
3 uncertainty, and that gives us the validated core, and
4 that's what we're looking for in this part of the
5 program, an SER on that.

6 Basically the SER -- sorry -- is on the
7 application methodology. I'm sorry. it's not on the
8 validated core. It's on the application methodology.
9 Okay.

10 And once we get that, we'll submit the
11 safety analysis report.

12 MEMBER FORD: So material degradation
13 issues, the only place it would come would be plant
14 parameter uncertainties?

15 MR. RAO: Yes, but we have not done that
16 specifically up yet. So I don't want to even imply.
17 That will come in this, okay, in the safety analysis
18 report. That's part of the next submittals.

19 So you'll be hearing about each one of
20 these, and you'll see that chart come up a few times.

21 Okay. I'm down to almost one more chart
22 after this, and basically we have simplified the
23 design with passive systems. The plant evaluations
24 are simpler. Calculations can be done at the back of
25 an envelope of the containment pressure. You can look

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1 at what we've done in the design in terms of LOCA.
2 We've added a lot more water to the vessel. That's
3 why you don't uncover the core.

4 And we can take a lot of uncertainty, you
5 know, injection rates, start times, VDCS flows, all of
6 those things, and it's not a plant that's sensitive to
7 any of those uncertainties.

8 The analysis is a lot less complex than in
9 the past. What you'll hear, again, later on -- I'm
10 just giving you an overview -- is that we're using the
11 best test for AOOs. Okay? For the three applications
12 here, we are trying to follow the procedure that's
13 approved by the NRC or suggested by the NRC. We're
14 using a best estimate code with uncertainties defined
15 as for our operating plants, the same as for AOOs for
16 operating plants, no different procedure, no different
17 application.

18 For ECCS/LOCA, since we had lots of margin
19 what we did was we're using best estimate code with a
20 simplified accounting of the uncertainties. It's a
21 simplified accounting just to save us work because,
22 you know, you can build the same procedures around 59
23 cases and do all of the uncertainties. All that you
24 will get is, you know, ultimately there will be no
25 change in the peak cladding temperature.

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1 So what we've done is a simplified
2 accounting of the uncertainties. It's just
3 simplified. It's more, you know -- it doesn't seem to
4 be evaluable, of any use to do all of those 59 cases.

5 MEMBER SIEBER: Are you going to explain
6 exactly what you mean by simplified later on?

7 MR. RAO: Later on.

8 MEMBER SIEBER: Thanks.

9 MR. RAO: Okay, but I do want to tell you
10 that, you know, there's a slight difference in the
11 application of the TRACG out here and just give you a
12 heads up. That's what you're going to hear.

13 MEMBER SIEBER: Okay.

14 MR. RAO: That's what issue we're looking
15 for as we go through the presentations.

16 For the containment and LOCA, we're using
17 a bounding calculation for the containment and LOCA
18 analysis, and we've also accounted for the
19 uncertainties, and we'll tell you how we've accounted
20 for the uncertainties.

21 Primarily the key issue out here is how do
22 you account for stratification and mixing. Okay?
23 Like I mentioned earlier, there are two components
24 that determine the containment pressure: how much air
25 gets pushed into the wetwell airspace, and there's no

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1 answer. You take all of it from the drywell and push
2 it into the wetwell. There's no uncertainty there.

3 The only question is calculating how much
4 stratification and mixing you get in the suppression
5 pool, and that will give you the vapor pressure.
6 That's a smaller part of the total containment
7 pressure, but it is the only one that will give you
8 any variation. Okay?

9 You can always do a bounding calculation
10 of the air being shoved over. Okay. So we will tell
11 you how we've done the bounding calculation for that
12 stratification. So that's where that bounding
13 calculation refers to.

14 There's low parameter uncertainty,
15 especially in the ECCS/LOCA. You know, the declining
16 temperature you see.

17 CHAIRMAN WALLIS: That looks like orders
18 of magnitude better than usual. I don't believe half
19 of the PCT.

20 MR. RAO: The core doesn't uncover. It's
21 the PCT that it doesn't matter out here.

22 CHAIRMAN WALLIS: It's so low it doesn't
23 matter.

24 MR. RAO: It doesn't matter.

25 CHAIRMAN WALLIS: So this observation is

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1 irrelevant.

2 MR. RAO: Yes, it doesn't uncover.

3 Okay. The substantial margins that exist
4 in the design, they're using integrated code. This is
5 what the ACRS has wanted for years. We've got that.
6 It's here. We're using it.

7 And it's not a code that we just
8 developed. It's been around for --

9 CHAIRMAN WALLIS: I'm surprised your
10 management allows you to pay for these enormous
11 margins, and usually it's economically beneficial to
12 get close to some limit rather than having an enormous
13 margin.

14 MR. RAO: Well, I'll explain.

15 CHAIRMAN WALLIS: You're now going to say
16 that, "Ah-ha, but now we're going to operate the power
17 by 50 percent or something"?

18 MR. RAO: No, no, no.

19 (Laughter.)

20 MEMBER SIEBER: That's tomorrow.

21 CHAIRMAN WALLIS: There must be something
22 that you're going to gain by --

23 MR. RAO: This will get me in trouble. We
24 developed the ESBWR in spite of management. Okay?

25 (Laughter.)

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1 MR. RAO: Okay. The --

2 MEMBER SIEBER: And so your work is not
3 done.

4 MR. RAO: No, no, no, no. There was a
5 reason --

6 PARTICIPANT: They're going to see the
7 transcript.

8 MR. RAO: That's fine.

9 (Laughter.)

10 MR. RAO: The issue really here is what is
11 the right power level. Okay? And we chose this power
12 level for two reasons.

13 We could have gone up -- in fact, when we
14 chose this power level, it was -- the EPR had gone up
15 with 1,700, the ABWR II had gone up to 1,700. Our
16 feedback from the utilities was 1,400 is about the
17 right power level. That was what the market was
18 telling us.

19 The second thing was that 7.1 meter
20 diameter. We felt comfortable with these margins, and
21 again, remember when you're trying to bring a new
22 product to market, you do have to have something that
23 stands out, and having the additional margin, and
24 hopefully it will help us get through the NRC review,
25 the ACRS review a lot easier. Okay?

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1 This is an important factor in the whole
2 design, getting passed through this right here.

3 MEMBER POWERS: He's issued a challenge
4 for you, Dr. Wallis.

5 MR. RAO: The challenge really is, you
6 know, right here on this chart. Okay? This is really
7 the challenge for all of us, is it's been a 15-plus
8 year technology and design program.

9 CHAIRMAN WALLIS: That doesn't sound to me
10 good. I mean, if it has taken so long, it suggests
11 that it's a very difficult thing to do. I don't think
12 it's a --

13 MR. RAO: No, it's not.

14 CHAIRMAN WALLIS: -- good thing to claim
15 that it has taken a long time and therefore it's good.

16 MR. RAO: No, it's not. Part of the
17 reason has been there has been no interest in the
18 market. So, you know, we're from California and no
19 wine before its time. No product before its time out
20 here, and if we had got the SBWR certified, no one
21 would say a word. Okay? It looks like there's an
22 interest out here.

23 So it's not the right time. Okay? I'm
24 not trying to imply that anyone do the same. It's an
25 extensive technology program. Simplification is by

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1 design. It's not just my words. You can see the
2 numbers. It's the design that's the issue.

3 The large vessel, you know, we -- by the
4 way, the large vessel actually doesn't end up costing
5 us much money. Just from a practical point of view,
6 it's just an extra ring. The most expensive part of
7 the vessel is the lower head. It's not the extra
8 rings up at the top, and the --

9 CHAIRMAN WALLIS: All of those
10 penetrations that you have down there is the problem?

11 MR. RAO: Yeah, that's what. You know
12 with the pumps and all of that, that's the most
13 expensive part, and just to cite the issue out here
14 not for review is that the vessel height does not set
15 the building height. It's different than the
16 traditional boiling water reactors.

17 So the challenges for the coming months
18 really are we need closure and confirmation, and one
19 of the issues that the utilities put up in their
20 presentations is regulatory risk, and this is one of
21 the issues they say about the ESBWR, is you guys don't
22 have a piece of paper to show to us that you can get
23 closure on any of these issues.

24 That's why we have renamed this the
25 technology closure program, not just the pre-

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1 application review. This is not, you know, just to
2 get a feeling for it. We wanted to show that, yes, we
3 don't need any testing. We can use the TRACG code and
4 we've done a good job.

5 And thank you.

6 MEMBER KRESS: Could you go back to your
7 slide number six? I don't know if you can back up or
8 not.

9 CHAIRMAN WALLIS: Just don't click to
10 exit.

11 MEMBER KRESS: Now, on your power flow
12 map, yeah, could you show me at full power where
13 you're operating? Right there. You don't have a
14 MELLA line because that's a pump characteristic.

15 MEMBER SIEBER: Right.

16 MR. RAO: Right.

17 MEMBER KRESS: So you're operating right
18 on that steep part of that natural convection line
19 right there.

20 MR. RAO: Right there. This, you know,
21 I'm trying to show a natural circulator and a forced
22 circulator.

23 MEMBER KRESS: Yeah, I understand.

24 MR. RAO: That chart is kind of
25 misleading. You've got to remember that the --

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1 MEMBER KRESS: Yeah, I understand.

2 MR. RAO: This should be the X axis for
3 the natural circulator.

4 MEMBER KRESS: Yeah.

5 MR. RAO: Because what it control --

6 MEMBER KRESS: It should be the other way
7 around.

8 MR. RAO: It should be the other way
9 around.

10 MEMBER KRESS: Yeah.

11 MR. RAO: But, you know, because people
12 are used to this chart, we're showing it this way.
13 This is -- you know.

14 MEMBER KRESS: Does that open up the
15 possibility of small perturbations in flow giving you
16 large perturbations in power?

17 MR. RAO: No.

18 Rob, do you want to answer that?

19 PARTICIPANT: No, because each point on
20 that curve corresponds to a particular control rod
21 position. As you pull rods, you get different points
22 of operation. You cannot go from one flow to another.
23 You cannot jump from one flow to another.

24 MEMBER KRESS: So this is not a natural
25 thing. It's a control rod.

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1 PARTICIPANT: Yeah.

2 MEMBER KRESS: I understand that. Okay.

3 Well, the question there then, another
4 question on defense in depth, do you have more than
5 one redundant system to shut down, scram (phonetic)
6 the reactor?

7 MR. RAO: Yes. We have, in addition to
8 the control rod drives, which are both electrically
9 and hydraulically driven --

10 MEMBER KRESS: That's sort of a diversity,
11 yes.

12 MR. RAO: That's the diversity there, and
13 we also have a boron injection system.

14 MEMBER KRESS: You have boron injections.
15 Okay. Thank you.

16 MEMBER SIEBER: That system would have to
17 be quite large compared to the current BWR --

18 MR. RAO: The boron injection system is
19 actually --

20 MEMBER SIEBER: High volume.

21 MR. RAO: -- an accumulator driven system.

22 MEMBER SIEBER: Right.

23 MR. RAO: It's a large tank, two large
24 tanks actually.

25 MEMBER RANSOM: Where is the boron

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1 injection system located? Is it outside the
2 containment or --

3 MR. RAO: It's outside the containment.
4 It's -- it's outside containment. It's up high.

5 MEMBER SIEBER: Yes.

6 MR. RAO: I can show you on the drawing in
7 the break.

8 MEMBER RANSOM: By natural circulation,
9 you mean, or do you have --

10 MR. RAO: No, no. It's a high pressure
11 accumulator driven system.

12 MEMBER RANSOM: Okay.

13 MR. RAO: It's on natural circulation.
14 It's accumulator driven. So it's high pressure
15 injection.

16 Just it's not part of the review, but ATWS
17 in this plant is handled at high pressure.

18 CHAIRMAN WALLIS: Any more questions at
19 this time?

20 MEMBER SIEBER: Well, just one. Are you
21 talking operating pressure and above when you say high
22 pressure?

23 MR. RAO: Yeah.

24 MEMBER SIEBER: Okay.

25 MR. RAO: You don't need to depressurize

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1 basically. You inject the boron. You remove the --
2 ATWS is a containment decay heat removal issue.

3 MEMBER SIEBER: Right.

4 MR. RAO: This one, we don't dump much
5 into the containment. We remove it directly from the
6 vessel to the isolation condensers.

7 MEMBER SIEBER: But the accumulators are
8 probably 1,500 pounds or better.

9 MR. RAO: In other pressure or --

10 MEMBER SIEBER: To start.

11 MR. RAO: I don't know the pressure. I
12 was going to say 2,000, but --

13 MEMBER SIEBER: Well, I was, too.

14 MR. RAO: Yeah. I think it is 2,000, but
15 we can give you the exact number.

16 MEMBER SIEBER: Well, it's not that
17 important. I was just trying to understand what it --

18 MR. RAO: Yeah. Well, it injects and it
19 basically shuts down. The key question is where do
20 you remove the steam. The way it works is initially
21 the relief valve opens. It dumps some energy into the
22 suppression pool, but very soon the isolation
23 condensers take over and it can remove the energy, and
24 so you stay at high pressure. You don't lose anymore
25 boron out of the water.

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1 MEMBER RANSOM: Atam, one other question
2 on your containment pressure slide.

3 MR. RAO: Yes, sir.

4 MEMBER RANSOM: I don't know what -- it's
5 page 11.

6 MR. RAO: Okay.

7 MEMBER RANSOM: Where does that eventually
8 go and what eventually turns it around?

9 MR. RAO: You have a turn-around in an
10 active system.

11 MEMBER RANSOM: Pardon?

12 MR. RAO: You turn on an active system
13 long term to bring the pressure down. That's a large
14 plot, you know. It's kind of misleading. It makes it
15 look like it keeps going on.

16 MEMBER RANSOM: Do you have a table you
17 can give to us of the volumes and the design, the
18 amount of water and GDCS in the wetwell and so forth?

19 MR. RAO: We can try to pull that
20 together.

21 MEMBER RANSOM: Yeah, I have the table.

22 CHAIRMAN WALLIS: I think it's time we put
23 an end to this. It has been a very useful overview.

24 Thank you very much. I think it has
25 helped us a great deal, and now we're going to dig

1 into the details, but first we will take a break.

2 Since we have taken so long, I think
3 everything is going to be moved up today by 45 minutes
4 or an hours. We should just plan accordingly, and we
5 should expect to be here until five or six o'clock and
6 not to finish by 4:15.

7 We will take a break now until 20 minutes
8 before 11, and I'd ask everyone to be back on time so
9 that we can start at that time.

10 (Whereupon, at 10:25 a.m., a short recess
11 was taken, reconvening in open session at 4:26 p.m.)

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1 (Whereupon, the proceedings in the
2 above-entitled matter went back on the record at 4:26
3 p.m.)

4 CHAIRMAN WALLIS: Back on the record.
5 We'll now hear from staff.

6 MS. CUBBAGE: Thank you. I'm Amy Cubbage,
7 Project manager, ESBWR pre-application review in NRR,
8 and I'm going to give a brief discussion on the scope
9 and schedule for the pre-application review. You've
10 seen this earlier today, but I just wanted to make a
11 couple of points here; one being that PRA is not
12 included in the pre-application review scope. That
13 will be addressed during the design certification
14 review. And ATWS and stability are not in the
15 current pre-application scope, but will likely be
16 added in early '04 as an addition to the pre-
17 application review.

18 And on the schedule slide, I'd just like
19 to point out that the staff has provided 317 RAIs to
20 GE at this point, and we're planning to issue
21 additional RAIs by the end of the month.

22 MR. POWERS: Do you get paid by the RAI,
23 or --

24 (Laughter.)

25 MS. CUBBAGE: Around 300. Is that better?

1 MR. POWERS: Maybe these guys can work a
2 deal and pay you more for non-RAIs.

3 MS. CUBBAGE: I'm afraid it doesn't work
4 that way.

5 MR. POWERS: Oh, all right.

6 MS. CUBBAGE: Research and NRR have
7 developed a pre-application review plan, and assembled
8 an inter-office review team. Ralph Landry has the
9 lead for the TRACG review. Muhhamad Razzaque will be
10 presenting the Tab D Scaling and Testing Review, and
11 Joe Staudemeier from Office of Research will discuss
12 the research activities associated with the SBWR. And
13 if there are no questions, I'd like to turn it over to
14 Ralph to get started.

15 CHAIRMAN WALLIS: Well, we're going to
16 have research activities later?

17 MS. CUBBAGE: Correct.

18 CHAIRMAN WALLIS: It seems as if we've
19 gone into a situation we've been in before, where
20 research comes after it's needed.

21 MS. CUBBAGE: Oh, later meaning in this
22 presentation.

23 CHAIRMAN WALLIS: No. I mean research is
24 going to be done after NRR has made some of its
25 decisions.

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1 MS. CUBBAGE: There are some activities
2 that are in direct support of the pre-application
3 review, and we'll discuss those. And then there are
4 other activities that will be in support of the design
5 certification.

6 CHAIRMAN WALLIS: But even those you're
7 going to have to hustle.

8 MS. CUBBAGE: That's right.

9 CHAIRMAN WALLIS: Okay. Sorry to stop
10 you. Go ahead, Ralph.

11 MR. LANDRY: I'm Ralph Landry from NRR,
12 Reactor Systems Branch. And this afternoon, I'm going
13 to try to get through this fairly quickly. Most of
14 the material has been touched on already, but I would
15 like to give a view of the staff over some of these
16 points. And I'm going to go through very quickly the
17 TRACG Code Review approach, who the team members are
18 involved in the review, a few of the technical issues
19 which have been raised. And on these issues, we don't
20 have answers yet. These are some of the points that
21 we've raised as concerns, and points that we've asked
22 in RAIs and are seeking to have addressed, a little
23 bit about the status of the RAIs, which Amy has just
24 mentioned, talk about some of the confirmatory
25 calculations that we have planned and that are

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1 underway, and a few of our conclusions.

2 The approach that we've taken to the
3 review of TRACG is two- pronged. One is reviewing the
4 documentation, and the second part is going to be
5 reviewing use of the code, analysis and performing of
6 confirmatory calculations.

7 Looking at the documents today, we've been
8 looking at the TRACG model description, VIA's BWR
9 application qualification, the SBWR application and
10 qualification and the input manual to the code. The
11 code documentation is fairly good. Looking at all
12 these different codes over the years, we've seen some
13 documentation that's been abysmal and that's kind.
14 We've seen some documentation that's far better.

15 The frustration we've had with this
16 documentation is the breadth of it. We began looking
17 at the model description document, which is noted as
18 Revision 2. It's the same volume that was submitted
19 for AOO reviews of TRACG. We were told that's the
20 document we're supposed to review for the model
21 description for TRACG part of this application. Well,
22 in performing that review, we found out that where's
23 all the containment stuff? This code is being used
24 for the reactor coolant system and for the
25 containment, but there was nothing in there applicable

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1 to the containment. OG said you have to back to Rev.
2 1 of the document, the SBWR version, to find the
3 containment material, so we went back to the Rev. 1 to
4 find that the containment relevant material, but it's
5 all relevant to the SBWR containment.

6 Then we said well, if we're going to look
7 at that, we have to go back and compare it to Rev. 0
8 to see what corrections were made, to see if they
9 updated as had been planned in the SBWR review. So
10 the frustration is, while we say we're looking at the
11 model description document, we're actually looking at
12 three volumes, three revisions of the same document,
13 and that material still isn't complete, and has
14 resulted in RAIs.

15 Looking at the description material, we
16 found a number of places where there are typographical
17 errors. There are equations where something as simple
18 as gravity has been left out of the equation. We
19 found in one of the figures in Section 6.6, units
20 which we have been trying to figure out what the
21 meaning of the units are. We found a figure that has
22 the units of walls per meter square per degree kelvin,
23 and we kept -- I don't know if it meant Wallises.

24 CHAIRMAN WALLIS: Watts.

25 MR. LANDRY: It meant Wallises per meter

1 squared. We have yet to figure out what a wall is, so
2 these are the kind of errors that we're finding that
3 you would expect in Rev. 2 to not see things like
4 this.

5 The analytical review has been to run the
6 TRACG code as we received it from General Electric
7 with the SBWR input model. We have their input --

8 CHAIRMAN WALLIS: Are you running their
9 code?

10 MR. LANDRY: Their code with their input
11 deck. I'll give you some results from that run later.

12
13 CHAIRMAN WALLIS: Does it run better than
14 TRACM?

