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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
(ACRS)

SUBCOMMITTEE ON THERMAL-HYDRAULIC PHENOMENA

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OPEN SESSION

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THURSDAY,

NOVEMBER 14, 2002

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ROCKVILLE, MARYLAND

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

COMMITTEE MEMBERS:

GRAHAM B. WALLIS, Chairman

SANJOY BANERJEE, Consultant

THOMAS S. KRESS, Member

FREDERICK MOODY, Consultant

VICTOR H. RANSOM, Member

VIRGIL E. SCHROCK, Consultant

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1 ACRS STAFF PRESENT:

2 PAUL BOEHNERT, Staff Engineer

3

4 ALSO PRESENT:

5 KEN CARLSON, Framatome ANP

6 RALPH CARUSO, NRC

7 HUEIMING CHOW, Framatome ANP

8 SARAH E. COLPO, NRC

9 JERRY HOLM, Framatome ANP

10 RALPH R. LANDRY, NRC

11 JAMES F. MALLAY, Framatome ANP

12 ROBERT MARTIN, Framatome

13 BILL NUTT, Framatome ANP

14 LARRY O'DELL, Framatome ANP

15 YURI ORECHWA, NRC

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C-O-N-T-E-N-T-S

1

2 NRR Presentation, Safety Evaluation Report

3 for S-RELAPS Realistic LB LOCA 837

4 A. Code Review Results,

5 R. Landry, NRR 838

6 B. Uncertainty Analysis Methodology,

7 Y. Orechwa, NRR 868

8 C. Staff Parametric Studies, S. Colpo, NRR . 939

9 D. SER Conclusions, R. Landry, NRR 959

10 Framatome Response to NRR, Dr. Nutt 978

11 Adjournment 1036

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

(8:31 a.m.)

CHAIRMAN WALLIS: This is a continuation of the meeting of the Thermal Hydraulics Subcommittee of the ACRS. And we're going to continue our investigation of the Framatome S-RELAP5 Realistic LB LOCA Code.

I have a request from Jim Mallay to start us off this morning.

MR. MALLAY: Thank you, Mr. Chairman.

I'm Jim Mallay. I'm Director of Regulatory Affairs for Framatome. And I just wanted to say a few words about yesterday's discussion.

Specifically, a number of you had mentioned that -- and I guess I'd say insisted on the fact that our documentation be presented a little more clearly. During that discussion, I think you provided a different perspective on how our documents are read. Specifically, we need to better communicate to knowledgeable third parties about how we actually apply our equations.

In some respects, the discussion yesterday was a little frustrating for us from Framatome for two reasons. First, we expended a great deal of effort in preparing excellent documentation. In fact, the NRC

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1 staff complimented us on several occasions about the
2 clarity and completeness of the documents we
3 submitted.

4 Second, those of us who are here attending
5 this meeting have a reasonably thorough understanding
6 of the implementation of the methodology. Therefore,
7 I guess I'd have to admit that we had a bit of a blind
8 spot concerning your comments about not adequately
9 communicating what we have done in the model.

10 As the discussion proceeded, we realized
11 you were exactly correct however. We assumed too much
12 on the part of the reader. Therefore, Framatome will
13 correct this situation. Because of the work involved,
14 obviously, to change this extensive documentation and,
15 of course, our ongoing obligation to fulfill many of
16 our contracts, the revision process cannot be
17 accomplished in the near term.

18 Just so you understand a little bit about
19 our overall strategy, we plan to expand the use of S-
20 RELAP5 to all of our thermal hydraulic safety
21 analyses. Assuming acceptance of this realistic LOCA
22 model, our next step is to apply the S-RELAP model to
23 BWR non-LOCA analysis. Subsequently, we will then
24 plan to apply this model to LOCA analyses for BWRs,
25 and eventually to a realistic LOCA application. We

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1 therefore envision a series of future submittals based
2 on this same basic platform.

3 Getting back to our commitment, however,
4 we plan to revise the theory manual, which is EMF-
5 2100, which presents the equations and how they're
6 applied. This will be done prior to the next formal
7 submittal of the S-RELAP code. Specifically, we will
8 provide a revised report to the NRC at a time that is
9 sufficiently prior to our next formal submittal of S-
10 RELAP so that final clarifications can be incorporated
11 at that time.