15 MR. LANDRY: I'm not addressing that.
16 We've been running TRACG, looking at some analyses and
17 some test cases, and we intend to do confirmatory
18 analyses using the contained code, look at the
19 containment part of the plant design. We want to use
20 TRACM TRACE. Sometimes I use TRACM, sometimes I call
21 it TRACE. I haven't gotten used to the name change
22 yet.

23 Then we want to look at a couple code,
24 coupling TRACM with CONTAIN. We're doing this because
25 we looked at the code and said okay, they're using one

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1 code to look at the reactor coolant system and the
2 containment.

3 CHAIRMAN WALLIS: It's actually TRACE.
4 It's the predecessor of TRACG.

5 MR. LANDRY: I think this is degenerating.
6 We looked at the code and said you're using one code
7 to do both the reactor coolant system and the
8 containment as one coupled continuous calculation.
9 We're not so sure about that.

10 What we would like to do is convert the
11 TRACG deck as it stands to run in TRACM. Well, for
12 comparison, here's a code of a similar lineage, some
13 differences. What would happen running the same model
14 on both codes? Well, the TRACM has some problems with
15 some of the aspects of the containment, so we said
16 okay, we can't do that. So what we're going to do is
17 we're going to take the TRACG input deck, disassemble
18 the deck. In other words, the reactor coolant system,
19 the containment. We're going to take the containment
20 and input it to CONTAIN. We're going to run a stand-
21 alone containment model.

22 Then we're going to run the converted
23 reactor coolant system model from TRACG with TRACE,
24 and then we're going to bring those two codes
25 together, which the coupling has been done now. And

1 so far we've gotten a run out to, I think it's 120,
2 150 seconds. But a combined calculation of TRACE and
3 CONTAIN so that we can see, does the reactor coolant
4 system with a realistic containment code give a result
5 similar to the result you get with TRACG running both
6 the reactor coolant system and the containment in one
7 code. This is an approach that we're taking to these
8 confirmatory calculations.

9 MR. POWERS: When you say similar, is that
10 something that is in the eyes of the beholder? Will
11 I know it if I see it, or is there --

12 MR. LANDRY: Yes.

13 MR. POWERS: -- criterion for what
14 "similarity" means?

15 MR. LANDRY: Right now we don't have
16 criterion other than we want to see what the results
17 are first, and are there differences, and then why are
18 there differences, if we see them? And what is the
19 magnitude of the differences, and what is the
20 significance of them?

21 MR. POWERS: Take something that's easier
22 to think about like suppression pool temperatures.
23 They have very mild suppression pool temperatures in
24 their calculations they showed today. What magnitude
25 of difference would cause you pause?

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1 MR. LANDRY: At this point we haven't
2 tried to figure out exactly the magnitude of what --
3 because we're just at the very infancy stage of this
4 process.

5 MR. POWERS: I understand. But I mean
6 your experience now.

7 MR. LANDRY: Right now we're so focused on
8 trying to get this to run, that we haven't gone back
9 and said magnitudes can we tolerate.

10 MR. POWERS: Well a lot of my motivation
11 for asking this question is because it's such an
12 onerous undertaking that you -- what I would like to
13 understand, is it a matter of seeing differences of
14 say 20 degrees, or is it a matter of seeing the
15 suppression pool get up to the point that it's closing
16 in on saturation?

17 MR. LANDRY: That would give us pause.

18 MR. POWERS: That would give you pause, I
19 know.

20 MR. LANDRY: Definitely.

21 MR. POWERS: Would the other one, 10 or 20
22 degrees, give you pause?

23 MR. LANDRY: Ten to twenty probably isn't
24 going to give us a great deal of concern.

25 MR. POWERS: Okay. I understand.

1 CHAIRMAN WALLIS: Now TRACG has been run
2 a lot of times, and TRACE has hardly been run at all,
3 so really you be perhaps testing TRACE rather than
4 TRACG.

5 MR. LANDRY: Well, TRACE has been run a
6 fair amount, and we're running it with a converted
7 input model.

8 CHAIRMAN WALLIS: So it has --

9 MR. LANDRY: Plus, it's being assessed by
10 research. Research is doing a lot of work. Very vast
11 for us.

12 CHAIRMAN WALLIS: Okay. It has a history
13 of actually being able to model BWRs and so on?

14 MR. LANDRY: Yes. They're working on
15 that, and working on comparisons. You'll hear more
16 about that from Joe Staudemeier later, but they're
17 working on a lot of assessment of TRACE versus not
18 only the test that General Electric has referred to,
19 but also the --

20 CHAIRMAN WALLIS: Okay. So we will hear
21 about that.

22 MR. LANDRY: Yeah. You'll hear more about
23 that from Joe.

24 The range of the review, Amy has already
25 covered. We're looking at LOCA, ECCS and containment

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1 performance with TRACG at this point. We are not
2 looking at in the pre-application review transients,
3 ATWS or stability. Those points are going to be
4 brought up later.

5 The people involved in the review are
6 myself, Shanlai Lu, Ed Throm and Andre Drozd, all from
7 NRR. It's a combination of reactor coolant system
8 analysts and containment analysts. We have contracts
9 with Brookhaven National Laboratories, ISL and
10 Oakridge to support us in the work.

11 Research has a team together, including
12 Joe. Joe Kelly is involved in it, Steve Bajorek, Jim
13 Han. Let's see, Kodak is involved in it. Al
14 Notofrancesco is involved in it. I think Dave
15 Bessette is involved in the work, plus they have
16 contractors. So it's a fairly large group of us
17 involved in it, but very limited focus pre-application
18 review. And you have to emphasize this. This is a
19 very limited focus review at this pre- application
20 stage. It's only on the code.

21 Some of the technical issues which we've
22 raised so far, and these are all in the RAIs, we're
23 concerned with the way reactor power is handled in an
24 accident and the analysis. We see no delay in reactor
25 SCRAM. Break initiates, reactor is SCRAMed

1 instantaneously. No four to eight second delay that
2 you normally see in a SCRAM.

3 What is that going to mean for some of
4 these breaks and the amount of power? We're concerned
5 about some of the mass and energy release through the
6 break and through the ADS. We've asked questions
7 about critical flow through valves, and the way it's
8 model. Virgil has already asked that question. We're
9 not going to the point that Virgil was asking, but we
10 have asked questions in that area already.

11 We're concerned about the PCCS
12 performance, and we're studying that performance since
13 it is such a critical system. Gravity draining and
14 the interfacial heat transfer and flashing we've asked
15 questions about.

16 Some of the modeling issues that we've
17 raised, include the use of a single vessel model for
18 both the reactor coolant system and the containment.
19 This is one of the problems that TRACE has, that you
20 can't use a single vessel for this entire system.
21 We're concerned as an extension of that, with the
22 thick heat structure that's around the vessel for the
23 main steam line break LOCA.

24 They have the reactor coolant system, they
25 have a containment, and they have our heat structure

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1 this wide between the two, but that number is
2 proprietary. Well, we're trying to figure out where
3 in the world it exists in reality. We don't know. We
4 can't find it.

5 CHAIRMAN WALLIS: What do you mean by heat
6 structure?

7 MR. LANDRY: A heat sink, a heat slab,
8 something that energy is absorbed by.

9 CHAIRMAN WALLIS: You mean a slab of
10 concrete?

11 MR. LANDRY: We can't find what it is.
12 We're concerned about radio distortions in their
13 model. Gravity is distorted, and we're concerned
14 about non-condensable distribution, questions which
15 you've already raised today.

16 MR. RANSOM: How is gravity distorted?

17 MR. LANDRY: The way the friction is
18 modeling, but Shanlai. (4:42:20)

19 MR. LU: Okay. I am Shanlai Lu from the
20 DSSA. We are currently looking at gravity and
21 parameters produced and the heat remaining from a UCCS
22 LOCA. The pancake will be contained, and part of the
23 vessel in terms of delivering it all together, and use
24 it as one single TRACG vessel model, the model into
25 our system. And we are trying to look at that to see

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1 whether numerically, because if you do have let's say
2 layer 21 to lay 31, is way above the reactor vessel
3 itself. Then numerically the pool is really high.
4 You have the elevation difference between the pool and
5 the reactor vessel itself. However, we tried to use
6 the TRACG, the one component compensated this part to
7 take into account the current that the gravity failure
8 had. So what we're trying to do is trying to verify
9 this, so this is correctly done. That's what we're
10 trying to do.

11 MR. RANSOM: I guess that's quite
12 dangerous if you have any loops.

13 MR. LU: Yes. That's a reason we want to
14 look into that, because if we go back to return PFM,
15 the stage, we have disconnected the elevation of the
16 loop, and the loop closure is not closely closed then.
17 You will have a problem with gravity.

18 MR. SCHROCK: Ralph, I don't know what
19 TRACE is.

20 MR. LANDRY: TRACE is TRACM.

21 MR. SCHROCK: TRACE is TRACM.

22 MR. LANDRY: TRACM has been renamed to
23 TRACE. That's why I said, I keep going back and
24 forth, referring to TRACE or to TRACM.

25 Some of the technical issues that we've

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1 identified with the transients, even though we're not
2 reviewing the transients at this point. The incorrect
3 core design, you've heard this morning that GE talked
4 about using a nine foot core when it's actually going
5 to be a ten foot core. Well, that's true of the LOCA
6 analyses also, and we've raised the question, what are
7 the fuel design parameters for this core?

8 They were supposed to have that
9 information to us last November. We're almost to the
10 middle of July, and we have yet to see it. We have a
11 contractor waiting to generate the core parameters for
12 us when we get that data from GE.

13 We're concerned about stability, and in
14 particular, stability of a pancake core. This core is
15 shorter and larger in diameter than typical. Those of
16 us that have been involved in past reactor work in the
17 past know that when you pancake a core, you create a
18 core that is less stable than a tall thin core.

19 CHAIRMAN WALLIS: Is this from a
20 neutronics point of view?

21 MR. LANDRY: Neutronically it's less
22 stable, so we're concerned about the stability of this
23 core, since it's being pancaked.

24 We're concerned about adequate heat
25 transfer data for the fuel design. The question was

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1 raised this morning about are we getting in the same
2 situation we were in with the GE 14 data, and the
3 Drexell-14 correlation? And we've identified this
4 concern to General Electric 14 because of inadequate
5 data. They're supposed to be obtaining those data
6 this summer, but this is an extension of that problem.

7 We have over 300 RAIs outstanding at this
8 point. We've asked 317, some of them have multiple
9 points, parts to them. It's many, many pages. They
10 range from modeling issues to typos. We've had a
11 number of telecons with General Electric. We've had
12 meetings, and we're going to have an all-day meeting
13 tomorrow with them reviewing the status of some of
14 these RAIs, and their responses to them.

15 The formal RAIs are due out the 18th of
16 this month, so we're pressing to conclude our RAI set
17 so that Amy can get those RAIs issued. Those
18 responses are due in August. If we're going to meet
19 the schedule that we're on today, which is an
20 extremely aggressive schedule for this SER, there
21 cannot be any slip in getting those responses. Now
22 we've indicated that a couple of times. Any slippage
23 at all, and it's just going to be impossible to meet
24 the schedule that we're on.

25 The confirmatory calculations that we are

1 performing, as I've said already, meaning running the
2 TRACG SBWR input deck on TRACG. We're running
3 contained input model. Some of those runs have
4 already been done. Those are using mass and energy
5 data generated by TRACG, and we're generating data now
6 with TRACM, TRACE, TRACM, whichever name you want to
7 use. Input model has been developed in conjunction
8 with research, and with ISL. And I'd like to note
9 that research has done an incredible job of helping us
10 with that problem. They've put a lot of effort into
11 it, debugged the code, debugged the input model, and
12 put a great deal of effort and a great deal of support
13 into helping us with that model generation.

14 TRACE-CONTAIN linkage is underway. It has
15 been linked, and the initial runs have started, we're
16 hopeful to have some good confirmatory calculations in
17 the not too distant future.

18 This table lays out a number of the
19 calculations that we're performing. These are the
20 major blocks, of course, all the sub- calculations
21 performed. But you see the initial GDCS and main
22 steam line break calculations with TRACG we've
23 completed. We're still studying the results. We've
24 started doing some PCCS calculations with TRACG.
25 We're looking at calculations to study energy

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1 conservation in TRACG, some calculations for gravity
2 flow. The main steam line break LOCA has begun with
3 CONTAIN. Some of those calculations have been
4 performed. The TRACE-CONTAIN link has been initiated.
5 We're going to look at GDCS LOCA. The GE-12 fuel,
6 that's what I alluded to that we need the fuel
7 information. We're waiting to get the information on
8 the fuel so that we can have Oakridge National
9 Laboratory generate the fuel parameters for us.

10 AOOs are planned after we get the correct
11 fuel model, and when we start into the transient
12 review phase, and we will probably do some of those
13 calculations with a linked TRACE part, so we can get
14 the 3-D core neutronics effects into TRACE also.

15 MS. CUBBAGE: Virgil, she's trying to get
16 you to use your mic.

17 MR. SCHROCK: Excuse me. How much do you
18 know about this new reactor core? I mean, when we
19 were looking at the uprates, we learned a lot about
20 the -- were exposed to a lot of information about the
21 non-uniform --

22 MR. LANDRY: Six parameters for us, so
23 that we can do a 3-D neutronics calculation that is
24 more representative of this core. If you remember
25 when we did the AOO review on TRACG, we did a lot of

1 calculations looking at the neutronics of the TRACG
2 model versus the neutronic feedback, or neutronic
3 response running TRACB with NESTLE and with PARCS.
4 And we feel very strongly that the response to a
5 number of the AOOs is highly dependent upon the core
6 design. And we cannot do that with a core that is not
7 the right core.

8 The present core is not the core going in
9 this plant, and we will not do calculations and spend
10 our money and waste our time when we don't have the
11 right fuel design.

12 This is the result -- you saw results from
13 General Electric of GDCS LOCA earlier. This is what
14 they -- this is something that they did not show you.
15 These are results from our calculations, their code
16 their input deck, running under the same operating
17 system, same class of computer, so the results should
18 be -- they should be getting these results.

19 If you look at the GDCS pool, if you look
20 at the wet well, if you look at the difference in
21 pressures between the air spaces, this is a question
22 that Graham asked earlier. You have an airspace above
23 the GDCS pool, you have an airspace above the
24 suppression pool. They're connected by three pipes
25 that are half a meter in diameter. Why are those

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1 pressures different? We look at that and start
2 scratching our head. These are fairly new results.
3 We're scratching our head looking at it and thinking
4 first, well, maybe it's a numeric problem. And then
5 we started looking at it more and saying no, we don't
6 think it's a numeric problem. We think it's a lousy
7 modeling problem. We think it's a very poor
8 normalization problem. If we look at the
9 normalization, what we see is in the GDCS, if you look
10 at Chester's figures on his page 5, the GDCS airspace
11 pressure is not the airspace pressure. It's the
12 center of the cell pressure. It's the pressure of the
13 air plus half of the waterhead. Waterhead gives you
14 pressure of half a PSI per foot.

15 You start measuring three, four, five
16 feet, you start changing your pressure by quite a bit.
17 This problem is what happens if you don't nodalize
18 correctly, and don't pay attention to the nodalization
19 of your plant. Those two volumes should not be at
20 different pressures with three pipes that are half a
21 meter in diameter connecting them.

22 CHAIRMAN WALLIS: The code is putting
23 water in there where there is no water?

24 MR. LANDRY: No. The code is measuring
25 what is supposed to be the air -- what is being output

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1 as the airspace pressure, is not the airspace
2 pressure. It's the airspace pressure, plus the
3 pressure head from half of the water that's in that
4 volume.

5 CHAIRMAN WALLIS: Well, why would you add
6 that water pressure?

7 MR. LANDRY: Because that's where the
8 pressure is being taken at the center of the cell.
9 The center of the other cell has no water in it.

10 CHAIRMAN WALLIS: It's just not physical.

11 MR. LANDRY: Right. That's what I'm
12 saying, it's not nodalized correctly, so this is --

13 MR. FORD: Have these differences been
14 discussed with GE, and they're just a question of
15 different analysis of this, or difference in
16 communications?

17 MR. LANDRY: They didn't say anything
18 about this to us, and this -- we were looking at this
19 and trying to figure out what's going on. This is
20 just in the last couple of days that we've been
21 looking at it, and putting together what we see going
22 on.

23 MR. FORD: Well, it's really not fair to
24 castigate them when they haven't given a reply to you.

25 MR. LU: Initially -- we have been

1 corresponding to GE regarding this, and the real issue
2 here is, we were trying to see whether it
3 conservatively predicted the mass, the non-condensable
4 mass above the GDCS pool, see whether it would give
5 the conservative water level at the end of the GDCS
6 LOCA.

7 CHAIRMAN WALLIS: Anyway, what this shows
8 is that when you run their code, you can find things
9 which you have to question.

10 MR. LANDRY: That's correct.

11 CHAIRMAN WALLIS: All right. And this was
12 an example of that.

13 MR. LANDRY: That's correct.

14 CHAIRMAN WALLIS: It doesn't show that
15 this issue has been resolved in any way.

16 MR. LANDRY: Right.

17 CHAIRMAN WALLIS: It's an example of what
18 can happen.

19 MR. LANDRY: This just adds further
20 support to the staff's view that we have to have the
21 code and the input models of applicants so that we can
22 do our own confirmatory calculations, we can do our
23 own investigations. If by doing our own
24 investigations we're able to plot some parameters that
25 we weren't seeing in the submittal, when we plotted

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1 some of these parameters, we said what's going on
2 here? We don't understand this. So it's just further
3 support for the position of staff that we need the
4 codes, and we need the models so that we can do our
5 own studies.

6 MR. BANERJEE: Is that little blip a
7 vacuum breaker?

8 MR. LANDRY: I don't know what that is at
9 this point. This little spot, I'm not sure at this
10 point. We haven't gone that far. It would not be
11 changes made in the design that would challenge the
12 capability of the code.

13 MR. POWERS: A change in the core height
14 by a foot represent a pretty dramatic change?

15 MR. LANDRY: Only if there are features in
16 the fuel design that were not modeled in the fuel
17 design capability of the code. If you had a core
18 model that could not handle water rise for some
19 reason, and you designed fuel -- and you put fuel in
20 that had water rise, could you model that? Or could
21 you fix the model so that it would? The height alone,
22 I would not see how height alone would call it into
23 question, unless there was something extremely
24 restrictive in the neutronic capability of the code
25 that it could not handle that change in neutronics.

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1 Does that answer your question, Dana? Thank you.

2 CHAIRMAN WALLIS: This is a very
3 restrictive thing. We heard this big presentation
4 this morning about how wonderful this reactor was, and
5 that's irrelevant. Everything that we're looking at,
6 you're looking at here is whether on TRACG is adequate
7 for analyzing this sort of a system. This has nothing
8 to do with how good a design it may be, and all those
9 things we heard about this morning. Simply the
10 adequacy of the code which is being assessed here.

11 MR. LANDRY: That's correct, Graham. And
12 that's why I tried to say that this is such a very
13 focused review, because it is very focused. It's
14 focused very strictly on the code applicability.

15 CHAIRMAN WALLIS: Do you look at things
16 like this Ontario Hydro Test, and make your own
17 assessment of it?

18 MR. LANDRY: We're looking at the --

19 CHAIRMAN WALLIS: All these other tests?

20 MR. LANDRY: We're looking at the
21 assessment. We don't have the Ontario data, but we're
22 going to try to get that data too, to look at it
23 ourselves.

24 MS. CUBBAGE: Okay. Muhhamad.

25 CHAIRMAN WALLIS: Well, from my own

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1 perspective, I haven't had time to look at this
2 extensive documentation you referred to, Ralph. I'm
3 just a little nervous about what I may find when I do.

4 MR. POWERS: Don't look at it then.

5 CHAIRMAN WALLIS: See, that's the
6 traditional advice from the more experience ACRS
7 Member than I am.

8 MR. POWERS: No, I make that no claim as
9 good advice to you. I only say that that will ease
10 your fears.

11 CHAIRMAN WALLIS: You're being facetious,
12 I think.

13 MR. RAZZAQUE: The team that is involving
14 the review of the Tab D testing and scaling are
15 myself, Andre Drozd of NRR, and from research side we
16 have Jim Han, David Bessette, and supporting is ISL.

17 This slide I basically identified some of
18 the -- we identified some of the significant RAIs that
19 we have issued so far. Again, the number of RAIs are
20 large, and it ranges from simple typo to some
21 significant issues regarding scaling and testing. We
22 may sent some of the RAIs in detail, but this is
23 basically in the brief title sort of thing. So I'll
24 just quickly go over them, unless you have some more
25 question, and elaborate any of those.

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1 The first one is obviously one question
2 raised during the meeting, was about scaling. The
3 higher tier, two-tier scaling methodology which was
4 used for the scaling analysis requires that you use
5 both the top down and the bottom up approach. GE's
6 report heavily relied on the top down approach, but
7 very little on the bottom up, so that's the purpose of
8 that question. The particular quantitative bottom up
9 analysis --

10 MR. SCHROCK: Well, they offered some
11 preliminary, at least, reaction to that. Were you
12 here? Did you hear what they said?

13 MR. RAZZAQUE: Yes. Yes, I did.

14 MR. SCHROCK: And that isn't sufficient?

15 MR. RAZZAQUE: We'll have to -- actually,
16 I haven't seen the information that's given on SBWR
17 report. In the SBWR report, it was almost
18 non-existent, but I will have to go and review the
19 ESBWR portion and make sure that we are satisfied with
20 it. But primarily, the question was that they're
21 heavily relying on the quantitative top down approach,
22 very little on the bottom up approach. That's
23 basically a different side. It may be adequate, maybe
24 the case can remain, but that was one question.

25 CHAIRMAN WALLIS: Did you have an RAI on

1 this assumption that any doubts of LG is the same in
2 the model and the prototype?

3 MR. RAZZAQUE: Which --

4 CHAIRMAN WALLIS: It seemed to be an
5 assertion with no basis in the scaling?

6 MR. RAZZAQUE: Which?

7 CHAIRMAN WALLIS: In the condensation,
8 phase change. They had some assertion that NLG, the
9 phase change per unit area was the same in the model
10 and the prototype, and therefore, to get the same
11 mass, you had to have to scale the areas in some sort
12 of way to get the flow rates right. There doesn't
13 seem to be any basis for this assertion that the
14 condensation rate was the same in the model and the
15 prototype.

16 MR. RAZZAQUE: You're talking about the
17 PCCS?

18 CHAIRMAN WALLIS: I was talking -- just
19 the top down scaling.

20 MR. RAZZAQUE: Oh,

21 CHAIRMAN WALLIS: That seemed to be --
22 otherwise, it seemed very simple. I mean, it seems
23 that the lengths have to be the same and various
24 things. And this assertion out of the blue, that the
25 rate of phase change, the phase change flux was the

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1 same in both systems. What justification is that?
2 I'm just wondering if you have an RAI on that issue,
3 that's all.

4 MR. RAZZAQUE: I'll have to go and check.
5 I didn't -- I just picked a few for presentation.
6 I'll have to double check that. And maybe we have an
7 RAI on that. That's almost a bottom up.

8 CHAIRMAN WALLIS: It is, yeah.

9 MR. RAZZAQUE: Rather than a top down
10 issue.

11 CHAIRMAN WALLIS: What's the
12 justification?

13 MR. RAZZAQUE: Also, I think as part of
14 the -- part of the RAI indicates that linking some of
15 the phenomena that has been identified from the bottom
16 up and top down to the part, that link should also be
17 made more thoroughly.

18 The next one was the PI-Groups which is
19 the groups for the three test facilities. GE has
20 relied on these test facilities to qualify TRACG code.
21 They have indicated that. The boron mixing is for the
22 ATWS, and the criterion for the stability test. They
23 have indicated that they used those facility data to
24 qualify TRACG.

25 Now in the scaling report, or any other

1 reports that we're reviewing, I haven't seen any
2 comparison of ESBWR versus these facilities scaling
3 groups, to make sure that these facilities truly can
4 represent the ESBWR design. In other words, can be
5 scaled out, so that's another RAI. So they will have
6 to provide that information.

7 Impact of potential distortion bias due to
8 heat loss. That's another question I think raised
9 sometime during the discussion, the heat loss. And
10 that RAI is out, and particularly in GIRAFFE facility
11 I think it should be more significant compared to
12 other facilities, because some of the GIRAFFE test was
13 done at operating temperature and pressure, whereas
14 the vessel wall is thinner, so more heat loss. But as
15 Bob Gamble has indicated, they have done something
16 about that in putting micro heaters to offset that.
17 So those kind of descriptions have to be provided to
18 justify that measure taken to offset the distortion.

19 The last one on this bullet here on this
20 slide also is another test distortion-related RAI,
21 which is relatively minor as my understanding is, but
22 still it's a distortion. And the PANDA and PANTHER's
23 condensers that they have used are full scale, but the
24 number of condensers they used are fewer; therefore,
25 the head area is smaller in the test.

1 Now when you scale that up, the surface to
2 volume ratio would be less in the ESBWR; therefore,
3 less heat loss through the headers. So it will have
4 some impact on the containment pressure. And the
5 report mentioned that, but didn't quantify it, so we
6 wanted them to quantify that just to make sure.

7 MR. BANERJEE: That's for PANDA. Right?

8 MR. RAZZAQUE: That's for PANDA and
9 PANTHER.

10 MR. BANERJEE: PANTHER is a stand-alone
11 system, full scale, isn't it?

12 MR. RAZZAQUE: Yes. Both PANDA and
13 PANTHER's condensers are full scale. But since it is
14 --

15 MR. BANERJEE: PANDA is a slice, so it has
16 end walls on the headers which are potentially sources
17 of heat loss.

18 MR. RAZZAQUE: Right. Right.

19 MR. BANERJEE: PANTHER is a stand-alone
20 facility just to look at the heat transfer. So how
21 does that affect --

22 MR. RAZZAQUE: What I'm basically talking
23 about is that when they were testing the condensers,
24 the heat removal capability of the PCCS condensers,
25 they have a header, common header. In the test

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1 facility, the header volume is smaller compared to the
2 ESBWR header, because the power is less.

3 MR. BANERJEE: Certainly, for PANDA. But
4 for PANTHER, I thought it was just a full scale --
5 maybe for the SBWR it was full scale.

6 MR. RAZZAQUE: For ESBWR, yeah, it is.

7 MR. BANERJEE: SBWR.

8 MR. RAZZAQUE: SBWR maybe it is full
9 scale, but for ESBWR --

10 MR. BANERJEE: It's only a 25 percent
11 difference.

12 MR. RAZZAQUE: Yeah. The power is
13 definitely much less than the SBWR power, so they used
14 three wall condenser.

15 MR. BANERJEE: Sure. Yeah, but poor
16 condenser -- I don't get the point about the PANTHER.
17 I get the point about the PANDA.

18 MR. RAZZAQUE: Okay.

19 MR. BANERJEE: I don't know what the
20 question is there, actually, regarding PANTHER.

21 MR. RAZZAQUE: Okay. They basically
22 should be the same question. Maybe it applies more to
23 the PANDA, but the whole idea was the header being
24 small in the test compared to the ESBWR. We have a
25 scaling of the header, not the condenser.

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1 MR. SCHROCK: PANTHER was a full scale --
2 MR. RAZZAQUE: Full scale system.
3 MR. SCHROCK: -- condenser typical of
4 SBWR.

5 MR. RAZZAQUE: Right. But I think the
6 number of condensers used was fewer in the test
7 facility than the ESBWR to remove the same amount of
8 -- the higher amount of power that ESBWR has.

9 MR. SCHROCK: Is that right?

10 MR. RAZZAQUE: Isn't it? That's my
11 understanding.

12 MR. BANERJEE: It's slightly bigger.

13 MR. GAMBLE: It's a components test.

14 MR. RAZZAQUE: Yes, you have --

15 MR. GAMBLE: The header is 35 percent
16 shorter than the ESBWR.

17 MR. RAZZAQUE: Yes, that's more likely.

18 MR. GAMBLE: It's primarily a PANDA issue.

19 MR. RAZZAQUE: Okay. This more applies to
20 PANDA issue. Okay. So that's basically the question.
21 When you scale the header up, you have -- but
22 discussion with GE on that, the impact should be 5 to
23 10 percent on the peak cladding, and that was their
24 rough estimate off-hand, so it shouldn't be a big
25 effect.

1 The heat in the containment, that's the
2 other distortion question that we have, is none of the
3 testing that was done, the sole heat in the
4 containment was considered, and what impact it has on
5 the containment parameters.

6 Intuitively, of course, it will have some
7 non-conservative effect on the short term in the
8 containment pressure. And in the long term, it's not
9 very clear which direction it's going to affect,
10 conservative or non-conservative, so we wanted them to
11 have some discussion and assessment on that, effect of
12 stored heat in containment structure on the
13 containment parameters, particularly the containment
14 pressure.

15 The next RAI is reactor pressure vessel
16 containment and dynamic interaction. We know that's
17 the case in real situation in any transient accidents.
18 Whereas the scaling groups, the scaling numbers, the
19 PI numbers, those were derived based on a single
20 differential equation, first order differential
21 equation in time. And the question we're asking is
22 did you look at the system of equation, a couple of
23 system of equations in deriving the scaling groups
24 from that, and see how that affects. The case may be
25 made that a simplifying assumption is valid, but it

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1 wasn't made. The case wasn't made, so that's the
2 other question.

3 In vessel nature of circulation effect on
4 flashing. Flashing was found out to be a significant
5 phenomenon in the reactor pressure vessel, not
6 particularly an effect on the water level. What
7 impact natural circulation within the vessel heads on
8 that particular phenomenon? That's the question, and
9 Ridge Scaling Group represented that in-vessel natural
10 circulation. That was missing again, so we wanted to
11 have some understanding which scaling group represent
12 that natural circulation within vessel, and its impact
13 on flashing, because flashing is an important
14 phenomenon. Maybe it can be ignored, but it wasn't --
15 the case wasn't made.

16 Now in dimensional groups criteria range,
17 this had to do with the PI-Group numbers. The
18 PI-Group that has been derived for the test in the
19 ESBWR has been compared in the table. And as long as
20 those PI-Groups are within one part to three, it was
21 considered acceptable. But the range -- the criteria
22 they used, GE used to be acceptable is as long as the
23 PI-Group numbers are within one part to three, but no
24 basis provided where that criteria came from, where
25 that range came from, one third to three. How do you

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1 know this is acceptable?

2 MR. KRESS: Traditionally, we've been
3 using .5 to 2.

4 MR. RAZZAQUE: Five to two?

5 MR. KRESS: Point five to two.

6 MR. RAZZAQUE: Point five to two.

7 MR. KRESS: We didn't bless that. We
8 question that.

9 PARTICIPANT: I don't think they had a
10 basis --

11 MR. KRESS: No, there was no basis for it.
12 It's just -- intuition was the basis.

13 MR. POWERS: AP1000 establishes a
14 tradition.

15 MR. BANERJEE: Well, most of the scaling
16 studies end up showing there's only one or two
17 PI-Groups which are of any importance anyway.

18 MR. RAZZAQUE: In which case?

19 MR. BANERJEE: In any case, so if those
20 are such that the response of the system is similar,
21 and you can probably do that on the back of an
22 envelope, then that's probably good enough. The rest
23 of it doesn't really matter.

24 MR. RAZZAQUE: Yeah. Particularly, the
25 PI-Groups which impact the figure merit. I mean,

1 there should be some link that how the change of the
2 PI-Group impact the figure of merit, which supposedly
3 the --

4 MR. KRESS: That's the right idea.

5 MR. RAZZAQUE: Right. And there should be
6 some --

7 MR. BANERJEE: There are very few which
8 do, in fact.

9 MR. RAZZAQUE: Maybe very few, but at
10 least very few those should be done. That way it
11 gives some comfort level that you didn't just take
12 from air, and there's some link with the scaling
13 group, with the code qualability. That's the argument
14 objective.

15 MR. KRESS: We thought you could actually
16 do them analytically, just vary the parameter and see
17 what it does.

18 MR. BANERJEE: In fact, that was what was
19 done for AP600.

20 MR. RAZZAQUE: I wasn't involved with
21 AP600. I don't know what the response was.

22 MR. BANERJEE: Solution to the lump
23 parameter equations.

24 MR. RAZZAQUE: Okay. But it may be
25 possible to do some linkage with key scaling group to

1 the -- maybe here it's the water level we're talking
2 about.

3 CHAIRMAN WALLIS: Well, you can always run
4 TRACG with the model.

5 MR. RAZZAQUE: So we'll have to see how --
6 what GE responds to that.

7 CHAIRMAN WALLIS: And then you can do
8 tests with parameters. You can say okay, let's run
9 TRACG with the real scaling, and then let's run it
10 with the actual model scaling and see if it's
11 sensitive to --

12 MR. RAZZAQUE: That's right. I mean, it's
13 possible -- it's not that you have to just intuitive,
14 or without any basis. I think there can be some
15 calculation done if one wants to, about how important
16 it is, and maybe it should be important at least for
17 doing one or two.

18 MR. BANERJEE: But if they reduced the
19 master equation to one, they seem to be going in the
20 right direction. They just have to justify that and
21 show whichever is the appropriate scaling group, and
22 that's it.

23 MR. RAZZAQUE: That's basically what we're
24 saying. Maybe, as I say, the simplifying assumption
25 may be valid, but the case wasn't made.

1 CHAIRMAN WALLIS: Right. So they have to
2 show that.

3 MR. RAZZAQUE: They have to show that.

4 CHAIRMAN WALLIS: Yeah.

5 MR. RAZZAQUE: Exactly. The last bullet
6 there is really regarding the quality assurance of the
7 tests, whether the tests meet Appendix B Quality
8 Assurance that NRC has. Primarily, the test which
9 they have saved, they are using for confirmatory
10 purposes. There are a few tests - I have the name
11 here. One is PANDA P, another is SIRIUS, at the
12 facility in Japan. Those test data are being used for
13 confirmatory in nature. That's what the term appears
14 in the report, "confirmatory in nature". What exactly
15 that means? What the confirmatory in nature
16 encompasses? And if you're relying on that data to
17 qualify the code, TRACG code, or certify the design,
18 it should meet all the Appendix B requirements. What
19 you call it, confirmatory in nature or not. So that's
20 that question. That's basically, as far as the
21 scaling and the last bullet was not quite scaling. It
22 was more of an Appendix B question.

23 These pages here regarding the Tab D and
24 PARC questions. The first one is TRACG analysis for
25 the bottom drain line break. They have provided main

1 steam line break. They have also provided the gravity
2 driven line break. As far as the bottom drain line
3 break, what we're interested is in more detail, long-
4 term containment parameters. That's what was, I
5 think, missing.

6 The next bullet is TRACG comparison with
7 PANDA PCS data. That comparison was given, but mostly
8 for the containment parameters, not for the reactor
9 pressure vessel parameters, like pressure and the
10 water level. So we want to see that comparison, TRACG
11 comparison with PANDA P reactor vessel parameter
12 information, pressure and water level.

13 MR. BANERJEE: But they didn't have much
14 of a reactor vessel. Right? In PANDA, they had a
15 little thing just generating some steam. It wasn't a
16 typical reactor.

17 MR. RAZZAQUE: Yeah. Maybe they can
18 provide the pressure. I don't know.

19 MR. BANERJEE: It was -- if you look, they
20 chopped it at the bottom. Right?

21 MR. RAZZAQUE: The author of the RAI, Dr.
22 Han -- Jim, could you help me out on that, what
23 exactly you want.

24 MR. HAN: Okay. Basically, as you know,
25 the PANDA P series tests are the only tests that half

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1 the ESBWR configuration, so those tests are important
2 to us. When GE compare the certain parameters in
3 their report, the comparison is only limited to
4 containment parameters, such as drywell or wetwell
5 pressure. We would like to see in addition to those
6 parameters, like reactor pressure vessel pressure and
7 water level. PANDA does have a reactor pressure
8 vessel.

9 MR. BANERJEE: But it's short, right?

10 MR. HAN: Short, doesn't matter. We'd
11 like to know the pressure. We'd like to know the
12 water level. And in addition to that, we also would
13 like to see the comparison on suppression pool water
14 level.

15 MR. BANERJEE: Right. The reactor
16 pressure vessel is totally atypical. It has very
17 little -- I mean, it's just a generator.

18 MR. HAN: Well --

19 MR. BANERJEE: I may be wrong, but perhaps
20 General Electric could answer whether -- I thought it
21 was chopped off at the bottom.

22 MR. HAN: It's chopped off only at the
23 bottom.

24 MR. BANERJEE: Right. George Adagaramneu
25 did these tests of PANDA, and he showed me this

1 facility, and it was just a little thing.

2 MR. RAO: The reactor part -- the vessel
3 part is not representative. He didn't think there was
4 any meaningful data to be obtained from the reactor
5 vessel. It's basically a containment test.

6 MR. HAN: Well, how about the pressure,
7 for example, because you have to know the reactor
8 system pressure, what is the driving force? Which
9 right -- as you said, right on the wetwell pressure,
10 we would like to see the difference.

11 MR. RAO: It's starting at very low
12 pressure.

13 MR. HAN: I know, but we would like to see
14 the difference between the reactor pressure vessel
15 pressure --

16 MR. RAO: Okay. All right. I mean, we
17 can provide the data. It's not clear to us why, but
18 if that's what you want, we can provide it.

19 MR. RAZZAQUE: Okay. The next RAI is on
20 the TRACG agreement comparison with GIST data. The
21 question is basically, the result has been provided,
22 and the result shows that the more recent version of
23 TRACG agrees much better with GIST data than the older
24 version of the TRACG. And the question is, what are
25 the difference -- what change is there, model change,

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1 or modem change or what? We just want to understand
2 that. That is the other question.

3 The last one there is a comparison of
4 important RPV and containment parameters for
5 counterpart integral test. There are several
6 counterpart tests that was done, PANDA M-3, PANDA P-2,
7 and GIRAFFE H-1, and we want to have a comparison of
8 these tests, because these are integral tests and how
9 to compare each other would be of help because of the
10 different scale size. So that's the other information
11 that we requested from GE.

12 CHAIRMAN WALLIS: Now you have some
13 conclusions here.

14 MR. RAZZAQUE: That's the last section,
15 and --

16 CHAIRMAN WALLIS: I think we can probably
17 read those. What I want to know is, you've sent out
18 a huge number of RAIs. And have you gotten responses
19 to these RAIs?

20 MR. RAZZAQUE: No.

21 CHAIRMAN WALLIS: So all this is out there
22 waiting for response.

23 MS. CUBBAGE: In a number of cases, we
24 have discussed the questions with GE and we haven't
25 received answers in letter form.

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1 CHAIRMAN WALLIS: And you're still
2 reviewing test reports. You're going to run your own
3 runs on TRACG and so on, so at the moment, we have no
4 idea what are going to turn out to be major issues, if
5 any. We have no idea. It's far too preliminary to
6 sort of say you have identified certain key issues.

7 MS. CUBBAGE: That's right.

8 MR. RAZZAQUE: I would think the issues
9 can be in the testing area, scaling-testing area or
10 the TRACG.

11 CHAIRMAN WALLIS: But it seems to be too
12 early for the ACRS to focus on anything.

13 MR. RAZZAQUE: Anything, including the
14 testing.

15 CHAIRMAN WALLIS: All we get is a general
16 impression of activity.

17 MR. RAZZAQUE: That's true. And one of --
18 my understanding is, one of the end product that GE is
19 interested from NRC, end- product after the
20 pre-application is not just the code -- approval of
21 the TRACG code, they also want that we tell that no
22 more testing is needed. Correct?

23 MS. CUBBAGE: Basically, it would be a
24 determination on the acceptability of the test program
25 for certification.

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1 MR. RAZZAQUE: So that would be the
2 outcome of the testing review, scaling testing, that
3 those were done adequately and no more tests are
4 needed. So it's too early to say -- come to that
5 conclusion, that's for sure. Absolutely. That's
6 basically it.

7 MS. CUBBAGE: If there are no more
8 questions, we can move on to the Office of Research.

9 CHAIRMAN WALLIS: What I learned from GE
10 was that they seem to have a lot of stuff. And
11 probably they have enough stuff for you to review it.
12 There's enough stuff there, enough substance that it's
13 worthy of review.