12 Our goal is to present the equations
13 actually used, including the loss factors, which you
14 will see later on are so very important to the success
15 of the model, and how two-phase flows are handled. We
16 will explain more clearly the conversion of the
17 complex geometries that we talked about yesterday to
18 the one-dimensional straight-line approach used in S-
19 RELAP5. Other similar changes will be made to help
20 the reader fully understand the implementation of the
21 model.

22 So I guess in conclusion, I appreciate
23 your pointing out some of the shortcomings in how
24 we've explained how the model is actually put
25 together. So, we will fix that.

1 CHAIRMAN WALLIS: All right. Thank you
2 very much. So we will see this documentation again?

3 MR. MALLAY: Yes.

4 CHAIRMAN WALLIS: I can't resist reminding
5 you that we had this conversation the last time or the
6 time before. There were some promises to improve
7 documentation when we first saw it, and that was I
8 think a year or two ago.

9 MR. MALLAY: That is true. We've had this
10 discussion on at least two previous occasions. I
11 think the context, or at least from my point of view,
12 the context of the conversation was a little
13 different. It was more toward the theoretical basis
14 of the equations, which of course we went over in some
15 detail yesterday.

16 I think the perspective we got yesterday
17 was how do you really use these equations in the
18 model? And I think that's the first time I really got
19 that message. So, that's what we'll do.

20 CHAIRMAN WALLIS: Well, certainly I think
21 also there should be more attention to -- what
22 approximations are being made? And there appears
23 sometimes to be a claim that some equation is just
24 truly basic and general when it is not. It's limited.
25 Maybe it's appropriate, but it's not the basic general

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1 equation.

2 MR. MALLAY: That's certainly true.

3 CHAIRMAN WALLIS: Okay.

4 MR. SCHROCK: So, Graham, I'd just like to
5 say to Jim that I found the preparation for answering
6 questions that I posed in writing was woefully
7 lacking. And the person who made the presentation was
8 not familiar with the issues involved. The nature of
9 the response was a series of rather vague view graphs,
10 which didn't even put them in the context of the
11 questions that had been posed.

12 So, I mention that because that's what I'm
13 going to say in my report. I don't think there was an
14 adequate response to questions, which in fact are
15 serious questions.

16 MR. MALLAY: Okay. We understand what
17 you're saying. There may have been some lack of
18 appreciation about what the questions were in
19 themselves. But, we understand.

20 MR. SCHROCK: Well, the way to resolve
21 that is to ask for clarification if the questions are
22 unclear.

23 MR. MALLAY: We understand.

24 CHAIRMAN WALLIS: So are we ready now?

25 DR. MOODY: On the upside, I want to

1 appreciate the answers that were given to my couple of
2 questions on the early blowdown. I never was quite
3 sure what had been done in RELAP to fix that problem.
4 One of my questions did not apply on part forces, but
5 at least I felt like that was well ordered. And I
6 felt much better after the explanation.

7 CHAIRMAN WALLIS: So are we ready to
8 proceed with the original plan?

9 I understand we're going to get an
10 overview of the code, and why it's good, and why it
11 works, and how it's been assessed.

12 MR. HOLM: Graham, this is Jerry Holm. We
13 were also asked a question about the use of the
14 Forslund-Rohsenow equation.

15 CHAIRMAN WALLIS: Oh, yes.

16 MR. HOLM: It's not on the agenda, but we
17 thought we'd --

18 CHAIRMAN WALLIS: Want to do that first?

19 MR. HOLM: -- do that first.

20 CHAIRMAN WALLIS: Yes, please do that.

21 MR. HOLM: Okay, so Ken Carlson will do
22 that.

23 CHAIRMAN WALLIS: The next time I see
24 Warren Rohsenow, I've got to ask him what he thinks of
25 this equation.

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1 MR. CARLSON: Basically, the -- well, I
2 have it written down that the question was --

3 COURT REPORTER: Excuse me. Are both
4 switches on?

5 MR. CARLSON: Oh. Sorry.

6 We're going to discuss the applicability
7 of the Forslund-Rohsenow of dispersed flow film
8 boiling. I believe the question was: Why is
9 Forslund-Rohsenow a dry-wall contact model? So, I'll
10 briefly go through the purpose of the Forslund's
11 experiment.

12 Observations by the experimentalists
13 briefly touch on the experimental procedures, and in
14 the end show a plot of Forslund's data compared to
15 T_{min} .

16 COURT REPORTER: If you lean towards this
17 one, it would be much better.

18 MR. CARLSON: Oh, okay. I'm sorry. I'm
19 not qualified to work this. It's pretty obvious on
20 that.

21 And these are just statements that we're
22 taking from the introduction to one of Forslund's
23 papers. Forslund wrote a report that was basically a
24 precursor to the one that was published in the ASME
25 journal.

1 They were interested in looking at
2 previous experimentalists, was looking at film boiling
3 with nitrogen. And so, there was a regime that was of
4 interest because there was a dip in the wall
5 temperature. When they noticed it was around 10 to 20
6 percent quality, they -- you see a break-up of the
7 liquid core into droplets and filaments. And Forslund
8 also observed that the droplets were prevented from
9 touching the surface by what he termed as Leidenfrost
10 effect.

11 He also -- just more verbiage on the
12 terminology. He felt like film boiling is also
13 applied to this high quality region, since it's
14 assumed that a vapor film covers the heating surface.

15 In his last statement, he says it is this
16 high quality dispersed from this region that is the
17 subject of this current investigation. And I put this
18 last statement in because there seems to be some -- or
19 at least maybe an unclear conclusion when he talks
20 about a low quality region that he's applying this
21 heat transfer coefficient to.

22 One of the ways to ensure that he was
23 going to get a high quality of data in the film
24 boiling region, he would measure the minimum heat flux
25 that would support film boiling. And he was going to

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1 run at two different mass fluxes: 70,000 pounds per
2 hour foot squared and 190,000 pounds --

3 CHAIRMAN WALLIS: One of the conditions of
4 the experiment, isn't this more fluid and more
5 pressure?

6 MR. CARLSON: Excuse me. It's nitrogen.
7 He's running at approximately 25 psi.

8 CHAIRMAN WALLIS: And Hynek also used
9 liquid nitrogen?

10 MR. CARLSON: He used liquid nitrogen. He
11 was running at, I think in his report he said -

12 CHAIRMAN WALLIS: Thirty psi.

13 MR. CARLSON: Fifteen psig, which would be
14 about 30, 29 to 30 psia.

15 MR. SCHROCK: Do you have any idea what
16 density ratio that would correspond to? What's the
17 equivalent for water pressure?

18 MR. CARLSON: Well, you know --

19 MR. SCHROCK: You're going to get at that.

20 MR. CARLSON: -- I actually did that
21 slide. It seemed like it was, it was around,
22 saturation around 250, wasn't it? Something like
23 that. I don't really remember. I'd have to look at
24 the presentation I did before.

25 MR. SCHROCK: Thank you.

1 MR. CARLSON: But I think it's around 250
2 psi or saturation equivalent to that.

3 So, Hynek followed up on some of
4 Forslund's work, made some observations, and he did
5 calculate a T_{\min} . He did use a different mass flux, so
6 there will be some variation between the T_{\min} that
7 Hyneck reported verses a T_{\min} that you would back out
8 of this. But I don't expect it to be significant.

9 MR. SCHROCK: Was Hynek also nitrogen?

10 MR. CARLSON: Yes. There were three
11 experimentalists. Lavarty was the first, who did film
12 boiling experiments, then Forslund, and then Hynek
13 came in afterwards and summarized some of Lavarty's
14 and Forslund's work. And also extended -- well, he
15 applied Forslund's correlation to water and another
16 fluid. I'm not -- I'd have to look at his paper to
17 report that. He came up with different multipliers,
18 coefficients on the correlation to look at, to make it
19 fit the data for water.

20 Forslund wanted to make sure that he
21 always had a stable film boiling, so they would start
22 off the experiment by first turning on the power to
23 the test section, and run it up to approximately room
24 temperature since that was way above the Leidenfrost
25 temperature, then instigate the nitrogen flow.