14 MR. RAZZAQUE: Right. When the responses
15 come --

16 CHAIRMAN WALLIS: I have no impression yet
17 from your work whether or not it's good stuff, and
18 adequate stuff.

19 MR. RAZZAQUE: At this stage, it is the
20 questions we have raised.

21 CHAIRMAN WALLIS: All right.

22 MR. RAZZAQUE: Until we hear responses
23 from them, I don't think we made any conclusion at
24 this point.

25 CHAIRMAN WALLIS: Okay.

1 MR. BANERJEE: Have you identified any
2 major hole in the testing or tests at the moment, just
3 looking at this huge amount of stuff which is around,
4 is there anything that you think --

5 MR. RAZZAQUE: My gut feeling is no.
6 Basically, probably you're asking for gut feeling.

7 MR. BANERJEE: Gut feeling, yeah. That's
8 it.

9 MR. RAZZAQUE: No.

10 CHAIRMAN WALLIS: So you go through the
11 motions of hundreds of RAIs, and there's nothing
12 substantial in it?

13 MR. RAZZAQUE: Yeah, we haven't gone
14 through it. Yeah, we haven't gone through those
15 information. First of all, the information is not
16 back yet. The question is just going out. Tomorrow
17 we're going to spend going through these RAIs, whether
18 they understand what we are asking for.

19 CHAIRMAN WALLIS: I just wonder if the
20 RAIs aren't becoming too trivialized. Really, you
21 ought to be able to focus on some things that really
22 matter. You've got hundreds of them. How do we know
23 which of them matter? How do they know which of them
24 matter? Maybe there needs to be a prioritization or
25 something of these RAIs.

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1 MR. RAZZAQUE: We write significant RAIs.
2 We do some prioritization.

3 MS. CUBBAGE: Well, I think today Muhhamad
4 has tried to highlight some of the more significant in
5 his mind questions.

6 MR. RAZZAQUE: Yeah.

7 MS. CUBBAGE: And, you know, I don't think
8 he's trying to say that GE won't be able to respond to
9 these questions. We just haven't been able to review
10 the responses at this time.

11 MR. RAZZAQUE: Right. But sake of
12 completeness, at least, they have to respond to these
13 kind of questions. As I said, from the up front, it
14 looks like there is no major holes or gaps, unless the
15 response we get is completely out of the way and that
16 we didn't expect.

17 CHAIRMAN WALLIS: Okay.

18 MS. CUBBAGE: Okay?

19 CHAIRMAN WALLIS: Move on.

20 MS. CUBBAGE: Joe.

21 CHAIRMAN WALLIS: Thank you very much.

22 MR. STAUDEMEIER: I'm Joe Staudemeier from
23 the Office of Research. I'm going to give you an
24 overview of the things we're working on in Research
25 related to ESBWR.

1 The focus of our Confirmatory Research
2 Program is to provide assessed independent analysis
3 tools to NRR to support the ESBWR design
4 certification, and primarily, its codes that we're
5 going to be providing to NRR that'll be qualified to
6 work and analyze ESBWR. We're also providing
7 assistance to NRR for the ESBWR pre- application
8 review in support of the code, and testing and scaling
9 review.

10 Right now in the pre-application stage,
11 we're providing support and reviewing the scaling
12 testing and TAPD PARC documents. Many of the RAIs
13 have come from the Office of Research reviewers, and
14 we're also demonstrating a proof of principle on
15 developing a coupling between TRACE and CONTAIN, so
16 that they can analyze some ESBWR accident scenarios.

17 MR. KRESS: Does GE have to pay for that,
18 or is that something that --

19 MR. STAUDEMEIER: No, that infrastructure,
20 considered infrastructure work. They have to pay for
21 the review of the documents. We're acting essentially
22 like a contractor, and that's directly fee billable,
23 but code development is considered infrastructure
24 work.

25 The work that will apply to the design

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1 certification stage is some TRACE code development
2 that I'll go over on later slides. Code assessment to
3 show that it's applicable to the accidents that they
4 want to use it for.

5 We're going to do a -- right now,
6 actually, we're doing a PUMA ESBWR Scaling Study,
7 which will look at how well PUMA can seemingly -- or
8 how well PUMA is as a scale facility for ESBWR
9 testing. We're going to be doing some PUMA testing
10 and some --

11 CHAIRMAN WALLIS: All this is in the
12 future, and we have not -- you have not yet done the
13 PUMA Scaling study?

14 MR. STAUDEMEIER: That's going on right
15 now.

16 CHAIRMAN WALLIS: Have not yet shown that
17 PUMA is a suitable facility for doing this testing,
18 have not done any testing. So all this is sort of way
19 in the future.

20 MR. STAUDEMEIER: Not too far off in the
21 future.

22 CHAIRMAN WALLIS: But it may turn out to
23 be not a very good idea to do testing at PUMA.

24 MR. STAUDEMEIER: And if we -- if the
25 scaling study says that, that its either not a good

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1 idea, or that area extensive modifications are made,
2 what we'll have to do is look at the results of the
3 scaling study.

4 CHAIRMAN WALLIS: Are you doing these
5 tests because you think the GE tests are inadequate?
6 If the PUMA test is a poor version of a GE test,
7 there's no sense in doing it, is there? If it's a
8 better test in some way --

9 MR. STAUDEMEIER: I mean, we believe it's
10 a better test in several ways, but --

11 CHAIRMAN WALLIS: So you're going to show
12 that, or you expect to be able to show that.

13 MR. STAUDEMEIER: We expect to be able to
14 show that, and it also gives us some independent data
15 of the code assessment.

16 MR. BANERJEE: Were you involved in the
17 PANDA data? I mean, was NRC a participant in those
18 tests?

19 MR. STAUDEMEIER: No.

20 CHAIRMAN WALLIS: I thought they said that
21 you were.

22 MS. CUBBAGE: In a reviewer standpoint,
23 not as a participant.

24 MR. STAUDEMEIER: Yeah. Previous PANDA
25 tests, I think there were NRC observers at some of the

1 tests, and I think they reviewed the QA Program, and
2 probably provided RAIs on the test, but I wasn't
3 involved in reviewing the PANDA tests back then, so
4 I'm not sure what the total involvement was.

5 MR. RAO: Yes. The NRC also participated
6 in applying test matrix, and reviewing the test, and
7 providing oversight.

8 MR. BANERJEE: That was in the M-series.
9 Right? Also, in the P-Series?

10 MR. STAUDEMEIER: Only M-Series.

11 MR. BANERJEE: Only M-Series.

12 MR. STAUDEMEIER: Yeah. P-Series came
13 after the SBWR review.

14 CHAIRMAN WALLIS: PUMA doesn't satisfy the
15 scaling criteria set out by GE, does it?

16 MR. STAUDEMEIER: I don't know what --

17 CHAIRMAN WALLIS: I don't think it does.
18 When they say you've got to duplicate links and
19 things, and I don't think it duplicates links very
20 well.

21 MR. STAUDEMEIER: Well, it's not a full
22 high scale facility. Yeah, that's --

23 CHAIRMAN WALLIS: So you're not going to
24 be well scaled according to their PI-Groups.

25 MR. STAUDEMEIER: Well, I don't think

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1 scaling -- I don't think only full height facilities
2 can be well scaled facilities. It depends on what
3 phenomena you're looking at. And, for instance, PUMA,
4 since it's quarter height and twice the power, time
5 runs twice as fast in PUMA.

6 CHAIRMAN WALLIS: Particularly for
7 gravitational driven things. You need to -- usually
8 you need to have the right height.

9 MR. KRESS: It's height versus --

10 CHAIRMAN WALLIS: Height versus resistance
11 and everything, and scaling sort of drives you to full
12 height.

13 MR. STAUDEMEIER: Well, if you want time
14 preserved it's full height.

15 MR. BANERJEE: Well, it's a major problem,
16 and you'd have to justify a reduced height facility
17 very, very carefully.

18 MR. STAUDEMEIER: Things become more
19 sensitive because DPs become scaled by DP over 4,
20 essentially.

21 MR. BANERJEE: It's hell, actually. So
22 we'll see this --

23 MR. STAUDEMEIER: It's been done before.
24 OSU was a problem that was sensitive like that.

25 MR. BANERJEE: It's very sensitive, and

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1 for a large number of the tests, they're not very
2 useful. I mean, for long term cooling, it's a
3 different matter. This was shown in the AP600 study,
4 as well. It's documented.

5 MR. STAUDEMEIER: But you'll have access
6 to the scaling study, and access to a presentation on
7 it in the future, if you want to.

8 MR. SCHROCK: What is the status of your
9 documentation on TRACE?

10 MR. STAUDEMEIER: TRACE documentation is
11 still in draft. I think everything is still pretty
12 much in draft form. It's fairly complete because it's
13 based mainly on TRAC documentation. Some of the
14 things aren't documented at all, like features that
15 have been added to be able to run RELAP decks, and the
16 code architecture isn't fully documented. The
17 programmer's manual isn't current. But in terms of
18 theory manual, like models and correlations, that's
19 fairly accurate. Input manual is accurate, even
20 though it's in draft form.

21 MR. SCHROCK: I can remember four or five
22 years ago, discussions developing on TRACM, and the
23 advice given would be useful if ACRS could see some
24 documentation on what's happening here, so it can
25 advise while it's happening, rather than when it's

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1 accomplished. Then we got a batch of documentation
2 that look like recycled dose elements reports. That's
3 all I've ever seen. Is there more than that?

4 MR. STAUDEMEIER: There is some fresh
5 documentation. I'd say a lot of it is still based on
6 Los Alamos reports, but I think you're probably going
7 to be getting to review that sometime in the near
8 future, the documentation. I'm not sure what the
9 latest schedule is to finalize documentation, but it's
10 certainly not before the end of this year.

11 CHAIRMAN WALLIS: So this is not a fee
12 billable thing. This whole PUMA thing is public
13 money.

14 MR. STAUDEMEIER: Yes. And I think the
15 distinction that makes it fee billable or not is if
16 NRR said they needed this test facility to certify the
17 ESBWR design, it would be fee billable, but that's not
18 the case.

19 CHAIRMAN WALLIS: I'm just wondering if
20 this is a well thought out thing to do, to run PUMA.
21 I don't know, because we haven't had a chance to
22 review it. I just wonder if at this stage it's the
23 right thing to do. There's all this other data out
24 there that GE has taken. I would think you'd want to
25 get the most out of that first, and see if there are

1 any gaps in it. Is PUMA filling some identified gaps
2 in the database?

3 MR. STAUDEMEIER: I don't think there's
4 been enough review of all the data yet to determine
5 that. There are some preliminary tests --

6 CHAIRMAN WALLIS: Maybe it's an attempt to
7 keep PUMA alive somehow.

8 MR. STAUDEMEIER: I'm not the person to
9 ask that.

10 CHAIRMAN WALLIS: Maybe in our research
11 report we can look at this carefully.

12 MR. STAUDEMEIER: That's, I guess -- it
13 may be something you want to review, is the PUMA
14 program and what it is.

15 CHAIRMAN WALLIS: I just don't want us to
16 have to come down in a negative way about it. I just
17 want to be sure that you know what you're doing. I
18 don't want to be negative about it, after we've had
19 enough to know, because at the moment, I just feel
20 uncertain.

21 MR. STAUDEMEIER: Okay. Well, I'll go
22 over a little bit about preliminary testing program,
23 and the scaling that's going on.

24 CHAIRMAN WALLIS: I don't know if you need
25 to do it now, but maybe -- go ahead. I'm sorry.

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1 MR. STAUDEMEIER: And we're starting up
2 some work on severe accident analysis. Right now
3 we're just looking at developing MELCOR input and the
4 actual analysis won't come for quite a while.

5 Okay. Right now we're providing technical
6 assistance and review of the scaling testing in PIRT
7 reports, and eventually we'll be providing a technical
8 evaluation report on the documents that NRR will use
9 in their safety evaluation.

10 CHAIRMAN WALLIS: This is all just
11 beginning too?

12 MR. STAUDEMEIER: Actually, it began a few
13 months ago. The RAIs are the first product of the
14 review.

15 CHAIRMAN WALLIS: So ISL has identified
16 some things that are worth following up?

17 MR. STAUDEMEIER: The ISL which is --
18 Marcos Ortiz is the person from ISL reviewing the
19 information. Marino DiMarzo from Research, Jim Han
20 from Research, and Dave Bessette from Research has all
21 contributed RAIs on those documents. So the status of
22 that is RAIs will be completed for testing reports in
23 the near future. They are already complete for
24 scaling and TAPD PIRT reports, and TERS are scheduled
25 to be completed in the fall, presuming that GE answers

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1 all the RAIs by then, and we come to closure on
2 issues.

3 The TRACE/CONTAIN coupling for ESBWR
4 calculations, TRACE is capable of modeling the ESBWR
5 reactor vessel and phenomena that go on in there.
6 It's not adequate for modeling the ESBWR containment
7 because of some reasons I'll get into it a little bit.

8 CHAIRMAN WALLIS: TRACE has not yet
9 modeled the ESBWR vessel.

10 MR. STAUDEMEIER: There is a TRACE model
11 of the ESBWR.

12 CHAIRMAN WALLIS: It has run?

13 MR. STAUDEMEIER: Yes. It'll run to
14 steady-state. I don't know if it's been run to
15 blow-down yet, but I'm not sure of the current status
16 of that.

17 CHAIRMAN WALLIS: But you're asserting
18 it's capable. That's a statement of faith, isn't it?

19 MR. STAUDEMEIER: Yeah. I mean, an ESBWR
20 vessel will blow-down like a regular BWR vessel, and
21 I know it can do a regular BWR vessel blow-down.

22 CHAIRMAN WALLIS: So it should be capable
23 based on its past performance.

24 MR. STAUDEMEIER: Yes. Okay. We have
25 CONTAIN which is capable of modeling ESBWR

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1 containment, because there was some work put into that
2 factor in the SBWR review to give it modeling
3 capabilities for SBWR. One of the things that's been
4 done to TRAC to make it into TRACE is to build-in this
5 coupling capability to other codes that we call the
6 exterior communications interface. And it's a
7 communications protocol between TRACE, and you can
8 build it into other codes so that the other codes can
9 request information from TRACE, and send information
10 back to TRACE, so that they can run in a parallel
11 mode.

12 And we've recently modified CONTAIN to
13 support the ECI so that it can run coupled
14 calculations of TRACE. We'll be modeling the ESBWR
15 vessel in TRACE, and model the containment in CONTAIN.
16 There is a CONTAIN model built, and the codes will run
17 in parallel, and communicate through the ECI. And
18 some preliminary calculations that are showing proof
19 of principle have been run.

20 CHAIRMAN WALLIS: This is reasonably
21 efficient and doesn't need an enormous amount of time
22 while they're communicating to each other?

23 MR. STAUDEMEIER: The communication time
24 is probably significant for the time it takes for a
25 CONTAIN time slip. I mean, essentially you're running

1 CONTAIN for free, I think, compared to TRACE, the
2 amount of computational time for time steps, because
3 CONTAIN is just a small number of coupled ODEs.
4 Whereas, the TRACE model has many volumes.

5 MR. POWERS: CONTAIN was going like a bat
6 out of hell compared to TRACE.

7 MR. STAUDEMEIER: Yeah. Coupling points
8 and modeling, but hopefully we'll get those things all
9 worked out in the future, and we'll get something that
10 runs reliably and stable. The time step control in
11 CONTAIN is fairly primitive compared to TRACE, and we
12 think that TRACE would be the limiting time step in
13 the calculation, but it turns out CONTAIN is what's
14 limiting the time step.

15 MR. BANERJEE: Is the coupling point
16 mainly the break, or are there other --

17 MR. STAUDEMEIER: There's several coupling
18 points. The break is one of them. SRVs going into
19 the suppression pool. There's pressure coupling
20 points at the top of the GDCS, so there's quite a
21 number of them.

22 Okay. The TRACE code development going
23 on, recently some work was completed to add the
24 capability to model advanced BWR fuel designs to both
25 TRACE and PARCS. PARCS is the 3-d kinetics code that

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1 also runs in a coupled mode with TRACE for doing
2 coupled thermohydraulic reactor kinetics calculations.

3 CHAIRMAN WALLIS: These are lousy
4 projectory things. I mean, the corners are almost
5 invisible, unless there's something wrong with my
6 eyes. I have to read the paper.

7 MS. CUBBAGE: I don't know if it's the
8 font or if it's the projector.

9 CHAIRMAN WALLIS: Well, you've got to fix
10 that somehow. It's gets dark and fuzzy in the
11 corners, and brights and shiny in the middle. I don't
12 know what it is, but it's lousy.

13 MR. POWERS: Getting cranky in your old
14 age here?

15 CHAIRMAN WALLIS: I'm trying to compete
16 with my colleague on my left.

17 (Laughter.)

18 MR. POWERS: Don't do that. He's a past
19 master.

20 MR. STAUEMEIER: Additionally, some
21 things are going to be added to TRACE in the future
22 that will allow it to better model coupled reactor
23 containment problems, such as ESBWR. And the two main
24 tasks that should help that out is to improve the
25 steam air condensation modeling for the PCCS, ICS, and

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1 the --

2 CHAIRMAN WALLIS: So when is the NRR going
3 to say that TRACG is okay for use with ESBWR? Isn't
4 it before all this has happened?

5 MR. STAUDEMEIER: This isn't going to
6 support the --

7 CHAIRMAN WALLIS: What is it supporting?

8 MR. STAUDEMEIER: The design certification
9 reviews.

10 CHAIRMAN WALLIS: So you're looking way
11 ahead.

12 MR. STAUDEMEIER: Right.

13 MR. LANDRY: Graham, Ralph Landry from
14 NRR. The TRACG review is going to be completed before
15 this is done, you're correct. At least that's our
16 anticipation. The work that is being done with TRACE
17 is in support of the design certification of the
18 plant. We are doing some calculations using CONTAIN
19 with TRACE currently, as part of our confirmatory
20 calculations, but those are not what we are basing
21 approval of TRACG on.

22 CHAIRMAN WALLIS: It would be rather
23 embarrassing if you approve TRACG, and then these guys
24 come up with different calculations a year from now
25 which show that the whole approval was in question.

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1 MR. LANDRY: That's always a possibility,
2 but you have to be able to, at that point, show which
3 code is actually correct then. And the way you do
4 that is by assessment against test data. If the code
5 is assessed against test data and shown to adequately
6 represent the test data, then it's hard to discount
7 it.

8 MR. SCHROCK: You're starting with the
9 assumption that one of them is correct.

10 (Laughter.)

11 MR. LANDRY: Thank you, Virgil.

12 CHAIRMAN WALLIS: Also, that the test data
13 is correct.

14 MR. SCHROCK: Or relevant.

15 CHAIRMAN WALLIS: Or well scaled.

16 MR. STAUDEMEIER: The tube condensation
17 model is going to be based on some work Joe Kelly did
18 back for actually SBWR, that was originally going to
19 be implemented into RELAP-5, and never got implemented
20 when the SBWR review was cut off, so the tube
21 condensation work is in a fairly advanced state, even
22 though it's just started. It's not like he's starting
23 from scratch. There's been many of the correlations
24 that have been developed already, and just need to be
25 implemented into the code.

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1 We also need to change the energy equation
2 to an enthalpy-based formulation to improve energy
3 conservation and flows across junctions with large
4 pressure differences. The difference in scheme in
5 TRAC right now with the energy equation, the work
6 term, PV work term is not treated very well. And
7 changing to the enthalpy formulation will give a
8 correct treatment of that, and give the right energy
9 deposition into the containment. We're keeping the
10 solution variables in the code the same. It's just
11 changing the equation that's being sought.

12 The containment-related code modifications
13 have just started. The condensation work is scheduled
14 to be completed by the end of September, and the
15 energy equation work should be completed by the end of
16 January next year.

17 MR. BANERJEE: Let me ask you a question.
18 A lot of this chimney stuff that the way TRACG is
19 handling it is backing it out of the drift flux-type
20 formulation, which is what anybody would do. How is
21 this handled in TRACE, the same way?

22 MR. STAUDEMEIER: Well, TRACE has a
23 different correlations package. It's actually --
24 TRACB has a correlations package that's very similar
25 to GE's.

1 MR. BANERJEE: Right.

2 MR. STAUEMEIER: The TRACE correlations
3 package currently is based on the TRAC correlations
4 package, so the DRAG correlations have a different
5 basis. I'm not sure -- they not based on drift flux
6 correlations though.

7 MR. BANERJEE: That's what I thought, so
8 how do you expect to handle level swell, because it's
9 not easy to do with the sort of fluid model unless you
10 back it out of the drift flux correlation.

11 MR. STAUEMEIER: Well, we'll do a code
12 assessment against some level swell experiments and
13 see how well it predicts it.

14 MR. BANERJEE: Okay. That hasn't been
15 done yet.

16 MR. STAUEMEIER: I think there's been
17 some preliminary assessment done. I'm not sure what
18 the results of that were, but that will be looked at
19 and see if it's adequate or not.

20 MR. BANERJEE: Right.

21 MR. STAUEMEIER: I guess one option is to
22 put an option in to use the TRAC BWR correlations
23 package in TRACE.

24 MR. BANERJEE: Right. It's notoriously
25 difficult to get it right if you don't back it out of

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1 drift flux. That's the reason they went that way.

2 MR. STAUDEMEIER: Well, I guess the only
3 data really available is steady state data, and for
4 that, the drift flux is just as good as --

5 MR. BANERJEE: Yeah, better.

6 MR. STAUDEMEIER: Okay. The TRACE code
7 assessment, right here I just have documented some of
8 the ESBWR-specific tests that we're going to be
9 looking at. But in addition to that, there will be
10 basic void fraction assessment and things like level
11 swell assessment that are also important calculations.

12 For the integral tests, we're going to
13 look at PUMA and PANDA data. The PANDA series is the
14 latest PANDA series, ESBWR PANDA series. We're
15 developing an input deck from information that came
16 out of an international standard problem that was
17 performed with some of the PANDA P-Series data.

18 MR. POWERS: Which problem was that?

19 MR. STAUDEMEIER: I'm not sure what the
20 number is.

21 MR. POWERS: In the 40s or the 30s?

22 MR. STAUDEMEIER: Forties again, but we
23 can get you a copy of the documentation, if you're
24 interested.

25 MR. POWERS: It would be useful.

1 MR. STAUDEMEIER: And the PUMA data, we're
2 going to be looking at the data that was already taken
3 back in the SBWR days, so that's existing. Purdue has
4 developed a TRACE stand-alone model that everything is
5 modeled in TRACE and is run through a main steam line
6 break calculation. There are some code deficiencies
7 that were identified, but it made it through to 7,000
8 seconds under a main steam line break calculation,
9 which is equivalent to 14,000 seconds of reactor time
10 essentially, so it made it pretty far into the
11 transient.

12 In terms of PUMA, there's some small
13 modifications to PUMA that are being made right now.
14 The GDCS is going to be connect -- is in the process
15 of being connected to the wetwell, and it actually may
16 already be connected as we speak. And some integral
17 tests are going to be run to see what the differences
18 just from that change between GDCS connected to the
19 drywell, and GDCS connected to the wetwell, to see
20 that the code can predict the differences between
21 those two different configurations.

22 There are some separate effects tests that
23 will also be run in PUMA, which are some condensation
24 tests that have been identified for tube condensation,
25 and also condensation in the wetwell, and that will be

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1 used to assess the condensation models that Joe Kelly
2 is going to be developing for TRACE. In addition to
3 the PUMA data, we'll also look at some other
4 condensation tests.

5 The status of that is the PUMA stand-alone
6 TRACE model has been run, code deficiencies have been
7 identified, and we'll look at resolving them in the
8 near future.

9 CHAIRMAN WALLIS: Was it run successfully?

10 MR. STAUDEMEIER: Well, it ran
11 successfully without crashing, I guess if that's what
12 you term "success". Some of the parameters that have
13 been predicted were not predicted so well. They
14 predicted GDCS injection to start too early. The GDCS
15 flow rate, they compared fairly well. Some things
16 compared fairly well, some things didn't compare that
17 well, which the new condensation models I think will
18 greatly improve code results.

19 MR. BANERJEE: Did it get the pressures
20 right?

21 MR. STAUDEMEIER: No. It over-predicted
22 the drywell pressure, and under-predicted the wetwell
23 pressure.

24 CHAIRMAN WALLIS: So you're now going to
25 tune TRACE to the PUMA test?

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1 MR. STAUDEMEIER: No, it's not going to be
2 tuned. I mean, the condensation models are going to
3 go independently of the PUMA tests. They'll be run
4 after the condensation models are implemented, but we
5 don't tune or adjust code results based on integral
6 test data.

7 Okay. There's a PANDA TRACE model that's
8 being developed right now in-house based on the
9 information from the International Standard Problem.
10 And there will also be coupled TRACE/CONTAIN decks for
11 both PUMA and PANDA that are going to be developed to
12 show that the coupling works, and that the coupled
13 calculations are giving good results.

14 Okay. Right now there's a PUMA ESBWR
15 scaling study going on out at Purdue for --

16 CHAIRMAN WALLIS: How long does TRACE take
17 to run compared with TRACG to solve the same problem?

18 MR. STAUDEMEIER: I don't know how long
19 TRACG takes to run on a given platform. I'd need to
20 know how long it takes to run -- Shanlai probably has
21 more experience.

22 MR. LU: The TRACG to run 72 hours, main
23 steam line break case. It takes about four days on
24 RVMS machine. But you tell transit in 72 hours. It's
25 very good in terms of running the TRACG. Right before

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1 the GDSC line break, look like it's very short. It's
2 a couple of hours, so that's TRACG code. TRACE code
3 right now in steady state, we reach very good steady
4 state code, 120 seconds right now we ran.

5 CHAIRMAN WALLIS: Steady state is really
6 of no interest.

7 MR. LU: Right. Well, that -- I'm talking
8 about the 120 seconds into the main steam line LOCA
9 case. It takes about 2 hours. Okay. But right now,
10 the --

11 CHAIRMAN WALLIS: It's comparable with
12 TRACG.

13 MR. LU: It's hard to compare because we
14 are running on a different platform.

15 CHAIRMAN WALLIS: You're running on Octave
16 platform?

17 MR. LU: The TRACE and the CONTAIN is
18 running on PCs, Pentium 4 and a bigger CPU. Whether
19 the NRR VMS is --

20 MR. STAUDEMEIER: Yeah, the machines that
21 TRACE runs on are quite a bit faster than the machine
22 that they have TRACG running on because that's quite
23 an old machine.

24 I believe the PUMA calculation to run out
25 to 7,000 seconds took on the order of one and a half

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1 days to two days, and that was on some kind of Pentium
2 4 that's about two gigahertz. But a lot of that time,
3 the code was bogged down with condensation
4 oscillations because of the bad condensation model in
5 the code. And I think the run time should improve
6 greatly when the condensation model gets fixed.

7 CHAIRMAN WALLIS: So 59 runs would take
8 half a year?

9 MR. STAUEMEIER: No, not -- I mean, we
10 have quite a few machines that we could run them on at
11 the same time.

12 (Laughter.)

13 CHAIRMAN WALLIS: Take 59 machines, right?

14 MR. ROSENTHAL: Excuse me. This is Jack
15 Rosenthal, Branch Chief in SMSMP. You know, it's --
16 we will be releasing production, a release version of
17 TRACE in the fall. And right now what you're doing is
18 you're comparing times on a beta version of the code.
19 And as we fix the physics in the code, we expect to
20 gain some run time speed, so it's just not a good
21 comparison. Measure us in the fall.

22 MR. STAUEMEIER: Okay.

23 CHAIRMAN WALLIS: So this is a simplified
24 BWR. There's nothing simplified about modeling it
25 with the code. It's still just as complicated, and

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1 takes as long.

2 MR. STAUDEMEIER: Probably longer right
3 now because the code was never really made to do all
4 the condensation at low pressure with non-condensibles
5 that it needs to do for the ESBWR model.

6 Okay. The scaling study, PUMA was
7 designed to a scaled SBWR integral test facility, and
8 it's scaled pretty well for that using inching
9 scaling. The ESBWR containment differs from the SBWR
10 containment topologically. The GDCS is now in the
11 wetwell, previously it was in the drywell. And in the
12 non-dimensional scaling ratios, like power to volume
13 and things like that are different things.

14 CHAIRMAN WALLIS: So the scaling basis is
15 very much like the APEX scaling basis, isn't it? APEX
16 is to AP600 about what PUMA is to SBWR.

17 MR. STAUDEMEIER: Yeah. Both core height,
18 both facilities were designed to look at long-term
19 cooling phase of the accident. APEX wasn't full
20 pressure. It was a reduced pressure. PUMA is full
21 pressure, and it's designed to pick up the transient
22 partway into it. It picks up from the late blow-down
23 phase, but from then on, it's a full pressure
24 facility. And time runs twice as fast, I think, in
25 both facilities. So the scaling study should be

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1 completed by the end of August. We'll evaluate the
2 scaling distortions that exist in the present
3 facility. If the scaling distortions aren't great,
4 then maybe the tests we're running now with just a
5 limited modification connecting the GDCS to the
6 wetwell instead of the drywell will be data that's
7 good enough.

8 If there's great scaling distortions, we'd
9 have to look at the modifications necessary to make
10 PUMA a well scaled ESBWR test facility, and decide
11 whether it's worth it to make those modifications and
12 do additional testing at that time. That decision
13 will be coming sometime in the fall, on what
14 modifications would be made, what impact they would
15 have on the tests, and whether to make --

16 CHAIRMAN WALLIS: So this facility and
17 this plan was not designed to answer specific
18 questions. It seems to be just sort of a catch-all,
19 where you want it and then you use it in ways yet to
20 be determined.

21 MR. STAUDEMEIER: Well, it's to look at
22 integral system response and provide data for the
23 codes that's representative of things that go on the
24 SBWR.

25 CHAIRMAN WALLIS: It's a very general kind

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1 of purpose.

2 MR. STAUDEMEIER: Right. It's more --

3 CHAIRMAN WALLIS: In other words, if
4 you're focusing on certain key questions which have
5 been identified --

6 MR. STAUDEMEIER: Well, passive heat
7 removal and system interactions between the various
8 places due to passive heat removal, I guess is the
9 main thing that the facility is looking at to make
10 sure there is no, I guess, surprises that pop up which
11 -- and also, to look at the whole transient from near
12 the beginning all the way through long-term cooling,
13 which it's -- I guess that's the one thing that makes
14 it unique compared to the other facilities, is it
15 covers a longer range of time in the accident.

16 Okay. PUMA confirmatory testing.
17 Currently right now, the old PUMA test data is being
18 used for TRACE/CONTAIN code assessment. Modifications
19 are underway to connect the GDCS change to the
20 wetwell, and the same tests will be run in that
21 configuration to examine the differences in the
22 facility response between the two different
23 configurations, and see that the code can predict the
24 difference in the two different configurations. Other
25 than the connections, the tests will be run in as

1 identical a manner as possible.

2 As I said, additional modifications may be
3 needed or identified based on the outcome of the
4 scaling study, which should be available at the end of
5 August. And also, the separate effects tests will be
6 used to study tube and suppression pool condensation.
7 It will be used as additional data for code assessment
8 of the condensation models that Joe Kelly is going to
9 be putting in the code.

10 The integral testing with this limited
11 modification is planned to start in August. Separate
12 effects testing is planned to start in September, and
13 a decision on additional facility modifications and
14 testing will be made in the fall after we get the
15 results of the scaling study, and do some sort of cost
16 benefit study on the outcome of that.

17 MR. ROSENTHAL: Do you expect --

18 MR. BANERJEE: Before we get on to --

19 MR. ROSENTHAL: Oh, I'm sorry.

20 MR. BANERJEE: I was just going to ask
21 you, the SBWR and PUMA were scaled, if you agree with
22 the scaling methodology they were scaled. And then
23 the ESBWR is just double the power or something
24 roughly, and volume. So why do you expect such a big
25 difference in the scaling between the two?

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1 MR. STAUDEMEIER: Well, the volumes aren't
2 scale. Like you double the power, but the drywell
3 volume isn't doubled, or the wetwell volume isn't
4 doubled. So actually, I think the first look at it
5 looks like you would have to remove volume in the
6 wetwell from PUMA, which would mean putting maybe --
7 I think one idea was putting hollow steel balls in
8 there or something to take up some of the volume.

9 MR. BANERJEE: Yeah, I remember now,
10 because the PANDA P-Series was different from the
11 M-Series. The volumes were all adjusted, so that's
12 what -- that's the main difference.

13 MR. STAUDEMEIER: Right.

14 MR. BANERJEE: Okay.

15 MR. ROSENTHAL: Before we get into just
16 the one slide on severe accident, if we try to look
17 into the future some months or a year or so, one could
18 anticipate that the real issues, or that there will be
19 issues on the SBWR concerning stability, neutron
20 thermohydraulic stability, and ATWS and stability
21 behavior during the course of an ATWS. And in
22 anticipation of that, what you want is a code that
23 couples neutronics and thermohydraulics in the
24 containment, and so that's the PARCS, TRACE/CONTAIN
25 coupling, will give us the tool to independently

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1 assess. I anticipate there'll be questions a year
2 from now.

3 Similarly, we did do some work with PUMA
4 and we're about to publish results of some stability
5 tests where, you know, they're electrically heated
6 rods, and we changed the heat flux just using
7 controllers, but did get some stability tests which
8 allow us to benchmark the code. And so it is
9 reasonable to anticipate that PUMA may play a role a
10 year from now in answering questions concerning
11 stability, so stability during the course of an ATWS
12 is of particular interest to me. But, of course,
13 that's what I've just said, trying to anticipate the
14 future is somewhat speculative, and I think that Joe
15 is absolutely right, you know, in saying we'll do the
16 scaling analysis. We'll do the analysis, and if it
17 makes sense, we'll run the facility. And if it
18 doesn't make sense, we won't do it.

19 MR. STAUDEMEIER: Stability experiments in
20 PUMA are the type of experiments that we looked at in
21 pre-EPRI, which is the flashing instability, with the
22 flashing in the chimney region. It's not density wave
23 instabilities.

24 CHAIRMAN WALLIS: That's dependent on the
25 balance between gravity and pressure, so how do you do

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1 this in a system which isn't full height? Do you run
2 it at --

3 MR. STAUDEMEIER: Well, you have to look
4 at your scaling groups and what they tell you about --
5 excuse me?

6 CHAIRMAN WALLIS: Run it at pressure below
7 the pressure that's actually anticipated in the SBWR?

8 MR. STAUDEMEIER: Well, it'll flash at --
9 I mean, the elevation where it flashes will be lower.
10 So as I said, the Dps are scaled by a quarter, so that
11 this pressure is full scale, but Dps are scaled by
12 quarter height, so the --

13 CHAIRMAN WALLIS: Well, I don't know if
14 that works out.

15 MR. STAUDEMEIER: You have to look at the
16 scaling --

17 MR. BANERJEE: Yeah. If you want to do
18 that, the modification needed is make it full height.

19 MR. STAUDEMEIER: Right. But I mean, you
20 get non-dimensional equations in scaling groups, and
21 you can compare that to the --

22 MR. BANERJEE: No. I think Graham's
23 question is the one that we all have, is as they were
24 saying, you've got this column of water right at the
25 top that starts to boil. And the reason it starts to

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1 boil is, of course, that the suppressed boiling due to
2 this gravity head.

3 MR. STAUDEMEIER: Right.

4 MR. BANERJEE: And then it goes out of
5 boiling, and it comes back into boiling. And, you
6 know, how do you do it without that gravity head? I
7 don't understand that.

8 CHAIRMAN WALLIS: You have to run it at
9 lower than design pressure.

10 MR. BANERJEE: You'd have to do some major
11 change, like Graham is saying.

12 CHAIRMAN WALLIS: Then you've changed all
13 the properties.

14 MR. RANSOM: I've never quite understood
15 the desire to, you know, try and maintain exact
16 similarity, which is never done, you know, in any of
17 these test facilities. But in terms of gravity, this
18 sticking to full height it seems to me is -- may not
19 be, you know, a necessary criterion. And in fact,
20 I've never understood why you can't use the codes
21 which embody all the physics of the hydrostatic head,
22 and the flashing effects, and compare full scale with
23 limited scale. And basically, we did do that in PUMA.
24 And, you know, within limited scaling. I mean, if you
25 go to extremes, of course, you would -- some of the

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1 phenomena might disappear. But examine the similarity
2 using the codes. It doesn't necessarily mean they're
3 exactly right, but you can go back and examine how
4 well does that kind of facility simulate the behavior
5 by comparing it with say a full-scale model of the
6 plant. And I think that's been quite successful in
7 that case. And you really need to look at it on that
8 basis. You have to look at a code model for the test
9 facility, and a code model for the full-scale plant,
10 and then compare those two to see are the same
11 phenomena present.

12 MR. BANERJEE: Sure. I mean, you can get
13 the same phenomena. Just heat up the core more and
14 you'll get boiling at the top. I mean, it's always
15 possible.

16 MR. STAUDEMEIER: I guess one thing -- I
17 mean, you come up with a stability boundary based on
18 non-dimensional equations, and maybe you run your code
19 to see if it predicts the same stability boundary that
20 the experiment does, and that gives you some
21 additional information of whether it can predict the
22 stability boundary in the full height.

23 MR. BANERJEE: The problem with Vic's
24 argument is really that the code should be a scaling
25 tool. And everything you do with the code, every

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1 experiment you do is, therefore, relevant. It doesn't
2 really matter. That's true if the code converges in
3 a mathematical sense. Most of these codes, however,
4 depend on fancy nodalization to make them come close
5 to reality. And the nodalization becomes a part of
6 the problem, and that's part of the CSAU methodology.
7 We understood that these codes would not converge when
8 we set that up.

9 MR. SCHROCK: I don't believe in that.

10 MR. BANERJEE: Well, but that's exactly
11 what happened.

12 MR. SCHROCK: I mean, you're making
13 approximations that are far greater in all the models.

14 MR. BANERJEE: You always change answers.
15 I mean, you saw that with the way the lower plenum is
16 nodalized in AP --

17 MR. SCHROCK: But those are for different
18 reasons. Those don't have anything to do with --

19 MR. BANERJEE: No, no, no. I'm saying
20 they don't --

21 MR. SCHROCK: Or converging in that sense.

22 MR. BANERJEE: You change the
23 nodalization, you change the answers. Unfortunately,
24 that's the state of the art right now. And, therefore
25 -- I mean, you want the experiments to be as nearly

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1 representative of reality as you can be, because you
2 want to nodalize them roughly the way you're going to
3 do it with the full plant.

4 MR. SCHROCK: Well, you can simply test
5 them by the model of the experiment. And, you know,
6 these things have to have some similarity between the
7 actual plant and the experiment in terms of lower
8 plenum, core locations, where the containment is
9 located. But generally, the experimentalist tries to
10 do that.

11 CHAIRMAN WALLIS: There's a sequence of
12 events though. It may be that if you have this column
13 of water suppressing the flashing that you won't get
14 flashing. But then if you have a much shorter column
15 of water in another test, you will get flashing.
16 You're getting something in one test that wasn't there
17 in the other test.

18 MR. STAUDEMEIER: Well, the flashing
19 happens at a higher elevation. The fluids don't keep
20 going up. At some point, it's going to flash.

21 CHAIRMAN WALLIS: The same pressure -- the
22 way it progresses depend on this hydrostatic head, so
23 something is going to be different about that.

24 MR. RANSOM: Well, the distribution will
25 be different within the core. That's true, but in

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1 general though, you will -- if it's a boiling
2 situation you will not see no flashing in one case,
3 and some in the other. I mean, and yes, appear in one
4 and not in the other.

5 CHAIRMAN WALLIS: But if you try to scale
6 flashing you'll find that the elevation things matter.

7 MR. RANSOM: I think it would be
8 worthwhile to look at some of these results that have
9 been obtained for, you know, the different scales, and
10 then comparing the two.

11 CHAIRMAN WALLIS: Well, presumably
12 flashing is one of the scaling parameters, and this
13 PUMA scaling study is --

14 MR. STAUEMEIER: Yes. The report is in
15 draft form. It should be finalized pretty soon, and
16 you can get a copy of it.

17 CHAIRMAN WALLIS: Did they convince you
18 that everything is all right?

19 MR. STAUEMEIER: I haven't read it yet,
20 so I don't know.

21 MR. BANERJEE: Well, Joe, as you know,
22 scaling for different accidents is very different,
23 whether you do it for a large break LOCA, small break
24 LOCA, stability or whatever. So if stability is going
25 to be one of the most important things you're looking

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1 at, then a scaling study has to be, you know, directed
2 in that direction specifically.