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1 And it would basically go through CHF in
2 the apparatus, or in the valve mechanism before heat
3 would get into the test section. So, they had stable
4 film boiling throughout the experimental test section.

5 Now, I have -- there's an error on the
6 slide. It should be T_{min} . And it's approximately 220.
7 T_{sat} was about 150 ranking, 150, 160. And all of his
8 data even at the low flow rates are way above it. The
9 T_{min} that he measured --

10 DR. BANERJEE: What are the units of
11 temperature?

12 MR. CARLSON: Rankines.

13 CHAIRMAN WALLIS: It just seemed to me
14 that T_{min} wasn't a magic constant, but it should depend
15 upon the velocity and various other things.

16 MR. CARLSON: Right. The correlations
17 I've seen for T_{min} have been cast in terms of latent
18 heat of vaporization and heat capacity, surface
19 tension.

20 CHAIRMAN WALLIS: They have gravity in
21 them. Some of them have gravity in there, which would
22 seem inappropriate in force convection.

23 MR. CARLSON: Pardon me?

24 CHAIRMAN WALLIS: Some of them have
25 gravity in the T_{min} as if it were sitting on a flat

1 surface.

2 MR. CARLSON: That's right.

3 CHAIRMAN WALLIS: But this is a force
4 convection experiment, which seems the mechanism is
5 completely different. It would be the same in outer
6 space as it would be on earth.

7 So, I will never believe a T_{\min} that has a
8 "g" in it for a force convection experiment, although
9 quite often it does.

10 MR. CARLSON: Quite often it does. Well,
11 quite often film boiling correlations have "g" in it
12 as well.

13 CHAIRMAN WALLIS: I know. Wrongly, they
14 use it wrongly.

15 MR. CARLSON: We're applying it to a
16 vertical --

17 CHAIRMAN WALLIS: It seems nautically
18 inappropriate. Do the experiment in space you get the
19 same answer.

20 MR. CARLSON: Yes. Let's assume -- I have
21 assumed anyway that the part of the coefficient in
22 front of film boiling style coefficients is to account
23 for gravity and really shouldn't be there.

24 CHAIRMAN WALLIS: So all these
25 temperatures are way above T_{\min} in these tests, right?

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1 MR. CARLSON: Yes. The two test series he
2 ran at two different heat fluxes -- or four different
3 heat fluxes: 20,000 BTUs per hour foot squared, 15,
4 10, and 5. He measured -- well, actually he measured,
5 under his flow rate conditions and under his test
6 conditions, a T_{\min} . The T_{\min} would come in at -- was it
7 what, 3200?

8 CHAIRMAN WALLIS: Those asymptotes are for
9 vapor alone I take it?

10 MR. CARLSON: I believe so, yes.

11 CHAIRMAN WALLIS: Then he correlated his
12 data in some dimensionless form that was mechanistic.
13 Then the real question is: How do you take this and
14 apply it to water?

15 MR. CARLSON: Hynek, I believe just fit
16 the data to water using various data sets available at
17 the time. I think Bennett was one of them. And as
18 far as I know, he just looked at what a multiplier
19 was. Rohsenow described a multiplier of K_1 times K_2 ,
20 which was basically an effective compensation for a
21 particular fluid that we were looking at.

22 CHAIRMAN WALLIS: So Forslund had a
23 dimensionless mechanistic correlation, and then
24 someone else checked it and it also worked for water?

25 MR. CARLSON: Changing the coefficients,

1 yes.

2 CHAIRMAN WALLIS: Sô there is work with
3 water, which corroborates this?

4 MR. CARLSON: Well, he didn't run --

5 CHAIRMAN WALLIS: No, Forslund didn't use
6 water. Someone else did.

7 MR. CARLSON: I think Hynek had looked at
8 other data sets, but I don't believe he generated new
9 data sets.

10 CHAIRMAN WALLIS: So your bottom line is
11 that the wall was not wet, is that it?

12 MR. CARLSON: Yes.

13 CHAIRMAN WALLIS: This is important in the
14 precursory cooling and rewet, is that what it is? And
15 the droplets that spit up in front of the quench
16 front?