3 MR. STAUDEMEIER: And it is --

4 MR. BANERJEE: Because it will be very
5 different for a large break LOCA or a small break
6 LOCA, or something.

7 MR. STAUDEMEIER: Yeah. There was scaling
8 analysis performed specifically for the stability
9 experiments.

10 MR. BANERJEE: Right.

11 MR. STAUDEMEIER: And that will be in the
12 final report document.

13 MR. POWERS: Let me just interject that
14 the way I understand, and I'm also extremely
15 sympathetic with Vic's point of view on this. When
16 you put together a facility, any experimental
17 facility, you're not perfectly simulating anything.
18 And if it so extraordinarily sensitive to one
19 parameter, that is the height, that you cannot in any
20 way model it in some approximate sense, it seems to
21 me, that it hopeless to build the plant. Because when
22 it gets fabricated, it is not going to be exactly the
23 same height as planned.

24 MR. BANERJEE: It doesn't have to be
25 exactly, but it shouldn't be one-quarter either.

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1 There's a big difference.

2 MR. POWERS: Well, it's a little bit of a
3 joke about the woman in the bar and the million dollar
4 offer here. We know what you are, we're just arguing
5 over price here.

6 (Laughter.)

7 MR. BANERJEE: A question of degree, I
8 think.

9 MR. KRESS: I don't think we should
10 prejudge this issue until we see the scaling analysis.
11 I think it's entirely possible to have a facility like
12 PUMA look at the flashing instability. You may have
13 to change some other parameters, such as the inlet
14 subcooling or the inlet heating or something like
15 that. I think you can look at it. I'd be anxious to
16 see the scaling first.

17 MR. POWERS: The larger issue, it seems to
18 me, Tom, is that we invent these incredible complex
19 and detailed computer codes, but when it comes to
20 designing our tests, we go back to very approximate
21 back of the envelope calculations. It's surprising
22 that we don't make greater use of the codes
23 themselves.

24 MR. KRESS: To do the scaling analysis.
25 Yeah, you could very well use it, adjust these

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1 parameters to see whether or not you get --

2 CHAIRMAN WALLIS: I think that's a very
3 good point. Before I would put a lot of money into a
4 quarter-scale experiment, I would want to run TRAC,
5 TRACE or something to show that I'm going to find the
6 kind of phenomena that I'm looking for, and there
7 isn't something which is affected by having it a
8 quarter.

9 MR. STAUDEMEIER: Yeah. I mean, I think
10 that will be done.

11 CHAIRMAN WALLIS: I missed something or
12 introduced something which wasn't there in the full
13 height.

14 MR. STAUDEMEIER: Yeah. In the PUMA
15 design, I think RELAP-5 was used to --

16 MR. RANSOM: Right. In fact, even in the
17 proposal we did that, you know, and showed that the
18 same phenomena were present or predicted to be present
19 in the sub-scale situation, and satisfied ourselves
20 that that was a reasonable approach. And I think in
21 the end, it really turned out that way.

22 MR. STAUDEMEIER: I'd also like to add
23 that it's interesting what a difference the head of
24 the subcommittee can make, because we're now going to
25 hit Canton with some of the subcommittee. He is

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1 absolutely against running something like RELAP-5 end
2 helping to do your scaling and work things out, so
3 it's a matter of opinion, I think, in some cases.

4 MR. BANERJEE: Well, it's sort of a
5 chicken and egg problem. It's an iterative process
6 because if the code can't handle say oscillations or
7 something, as you remember at that time, there was a
8 problem because in the core uncovering phase, the
9 codes would go into these enormous oscillations
10 because it would slip at low pressure. So how could
11 you use the code to do any scaling analysis?

12 MR. STAUDEMEIER: Yeah.

13 MR. BANERJEE: And Ivan was absolutely
14 right.

15 MR. STAUDEMEIER: Yeah, you have to use
16 good judgment in how you --

17 CHAIRMAN WALLIS: Well, remember AP600.
18 We had this business of the fangs, the CMTS filled up
19 with water.

20 MR. STAUDEMEIER: Right.

21 CHAIRMAN WALLIS: And then when you went
22 to the full-scale, there was enough gravitational head
23 so this never happened.

24 MR. STAUDEMEIER: That's not true exactly.

25 CHAIRMAN WALLIS: So it was a phenomenon

1 which changed completely when you went from small
2 scale to --

3 MR. STAUDEMEIER: What happened in full
4 height RELAP-5 calculations --

5 CHAIRMAN WALLIS: You couldn't possibly
6 suck the waters up that far because there was so much
7 gravitational head.

8 MR. STAUDEMEIER: It depended on the
9 break, actually. For that one break, it couldn't
10 happen, but there were other breaks where it actually
11 could happen, and did happen in RELAP-5 calculations.
12 It was a limited viewpoint, I think given at the time,
13 that it could only happen in --

14 CHAIRMAN WALLIS: I see. Okay. Well, we
15 should probably move on.

16 MR. STAUDEMEIER: Okay. For severe
17 accident analysis, there's a MELCOR model that's under
18 development. Look at in-vessel melt retention and
19 other severe accident management strategies --

20 MR. KRESS: Has that been put forth as an
21 accident management strategy by GE?

22 MR. STAUDEMEIER: I think unofficially
23 it's been put forward. I don't think there's any
24 official documents yet that say that.

25 MR. KRESS: Well, the only database I know

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1 is for PWR, so we don't have this forest of control
2 rods coming up there. I don't know how you deal with
3 that in terms of cooling on the outside of the vessel.

4 MR. STAUDEMEIER: Yeah. So as I said,
5 that the calculations will be starting later on, once
6 we get more of, I guess, some official information
7 from GE on what needs to be analyzed. And also, the
8 severe accident calculations will be supporting any
9 PRA studies that go on for this plant.

10 MR. POWERS: It matters not on your heat
11 transfer. I mean, there's some cooling chemistry that
12 will take it --

13 MR. KRESS: The chemistry will take care
14 of it for us.

15 MR. POWERS: We won't have to worry about
16 it.

17 MR. ROSENTHAL: I think that the --
18 actually, we had a Lesson Learned from AP1000, where
19 we did a lot of early thermohydraulic work, and then
20 had to play catch-up in the severe accident arena. So
21 we got a little bit smarter now with ESBWR, and said
22 okay, the thermohydraulic work is obviously starting
23 far in advance of lots of other disciplines that exist
24 in NRR, for example. You're hearing -- as you
25 observed, you're only hearing a small piece of all the

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1 kinds of review that would be done, but we recognize
2 that we should start building a MELCOR deck now so
3 that we'd be able to answer the questions to support
4 the PRA review, rather than waiting a year from now.
5 And that's all we're really trying to do, is get a
6 start on what we know will be important.

7 MR. KRESS: Did the GE PRA use MAP?

8 MR. POWERS: Shows sound good thinking
9 there.

10 MR. STAUDEMEIER: I also think they may
11 have a MELCOR model for GE. And I'm not sure what the
12 status of that is, and that we may be getting a copy
13 of it.

14 MR. POWERS: More interesting than
15 in-vessel retention is going to be accident management
16 strategies to control gaseous iodine.

17 MR. STAUDEMEIER: Okay. The summary of
18 what we're doing is --

19 MR. POWERS: I mean, the problem is you
20 put them into -- the iodine into the suppression pool
21 and yo continue to blow gas through it, you're going
22 to pull it right back out again. I mean, it's a clear
23 result out of NUREG 1150, as you continue to blow
24 through the pools, you just pull the iodine right back
25 out again.

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1 MR. STAUDEMEIER: Okay. Most of the
2 pre-application work is on schedule. We're a little
3 bit behind on the testing review compared to where we
4 wanted to be initially, and also the CONTAIN/TRACE
5 coupling. I think we had hoped to have some full
6 calculations done by this time, and have run into a
7 few problems with that. But I think we're on schedule
8 to resolve them fairly soon.

9 MR. SCHROCK: And that contained coupling
10 to TRACE is related to the pre-application review?

11 MR. STAUDEMEIER: Well, I know NRR wants
12 to use some of these calculations in their
13 pre-application review as comparing -- doing some
14 independent calculations to compare to the TRACG
15 calculations.

16 MR. SCHROCK: Because when I read that, I
17 thought they were referring to research commitments to
18 assist NRR in the --

19 MR. STAUDEMEIER: Well, it's both of
20 those. Yeah, both of those activities are for
21 pre-application review, both the assistance in
22 reviewing the topical reports, and also this
23 TRACE/CONTAIN coupling.

24 And the additional activities in support
25 of the design certification, they're not on quite as

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1 tight a schedule, and I think they should be done to
2 support the design certification review. We should
3 have code modifications and assessment done by that
4 time, and have a fairly well-assessed code that NRR
5 can use to do independent accident calculations.

6 And we may identify some additional
7 activities in the future as GE submits additional
8 information, such as ATWS and stability, that will
9 require at least some additional code assessment to
10 look and see that the code is okay for predicting that
11 type of stuff. Any more questions?

12 CHAIRMAN WALLIS: Thank you very much.
13 I'm trying to figure out what we need to do now.
14 We've learned from GE and from RES and from NRR what
15 the status of things is, and it seems premature for us
16 to reach any conclusion whatsoever.

17 MS. CUBBAGE: Right. I think at this
18 stage, we're not requesting a letter, but we'll be
19 coming back in the fall with a draft safety evaluation
20 report.

21 MR. KRESS: It's on the Full Committee
22 agenda?

23 CHAIRMAN WALLIS: That's why I was asking.
24 I think there's something on the Full Committee
25 agenda.

1 MS. CUBBAGE: Oh, Full Committee, we're on
2 the agenda this Thursday at 12:45.

3 MR. CARUSO: Do you expect anything out of
4 that, or is that just a get to know you meeting?

5 MS. CUBBAGE: I believe it's just an
6 informational brief.

7 MR. CARUSO: You don't expect a letter or
8 a report, or anything like that.

9 MS. CUBBAGE: No, we don't.

10 MR. CARUSO: But the meeting on Thursday,
11 that's not just going to be thermohydraulics. That's
12 going to be ESBWR. Right?

13 MS. CUBBAGE: Well, it's a very short time
14 window, and I believe GE is going to make a short
15 presentation, and the staff is going to be available
16 if the committee has any questions.

17 CHAIRMAN WALLIS: But it's not related to
18 this Subcommittee Meeting, is it?

19 MS. CUBBAGE: Yes.

20 CHAIRMAN WALLIS: Is it something else?

21 MS. CUBBAGE: It is related to this.

22 CHAIRMAN WALLIS: It is?

23 MR. CARUSO: Is it? It's supposed to be
24 thermohydraulics, or is just to be an overview of
25 ESBWR. That was my understanding.

1 MS. CUBBAGE: Well, Atam, what do you have
2 planned for Thursday?

3 MR. CARUSO: Well, do you guys want the
4 meeting on Thursday? I know what you want. Excuse
5 me. You're not going to get that.

6 MR. POWERS: They wish it was --

7 MR. CARUSO: What you expect.

8 MR. POWERS: Well, put a proposal in front
9 of Tom. He might go for it.

10 MR. RAO: No. What we wanted was answers
11 on these questions, do these look like there are any
12 significant issues on the thing. But I think Graham
13 has said that you don't have the information to pass
14 any judgment on any of those issues, and so actually,
15 maybe at this stage, it's premature to have a meeting
16 actually.

17 CHAIRMAN WALLIS: Well, you're on the
18 schedule and it's in the Federal Register.

19 MR. RAO: Yeah.

20 MR. CARUSO: You have to come and talk.

21 CHAIRMAN WALLIS: You have to do it.

22 MR. RAO: Yeah. We can talk. You know,
23 we can talk.

24 (Laughter.)

25 MR. CARUSO: Well, you've been summoned to

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1 Washington.

2 MR. RAO: It's after lunch, and so we
3 don't want to make it such that it puts everyone to
4 sleep.

5 CHAIRMAN WALLIS: How long do you have to
6 talk? It's a long time, isn't it? It's a major
7 thing.

8 MR. RAO: It's a two hour window there.

9 CHAIRMAN WALLIS: Yeah, that's my
10 impression, it's a major thing.

11 MS. CUBBAGE: As you could tell from this
12 morning, Atam will be able to fill that easily.

13 CHAIRMAN WALLIS: What are you going to
14 do, try to compress what we heard today into these two
15 hours? What's the intent?

16 MS. CUBBAGE: No, the staff won't be
17 presenting. And I think you're basically just going
18 to hear --

19 CHAIRMAN WALLIS: The staff won't be
20 presenting at all.

21 MS. CUBBAGE: No.

22 MR. CARUSO: That's why I said, I thought
23 this was just a get to know you type presentation.

24 CHAIRMAN WALLIS: Get to know you? We
25 know you all. I think the Full Committee has seen you

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1 before too. And my advice would be to give more
2 substance than the sort of sales pitch to the ESBWR,
3 which we've heard before, which is very nice. But I
4 would -- and I think what's impressive is that this is
5 the results that you can always go something like 2
6 meters of collapsed water above the core no matter
7 happens, and you've got -- you know, not sort of
8 pushing some regulatory limit. You seem to be steering
9 way clear of all the regulatory limits, and that's the
10 sort of message I think you want to convey, a message
11 of what you've learned from your testing, and why the
12 testing is adequate to give confidence in your
13 assertions.

14 MR. SCHROCK: Operators have a lot of time
15 to sit around and think about that.

16 CHAIRMAN WALLIS: Right. That's what I
17 would think you want to concentrate on, because the
18 committee has seen this sort of thing, the overview of
19 what this thing is, and why it's a good machine, and
20 beautiful and everything. WE've heard all that
21 before.

22 MR. KRESS: I think you may need to do a
23 little of that.

24 CHAIRMAN WALLIS: You may do a little bit
25 of that to orient them, but the main thing is what's

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1 the bottom line? This thing seems to be much more
2 conservatively safe than all of the other things that
3 are out there. Isn't that the message you want to put
4 across?

5 MR. RAO: Yes.

6 CHAIRMAN WALLIS: And also, I think the
7 adequacy of the test program is something you maybe
8 need to put across.

9 MR. KRESS: Or at least bring up the point
10 that that's the issue we're looking at.

11 MR. RAO: From our perspective it's, you
12 know, the idea of trying to get closure on some of
13 these issues is a very important consideration from
14 our perspective.

15 MR. KRESS: I think you had a couple of
16 slides that showed the extent of the test program that
17 exists, which I think is very brilliant. I don't
18 think we saw that before, and that's worth bringing
19 out.

20 MR. POWERS: I think you can rest assured
21 you will get a question on your material selection
22 program.

23 MR. RAO: I think I've made that clear.

24 CHAIRMAN WALLIS: Is there enough for you
25 to go on, to know what you want to present? It's your

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1 opportunity to get this ball rolling, it seems to me,
2 before the Full Committee in a serious way.

3 MR. RAO: Okay. WE'll investigate that.

4 CHAIRMAN WALLIS: Now from what we've
5 learned today, and I'd invite the Committee Members to
6 give comments, do we want to have it on the record?
7 I'm not sure we need to have the record, do we?

8 MR. CARUSO: I would suggest -- I mean,
9 Graham, if you want to, you could talk about the fact
10 that we had this meeting, and that they presented a
11 lot of information about the test programs.

12 CHAIRMAN WALLIS: That's for Thursday.

13 MR. CARUSO: For Thursday.

14 CHAIRMAN WALLIS: Right. But I thought
15 just to round-out today, I think we ought to have some
16 frank opinions from the Committee Members. I'm not
17 sure this needs to be on the record. Are we obligated
18 to have it on the record?

19 MR. CARUSO: You mean the discussion right
20 now?

21 CHAIRMAN WALLIS: Yes. If we have a sort
22 of a caucus or discussion.

23 MR. CARUSO: It doesn't have to be.

24 CHAIRMAN WALLIS: Can we say goodbye to
25 the record?

1 MR. CARUSO: I think so.

2 CHAIRMAN WALLIS: Okay. So please close
3 the record now. Now we'll be off the record.

4 (Whereupon, the proceedings in the
5 above-entitled matter went off the record at 6:34
6 p.m.)

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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
Meeting of the Subcommittee
On Thermal-Hydraulic
Phenomena
OPEN SESSION

Docket Number: n/a

Location: Rockville, MD

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GE Nuclear Energy

ESBWR Design Overview and Technology Closure

***Atam Rao
Project Manager ESBWR
GE Nuclear Energy, USA***

***ACRS Thermal Hydraulics Sub-comm.
July 8, 2003,
Rockville, Maryland***



Outline

- **Goals for the Technology Closure Program**
- **ESBWR Design and Program Overview**
 - simpler with more margin – by design
 - focus on safety systems & containment
 - use of single integrated computer code for analysis
 - comprehensive testing and analysis basis
- **Overview of Submittals**
 - 7 new submittals
- **Summary and Conclusions**

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Goals for the technology closure

- Approval of the use of TRACG for analysis
 - vessel response to pipe break – loss of coolant accident (called ECCS/LOCA)
 - containment response to pipe break (called Containment/LOCA)
 - vessel response to anticipated operational occurrences (called AOO)
 - plant response to anticipated transients without scram (ATWS) and normal operation stability (ODYSY) – LATER
- Confirmation of the adequacy of TRACG
 - adequacy of the qualification base and approach

Is a 15+ year comprehensive technology program enough?

Technology closure plan for ESBWR

- Approval of TRACG Application for ECCS/LOCA
 - Based on the TAPD and its implementation
 - Based on the qualification studies
- Approval of TRACG Application for containment/LOCA
 - Based on the TAPD and its implementation
 - Based on the qualification studies
- Approval of TRACG Application for AOO
 - Based on the TAPD and its implementation
 - Based on the qualification studies and operating plants
- TRACG Application for ATWS
 - Based on the TAPD and its implementation
 - Based on the qualification studies
 - Contingent on application methodology*
- ESBWR stability evaluation
 - Based on the TAPD and its implementation
 - Based on the qualification studies
 - Contingent on ODYSY/TRACG application methodology*

*Changed plan

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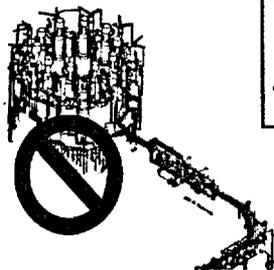
Comparison of Key ESBWR Parameters to Operating BWRs

Parameter	BWR/4-Mk I (Browns Ferry 3)	BWR/6-Mk III (Grand Gulf)	ABWR	ESBWR
Power (MWT/MWe)	3293/1098	3900/1360	3926/1350	4000/1390
Vessel height/dia. (m)	21.9/6.4	21.8/6.4	21.1/7.1	27.7/7.1
Fuel Bundles (number)	764	800	872	1020
Active Fuel Height (m)	3.7	3.7	3.7	3.0
Power density (kw/l)	50	54.2	51	54
Recirculation pumps	2(large)	2(large)	10	zero
Number of CRDs/type	185/LP	193/LP	205/FM	121/FM
Safety system pumps	9	9	18	zero
Safety diesel generator	2	3	3	zero
Core damage freq./yr	1E-5	1E-6	1E-7	1E-7
Safety Bldg Vol (m ³ /MWe)	115	150	160	70

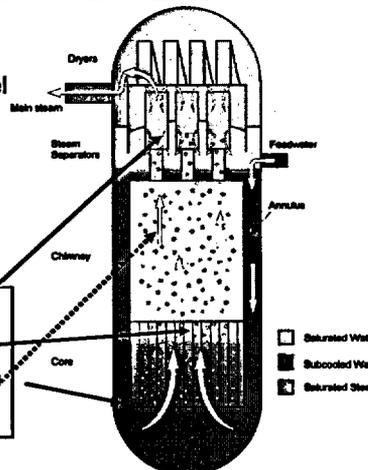
Evolution Within a Small Range Minimizes Operational Risks

Natural Circulation – Simplification Without Performance Loss

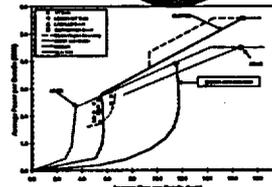
- **Passive safety/natural circulation**
 - Put the water in the vessel – larger vessel
 - Increase driving head – larger vessel
- **Significant reduction in components**
 - Pumps, motors, controls, HXers
- **Load following with Control Rod Drives**
 - Minimal impact on maintenance



- **Reduced flow restrictions**
 - Improved separators
 - Shorter core
 - Increase downcomer area
- **Higher driving head**
 - Chimney/taller vessel

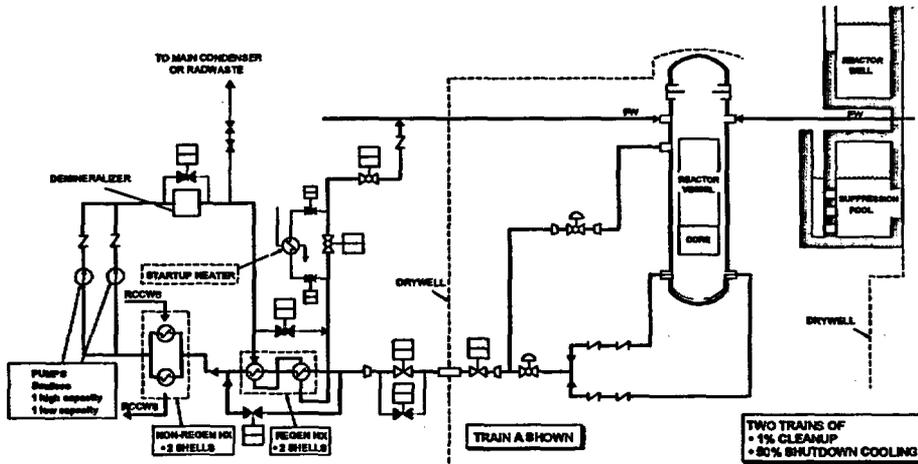


- Saturated Water
- Subcooled Water
- ▣ Saturated Steam



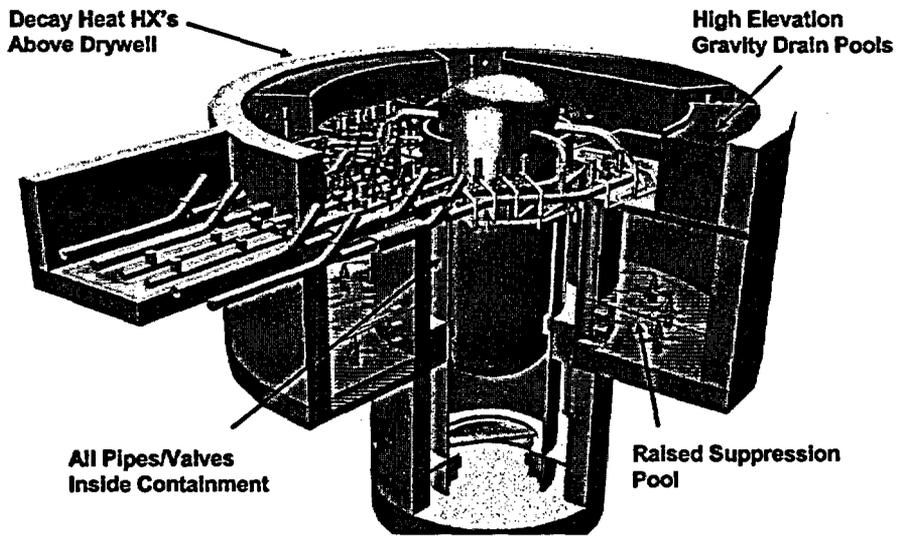
Enhanced Natural Circulation Compared to Standard BWR's

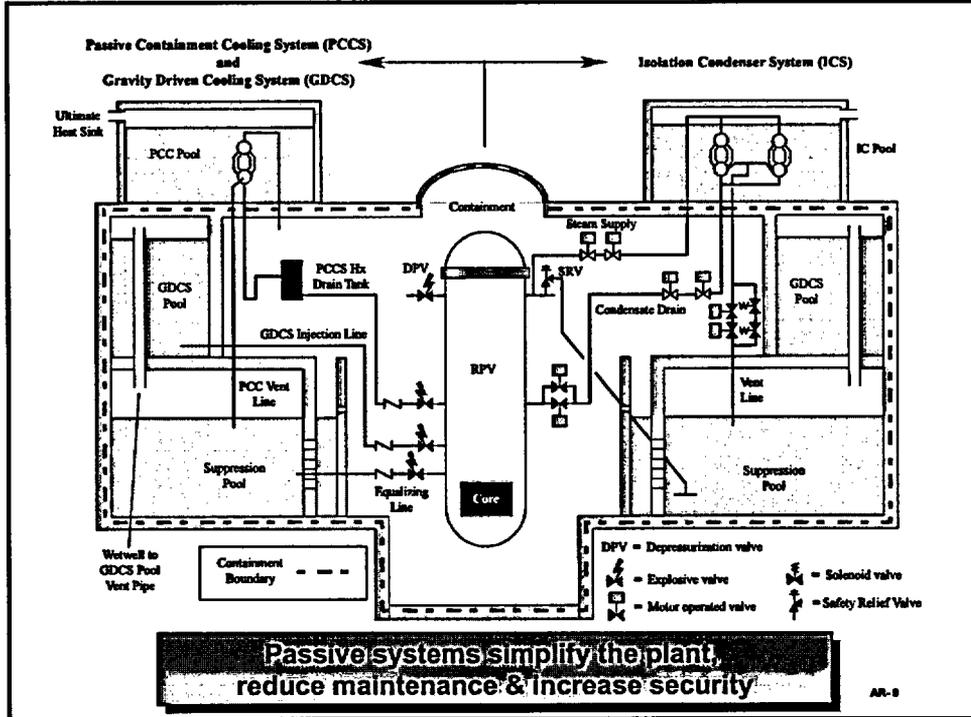
Reactor Water Cleanup / Shutdown Cooling System
(both systems combined for ESBWR)



**Standard 2x1% reactor water cleanup system with
 Unique full pressure shutdown cooling system**

Passive Safety Systems Within Containment Envelope



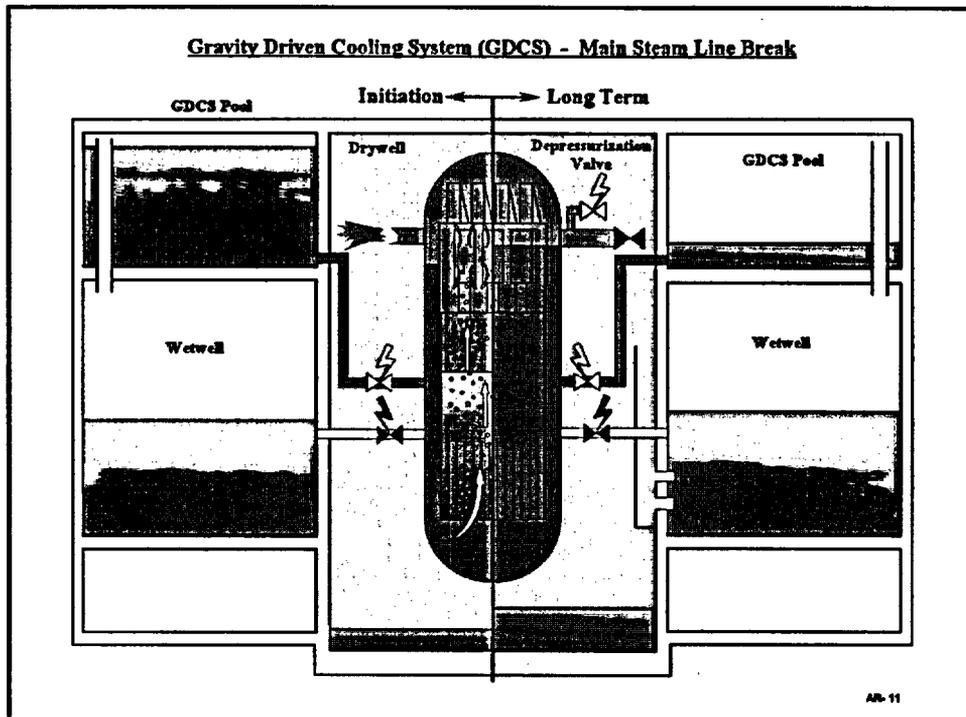


Design philosophy for core cooling

- **Increase Inventory in the vessel**
 - Use taller vessel - NEW
 - Increase amount of subcooled water - NEW
- **Minimize Inventory loss from the vessel**
 - Eliminate large pipes below the core and minimize other pipes - NEW
- **Keep core covered after Initial blowdown**
 - Shorter core lower in the vessel - - NEW
- **Provide Inventory makeup – low head using gravity**
 - Provide diverse depressurization system for high reliability - NEW
 - Required makeup rate is very low
 - Multiple pools rely on gravity to fill vessel - NEW
 - No high capacity systems needed
 - Fewer systems interactions
- **Utilize Integrated BWR analyses tools**

Design features improved the plant response

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Design Philosophy for decay heat removal

- **Remove Decay Heat From Vessel**
 - Main Condenser
 - Full pressure normal shutdown cooling system - NEW
 - Isolation condensers - NEW
 - Remove vessel heat through relief valve opening
- **If Needed, Remove Heat From Containment**
 - Passive containment cooling (PCC) Hx (safety-grade) - NEW
 - Always available and drywell/wetwell pressure difference removes the non-condensables from the heat exchangers
 - Condensed steam returns to drywell/vessel, non-condensables collect in the wetwell airspace
 - No operator action needed for 72 hours
 - Suppression pool cooling (non-safety)

Several Diverse Means of Decay Heat Removal

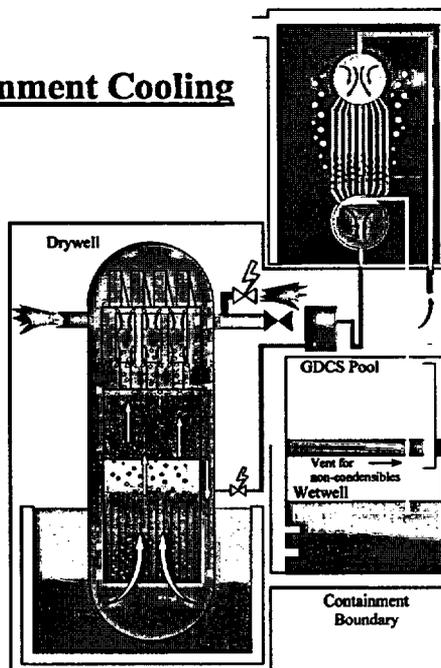
A8-12

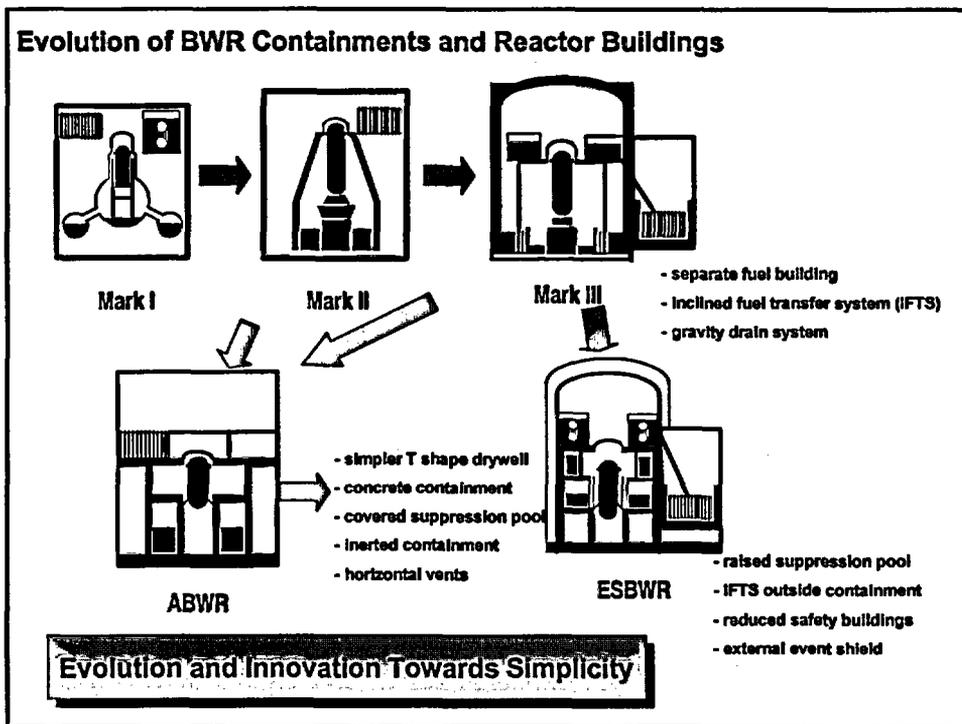
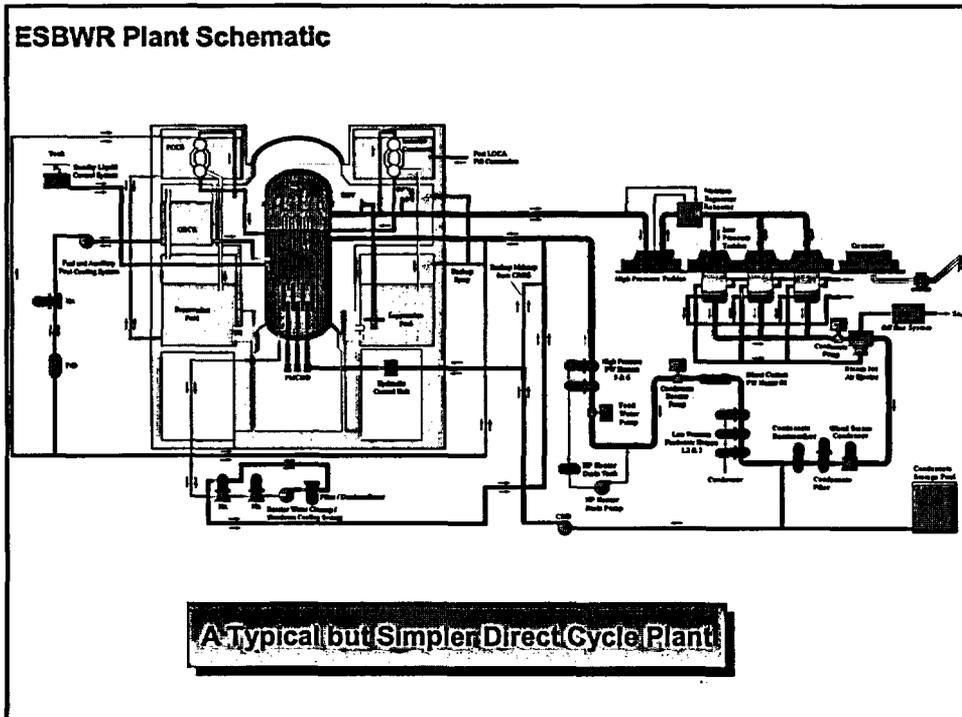
Decay Heat Removal from Containment - How it works

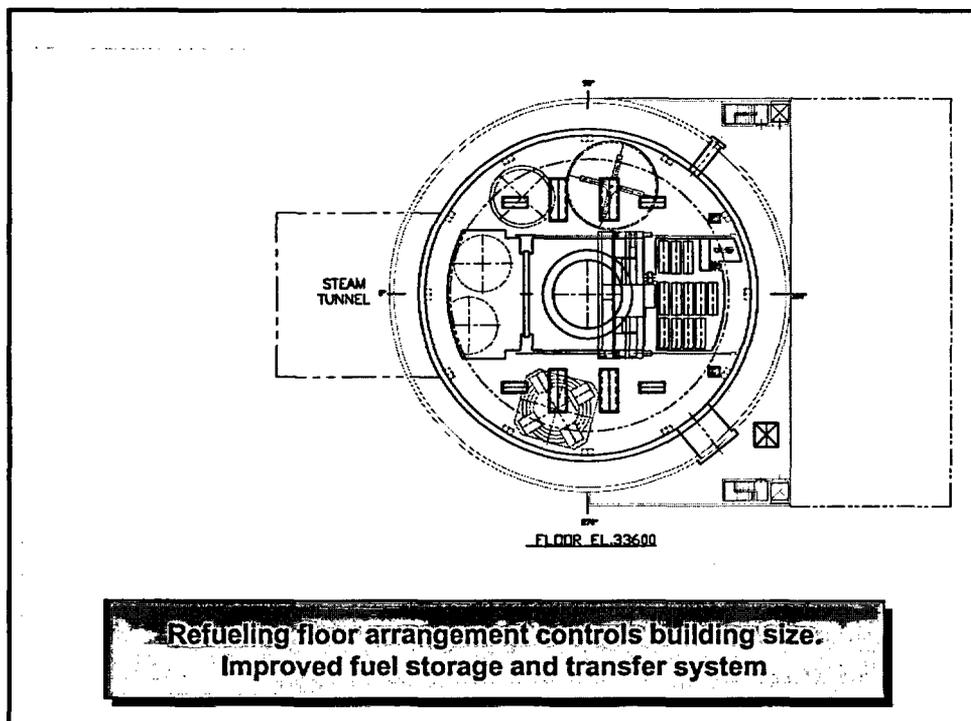
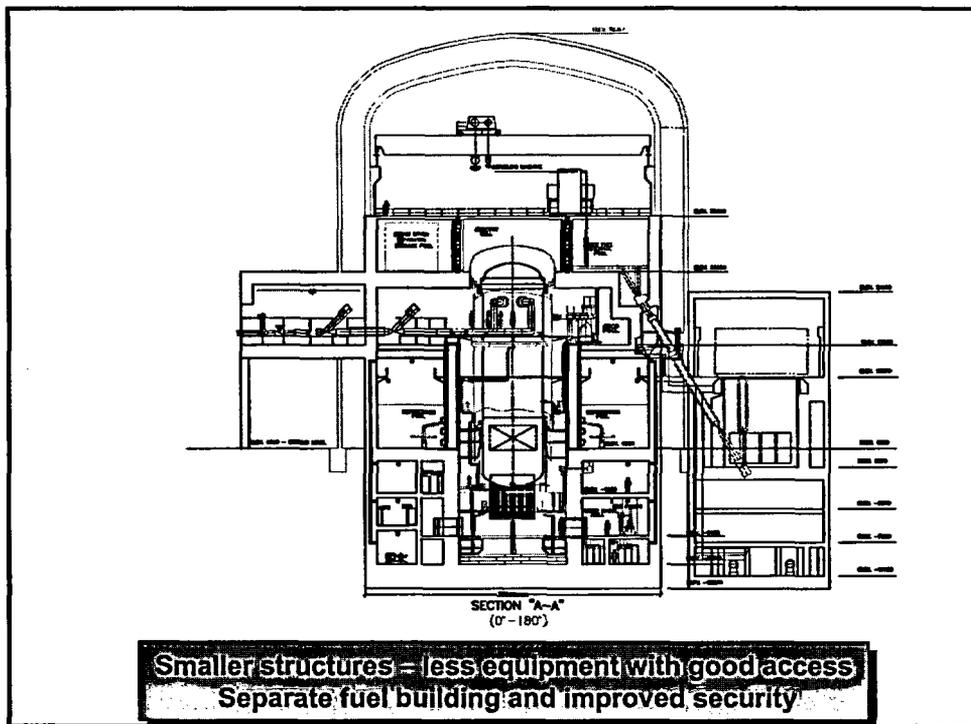
- Initially steam (blowdown energy) flows to large heat sink in containment (suppression pool) and through heat exchangers
- Longer term (decay heat) steam flows to heat exchanger (similar to an isolation condenser) and heat is transferred outside containment
 - vertical tube heat exchangers in a pool of water
 - non condensables removed by pressure difference between drywell and wetwell
- Containment pressure determined by non-condensables in wetwell airspace and vapor pressure

Concept is simple, reliable - extensive testing and analysis provide high confidence in the design margin