17 MR. CARLSON: Yes.

18 CHAIRMAN WALLIS: Okay. Any questions?
19 Can we move on?

20 DR. RANSOM: Did you ask this question?

21 CHAIRMAN WALLIS: No.

22 DR. RANSOM: How did this question come
23 up?

24 CHAIRMAN WALLIS: What's the origin of the
25 question?

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1 MR. CARLSON: What's the origin of the
2 question, Jerry?

3 MR. HOLM: This is Jerry Holm from
4 Framatome.

5 This was a question asked of us by the NRC
6 staff. And at this point, we still have not reached
7 agreement with them on this point. That's why it was
8 forwarded to us by --

9 DR. RANSOM: What? On the applicability
10 of this correlation for use in the film boiling
11 review?

12 MR. HOLM: Right. We are still
13 disagreeing that it's a dry-wall contact verses a wet-
14 wall contact.

15 CHAIRMAN WALLIS: But it still gives you
16 the heat transfer coefficient whatever it is. Isn't
17 that --

18 MR. HOLM: We would take a bottom line of
19 "A" -- you know, we used it in our assessments so it's
20 validated that way. And then staff asked us to go off
21 and do a sensitivity study. It turns out that it is
22 actually not very important. If you set the
23 coefficient to zero, it only affects the PCTs by a few
24 degrees.

25 So, I think at this point we're agreeing

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1 to disagree on because it's low impact.

2 CHAIRMAN WALLIS: So you're saying if you
3 get steam cooling instead of precursory cooling by
4 film boiling it doesn't make any difference?

5 MR. CARLSON: Yes, not much difference.
6 In the low-flow cases, there is a very small change in
7 PCTs, less than three degrees.

8 In the high-flow cases, there was a bit
9 more. Forslund-Rohsenow is more important for, once
10 you turn it over to the PCT, it acts as the precursor
11 for quenching. So without Forslund- Rohsenow, you
12 change it to either never quench in the upper regions
13 of the experiment or quench at such a late time.

14 MR. LANDRY: Dr. Wallis?

15 CHAIRMAN WALLIS: Yes.

16 MR. LANDRY: Ralph Landry from the staff.

17 The reason we disagree with the
18 correlation is not concerning PCT and the actual
19 quench. The point at which we disagree with use of
20 the correlation is when you're at a wall temperature
21 above T_{min} .

22 Reading Forslund and Rohsenow's paper, it
23 very clearly states that the concern here is with
24 dispersed flow film boiling region where heat is
25 transferred from the wall to a possibly super heated

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1 vapor, and from this vapor to liquid droplets.
2 Superimposed on this two-step process is an additional
3 amount of heat that transferred from the wall -- to
4 the wall, directly to the liquid droplets.

5 And the fact that Forslund-Rohsenow
6 experiments were run at extremely high mass fluxes
7 compared to the mass flux that will occur in slow
8 reflood process, the mass fluxes are in order of 10 to
9 100 times the mass flux one would see in the low
10 reflood rate calculation.

11 We have looked at a number of papers. We
12 provided to Framatome a list of 35 papers, and I have
13 18 of them with me right now, which all disagree with
14 use of this correlation that, temperatures above T_{min} .
15 We simply don't agree with them that it is valid when
16 the wall temperature is above T_{min} .

17 We have discussed this matter with
18 Professor Griffith, who is cited in the paper as one
19 of the reviewers. We talked with Pete last week and
20 Pete very strongly disagrees with use of this
21 correlation in rod bundles at these high mass fluxes,
22 and stated that this correlation is a method of
23 desuperheating vapor that should not ever be used in
24 contact with a wall.

25 When we asked Framatome to do the

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1 calculations, we specified that the calculations,
2 which Ken has alluded to, were to set a multiplier on
3 Forslund-Rohsenow to zero when T_{wall} was greater than
4 T_{min} . We are not disputing the correlation when T_{wall}
5 is between T_{min} and the quench. It is when the T_{wall} is
6 above T_{min} that we have the disagreement with use of
7 this correlation.