Passive Containment Cooling

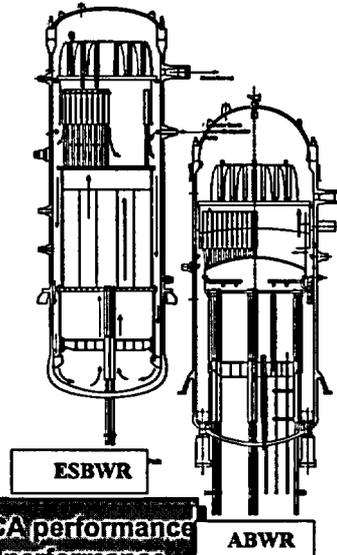






Design Features Affecting Plant Response

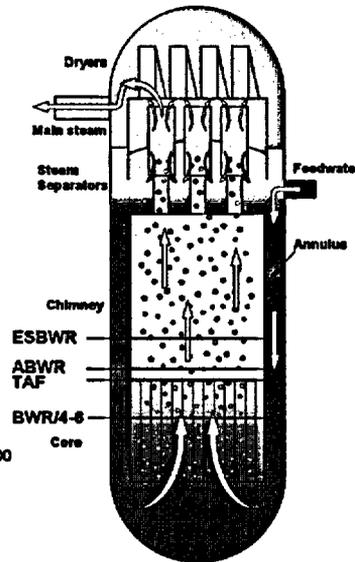
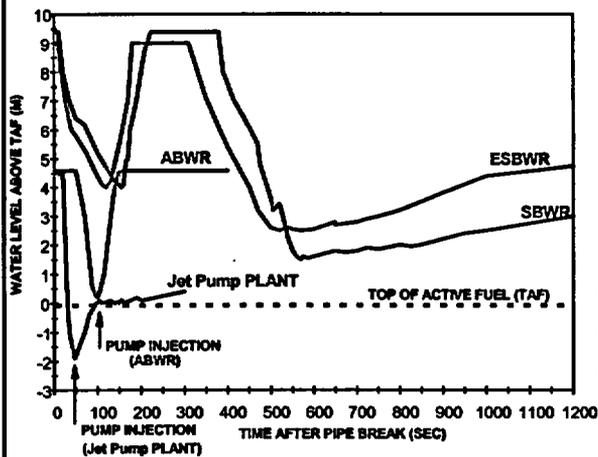
	ESBWR	ABWR	BWR5	BWR4
Large pipes below core	No	No	Yes	Yes
Core height, m	3.05	3.66	~3.66	~3.66
TAF above RPV bottom	~ 1/4	~ 1/2	~1/2	~1/2
Separator standpipes	Long	Short	Short	Short
Vessel height, m	27.7	21.1	~21.9	~21.8
Water volume outside shroud (above TAF), m ³	222	88	94	92



Greater water inventory - improved plant LOCA performance
Larger steam volume - improved transient performance

Water Level in Shroud Following a Typical Pipe Break

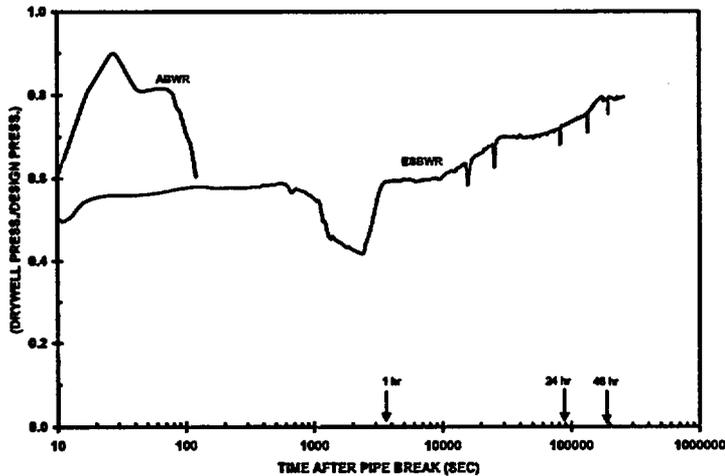
(values are intended to show typical trends for limiting breaks)



ESBWR Margins are Increased Over Past Plants

Containment Pressure Following a Pipe Break

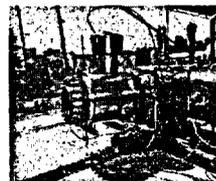
(values are intended to show typical trends for limiting breaks – ESBWR has lower design pressure than SBWR)



Large margin to design pressure

Technology Program for Features New to SBWR/ESBWR

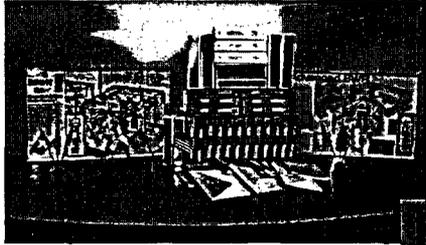
- Component tests
 - Full scale components tests – DPV valves and vacuum breaker
 - Full scale isolation condensers & PCCS heat exchangers
- Integral tests
 - Integral tests at different scales – 1/800 to 1/50
 - System interaction tests
 - Large hydrogen releases
- Testing used to qualify computer codes
- Extensive international cooperation
- Extensive review and participation by NRC staff
 - Test matrix
 - Running of actual tests
- Decay Heat Removal – additional confirmatory tests
 - 8 Integrated system tests run in PANDA



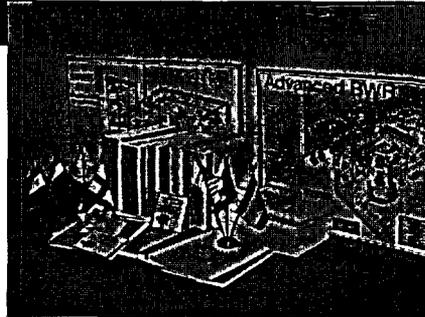
Steam Depressure Valve in the Test Facility

A complete, multi-year technology program supports the design

ESBWR Design/Technology based on SBWR and ABWR

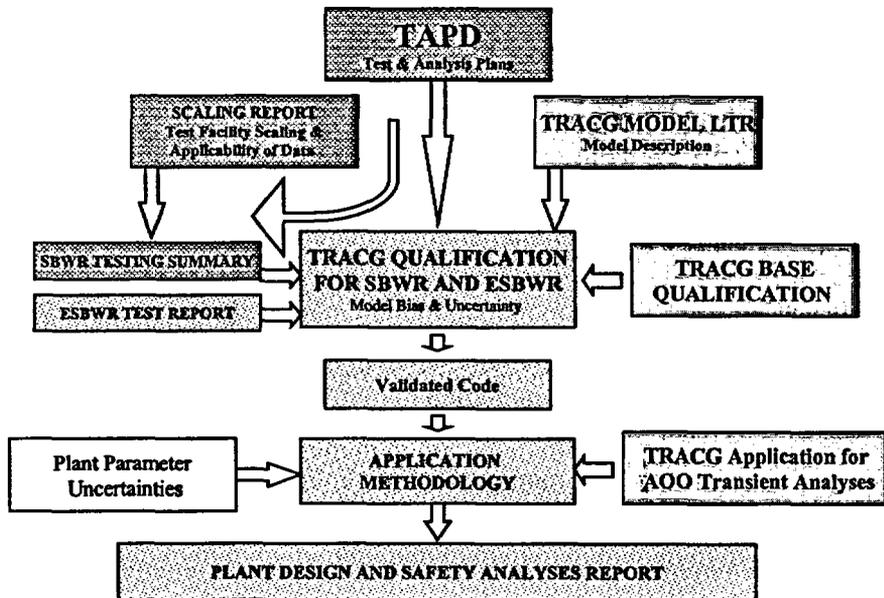


Extensive new submittals



Extensive SBWR submittals and reviews, new test data and reports, coupled with design changes to add margin

ESBWR Technology Program Elements



ESBWR Technology Program Summary

- **Passive safety systems have simplified the plant design**
- **Plant evaluations are simpler**
 - **Less complex analyses**
 - Best estimate with uncertainties defined as for operating plants - AOO
 - Best estimate with simplified accounting of uncertainties - ECCS/LOCA
 - Bounding calculation for containment/LOCA
 - **Low parameter uncertainty - $\pm 0.5C$ for PCTI**
- **Substantial margins exist in the design**
 - Improved integrated code show better performance
 - Defense in depth systems provide additional back-up
- **Extensive qualification of TRACG**
- **Technology issues extensively studied**
 - Independent studies provide confidence in technical bases

Performance improved by design features
Improved performance measured by qualified methods

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ESBWR Program Summary and Conclusion

- **15+ year technology and design program**
 - a BWR with less components
- **Simplification and margins by design**
 - large vessel results in benign response
 - analysis is simplified
- **Challenges for the coming months**
 - need closure and confirmation that regulatory risk is manageable

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0. PEU



ESBWR Pre-Application Review

Amy Cubbage, Project Manager
New Reactor Licensing Projects, NRR

ACRS Thermal Hydraulic Subcommittee
July 8, 2003



ESBWR Pre-Application Scope

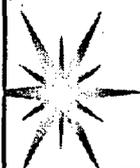
- ▶ TRACG Application for ESBWR LOCA and Containment Analyses
- ▶ TRACG Qualification for ESBWR
- ▶ Test and Analysis Program Description (TAPD) and PIRT
- ▶ SBWR and ESBWR Testing Reports
- ▶ ESBWR Scaling Report



ESBWR Pre-Application Schedule

Phase 1	June 2002 – August 2002
ESBWR Submittals	August 2002 – January 2003
RAIs	July 2003
Draft SER on TRACG, Scaling, Testing and PIRT	October 2003
ACRS T/H Subcommittee Meeting	November 2003
ACRS Full Committee Meeting	December 2003
Final SER on TRACG, Scaling, Testing and PIRT	January 2004
Design Certification Application	Mid CY2004

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TRACG for ESBWR LOCA and Containment Analyses

**Ralph Landry,
Reactor Systems Branch, NRR**

**ACRS Thermal-Hydraulic Subcommittee
July 8, 2003**

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TRACG for ESBWR LOCA and Containment

Table of Contents

- ▶ TRACG Code Review Approach
- ▶ Review Team
- ▶ Technical Issues
- ▶ RAI Status
- ▶ Confirmatory Calculations Status
- ▶ Conclusions

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TRACG for ESBWR LOCA and Containment

TRACG Code Review Approach

- ▶ Document Review
 - ▶ TRACG Model Description
 - ▶ TRACG Application for ESBWR
 - ▶ TRACG Application for SBWR
 - ▶ TRACG Qualification for ESBWR
 - ▶ TRACG Qualification for SBWR
 - ▶ TRACG Input Manual

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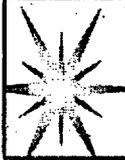


TRACG for ESBWR LOCA and Containment

TRACG Code Review Approach

- Analytical Review
 - TRACG ESBWR Input Model
 - TRACG Analysis and Test Cases
- Confirmatory Analyses
 - CONTAIN
 - TRACE
 - Coupled Codes: TRACE/CONTAIN

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TRACG for ESBWR LOCA and Containment

Range of TRACG Review

- LOCA ECCS Performance
- LOCA Containment Performance

Not Covered in Current Pre-Application Scope

- Transients
- ATWS
- Stability

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TRACG for ESBWR LOCA and Containment

NRR TRACG Code Review Team:

- R. Landry, lead
- S. Lu
- E. Throm
- A. Drozd
- Contractors: BNL, ISL, ORNL

RES support with TRACE/CONTAIN Development

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TRACG for ESBWR LOCA and Containment

Technical Issues – ECCS and Containment

- Reactor Power (Decay Heat) History - Full Power Operation After Break not Considered
- Mass & Energy Release – Break & ADS
- Critical Flow (Valve Size & Modeling)
- PCCS Performance
- Gravity Draining
- Interfacial Heat Transfer and Flashing

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TRACG for ESBWR LOCA and Containment

Technical Issues – Modeling

- Single Vessel Model (RPV/Containment)
- Thick Heat Structure Around Vessel for MSLB LOCA
- Radial Distortion
- Gravity Distortion
- Non-condensable Distribution

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TRACG for ESBWR LOCA and Containment

Technical Issues – Transients

- Incorrect Core Design – 9 ft vs. 10 ft
- Stability of Pancake Core
- Adequate Heat Transfer Data for Fuel Design

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TRACG for ESBWR LOCA and Containment

RAI Status

- ▶ Approximately 300 RAIs
- ▶ Range from Typos to Modeling Issues
- ▶ Multiple Telecons and Meetings on RAIs
- ▶ Formal RAIs Due July 18
- ▶ Responses Due Mid-August

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TRACG for ESBWR LOCA and Containment

Confirmatory Calculations Status

- ▶ TRACG ESBWR Input Deck Run
- ▶ CONTAIN Input Model Developed by RES
- ▶ TRACE Input Model Developed by NRR/ISL
- ▶ TRACE/CONTAIN Underway

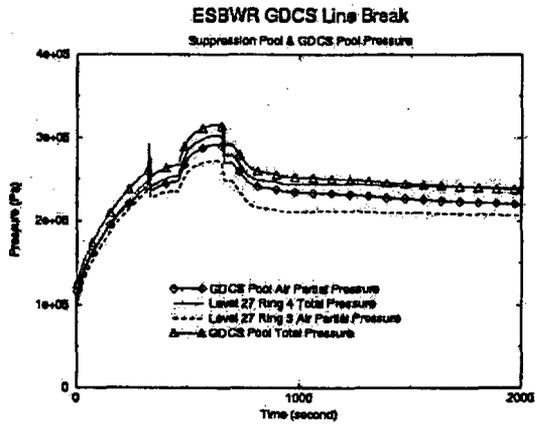
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TRACG for ESBWR LOCA and Containment

Calc	Description	Code	Status
1	GDCS LOCA	TRACG	Completed
2	MSLB LOCA	TRACG	Completed
3	PCCS	TRACG	On-going
4	Energy Cons	TRACG	On-going
5	Gravity Flow	TRACG	On-going
6	MSLB LOCA	CONTAIN	On-going
7	MSLB LOCA	TRACE/CONTAIN	On-going
8	GDCS LOCA	TRACE/CONTAIN	On-going
9	GE-12 Fuel	HELIOS	Planned
10	AOOs	TRACG	Planned
11	AOOs	TRACE/PARCS	Planned

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TRACG for ESBWR LOCA and Containment



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TRACG for ESBWR LOCA and Containment

Conclusions

- ▶ Documentation Is Extensive
- ▶ Quality Has Improved Over SBWR
- ▶ Aggressive Schedule
- ▶ Thorough and Extensive Staff Review

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ESBWR TAPD, Testing and Scaling

Muhammad Razzaque,
NRR/DSSA/SRXB

ACRS Thermal-Hydraulic Subcommittee
July 8, 2003

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ESBWR TAPD, Testing and Scaling

TAPD, Testing and Scaling Review Team

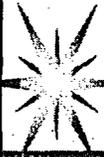
NRR Reviewers:

Muhammad Razzaque
Andre Drozd

RES Reviewers:

James Han
David Bessette
Marino DiMarzo
Contractor: ISL

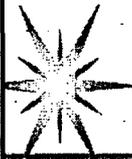
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ESBWR Testing and Scaling RAIs

- Bottom-up scaling analysis (RAI 15)
- Comparison of PI-Groups with 1/6 Scale Boron Mixing Test, CRIEPI and Dodewaard (RAI 177)
- Impact of potential distortion/bias due to heat losses in test facilities (RAI 13)
- Impact of increased PCCS heat removal capacity in PANDA and PANTHERS on peak containment pressure (RAI 14)

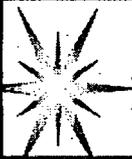
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ESBWR Testing and Scaling RAIs (Cont.)

- ▶ Test Distortion due to stored heat in containment structures (RAI 273)
- ▶ RPV and containment dynamic interactions (RAI 286)
- ▶ In-vessel natural-circulation effect on flashing (RAI 290)
- ▶ Non-dimensional groups criterion range (RAI 292)
- ▶ Compliance with 10 CFR Part 50 Appendix B Quality Assurance requirements for ESBWR test programs (RAI 25)

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ESBWR TAPD and PIRT RAIs

- ▶ TRACG analysis for ESBWR bottom drain line break (RAI 183)
- ▶ TRACG comparison with PANDA P-Series data (RAI 179)
- ▶ TRACG agreement with GIST data (RAI 181)
- ▶ Comparisons of important RPV & Containment parameters for counterpart integral tests (RAI 180)

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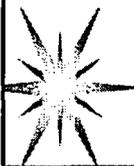


ESBWR Scaling Testing, TAPD and PIRT

Conclusions

- Documentation is extensive
- Overall quality of ESBWR scaling analysis has improved over SBWR
- Significant questions to be addressed
- Thorough and extensive staff review resulted in large number of RAIs
- Test reports still under review - Additional RAIs expected

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ESBWR Confirmatory Research Program

Joseph Staudenmeier,
Safety Margins and Systems Safety Analysis Branch, RES

ACRS Thermal-Hydraulic Subcommittee
July 8, 2003

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ESBWR Confirmatory Research Program

- ▶ The focus of RES confirmatory research program is to provide assessed independent analysis tools to NRR to support ESBWR design certification
- ▶ RES is also providing assistance to NRR for the ESBWR pre-application review.

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ESBWR Confirmatory Research Program

Pre-Application Stage

- ▶ Review of Scaling, Testing, and TAPD/PIRT Documents
- ▶ TRACE/CONTAIN Coupling for ESBWR Calculations

Design Certification Stage

- ▶ TRACE code development
- ▶ TRACE code assessment
- ▶ PUMA/ESBWR scaling study
- ▶ PUMA Testing
- ▶ Severe Accident Analysis

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ESBWR Confirmatory Research Program

- RES (with ISL contract support) is providing technical assistance in the review of GE's Scaling, Testing, TAPD, and PIRT topical reports. The RES product will be Technical Evaluation Reports (TERs) input to NRR Safety Evaluation Reports (SERs).
- Status: RAIs are complete for the Scaling, TAPD and PIRT topical reports. RAIs will be completed for the Testing reports in the near future. TERs are scheduled to be completed in the fall.

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TRACE/CONTAIN Coupling for ESBWR Calculations

- TRACE capable of modeling ESBWR reactor vessel
- Currently, TRACE not adequate for modeling ESBWR containment
- CONTAIN capable of modeling ESBWR containment
- TRACE supports coupling to other computer codes and other TRACE calculations through the ECI (Exterior Communications Interface)
 - CONTAIN modified to support the ECI
 - TRACE will be used to model the ESBWR vessel
 - CONTAIN will be used to model the ESBWR containment
 - The codes will communicate through the ECI
- Status: ESBWR CONTAIN decks has been developed for standalone and coupled calculations. The coupled TRACE/CONTAIN code system is now in the testing and debugging stage.

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TRACE Code Development

- Capability to model advanced BWR fuel designs added to TRACE/PARCS (3d reactor kinetics) code system
- TRACE will be modified to allow modeling coupled reactor/containment problems such as the ESBWR
- Two tasks have been identified that would improve TRACE's capabilities for modeling the ESBWR reactor/containment system:
 - Improve steam-air condensation modeling for the PCCS, ICS, and suppression pool
 - Change energy equation to an enthalpy based formulation to improve energy conservation in flows across junctions with large pressure differences
- Status: Containment related code modifications have started. Condensation work is scheduled to be completed in September 2003. The energy equation work is scheduled to be completed in January 2004.

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TRACE Code Assessment

- TRACE and TRACE/CONTAIN will be assessed against data applicable to the ESBWR design
 - Integral Tests
 - PUMA
 - PANDA
 - Separate Effects
 - PUMA and other condensation tests
- Status:
 - PUMA standalone TRACE model has been run (at Purdue University) for MSLB test - Several code bugs/deficiencies have been identified
 - PANDA TRACE model and PUMA TRACE/CONTAIN model under development in house
 - PANDA TRACE/CONTAIN model and separate effects test TRACE models will also be developed

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PUMA/ESBWR Scaling Study

- PUMA was designed to be a scaled SBWR integral test facility
- ESBWR containment differs from SBWR containment
 - Topologically (GDCS is now in the wetwell)
 - Non-dimensional scaling ratios
- Scaling study underway
 - Evaluate the scaling distortions that exist in the present facility
 - Determine modifications necessary to make PUMA a well scaled integral ESBWR test facility
- Status: Preliminary results will be available at the end of August 2003

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PUMA Confirmatory Testing

- PUMA test data will be used for TRACE/CONTAIN code assessment
- Modifications are currently underway to connect the GDCS tank to the wetwell
- Additional modifications may be needed based on conclusions of ESBWR/PUMA scaling study
- Integral Effects Tests will be performed to examine difference in system performance between the wetwell and the drywell GDCS configuration
- Separate Effects Tests will be performed to study tube and suppression pool condensation
- Status:
 - Integral testing planned to start in August 2003
 - Separate effects testing planned to start in September 2003.
 - Decision on additional facility modifications and testing will be made this fall after the results of the scaling study are complete.

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ESBWR Severe Accident Analysis

- ▶ ESBWR MELCOR Model under development
- ▶ In-vessel melt retention and other severe accident management strategies will be analyzed
- ▶ Status: Analysis will begin during the design certification phase

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ESBWR RES Program Summary

- ▶ Most of the ESBWR pre-application work is on schedule
- ▶ RES activities in support of the design certification are scheduled to be completed in time to support the ESBWR design certification
- ▶ Additional RES activities will probably be identified as GE submits additional information for review (e.g. ATWS and Stability)

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