8 When that is done, it affects the -- and
9 I was going to talk about this this afternoon too.
10 The effect is to raise the temperature on the order of
11 5 to 18 degrees Fahrenheit over the temperature that
12 occurs if you allow Forslund-Rohsenow to be included
13 in the heat transfer model. It extends the quench
14 time, but it has no effect whatsoever on PCT.

15 So on that basis, the staff's position is
16 we do not agree with Framatome on the use of Froslund-
17 Rohsenow above T_{min} . However, the effect is so small
18 that we have agreed to disagree.

19 CHAIRMAN WALLIS: Well, I'm glad you're
20 doing such a thorough job of review. I'm a little
21 puzzled about your statement of T_{min} , that you don't
22 use it above T_{min} because the figure we just saw showed
23 all the data points way above T_{min} . And, I thought the
24 whole idea of the correlation was to provide a
25 correlation when you were above T_{min} rather than below

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1 it.

2 MR. LANDRY: Our reading of a number of
3 the other papers dealing with dispersed flow film
4 boiling indicates that the Forslund-Rohsenow
5 correlation should not be used above T_{\min} and you
6 should rely on other heat transfer mechanisms.

7 CHAIRMAN WALLIS: But you saw the figure
8 though just now, and all the data are way above T_{\min}
9 So, I'm puzzled. But I haven't seen all these papers.

10 MR. LANDRY: But those figures were taken
11 at very low temperatures. This was done with liquid
12 nitrogen in a small tube. And it is now being applied
13 to water at very high temperature in a bundle.

14 We do not feel that this can be directly
15 taken from the experimental conditions to the
16 conditions that occur --

17 CHAIRMAN WALLIS: Well, you can work it
18 out with Framatome. We're not being asked to give an
19 opinion on this particular issue.

20 MR. LANDRY: That's why the staff's view
21 is that we have simply agreed to disagree that this
22 does not affect PCT. It only affects the time to
23 quench and has a minimal effect on the temperature
24 beyond --

25 CHAIRMAN WALLIS: It doesn't affect it for

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1 this particular application. You might for other
2 applications have to examine it more carefully.

3 MR. LANDRY: That's right. And that's why
4 we have identified in the SER our disagreement over
5 this correlation.

6 CHAIRMAN WALLIS: Okay.

7 DR. BANERJEE: Ralph, there was an
8 extensive review of this by Yadigaroglu and Andreani.

9 MR. LANDRY: That's one of the papers I
10 have right here.

11 DR. BANERJEE: What was their view of it?

12 MR. LANDRY: They did not --

13 DR. BANERJEE: Did they come up with any
14 sort of suggestion?

15 MR. LANDRY: I'd have to go back and read
16 the exact statement, but they did not agree with use
17 of this correlation about T_{min} .

18 DR. RANSOM: On this figure, the dashed
19 curves are never explained, are they?

20 MR. CARLSON: Oh, the dashed curves.

21 CHAIRMAN WALLIS: Maybe that's a
22 prediction of some sort?

23 MR. CARLSON: I think that's the
24 prediction, but I would have to look at the paper to--

25 DR. RANSOM: Prediction by Forslund?

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1 MR. CARLSON: By his computations, yes.

2 DR. RANSOM: For the nitrogen case or for
3 water?

4 MR. CARLSON: The nitrogen case.

5 CHAIRMAN WALLIS: This is nitrogen. Well,
6 maybe anyone who is interested can get these papers
7 from Ralph and look at them.

8 I think we have to move on with this
9 particular part of the meeting. We'll finish this
10 part and move on to the main schedule.

11 Can we go back to the main plan?

12 MR. BOEHNERT: Okay. Now, I understand we
13 go into closed session, is that correct? So, anyone
14 who doesn't have an agreement with Framatome to be
15 here should leave.

16 And transcriber, we'll go into closed
17 session.

18 (Whereupon, at 8:59 a.m., proceedings went
19 into Closed Session.)

20

21

22

23

24

25

1 CHAIRMAN WALLIS: Okay. Let's go back
2 into open session. We're now going to hear from the
3 staff. Ralph Landry of NRR will start off.

4 MR. BOEHNERT: Oh, by the way. Just for
5 everybody's information, we are in open session now.

6 CHAIRMAN WALLIS: Are we going to be
7 closed any --

8 MR. LANDRY: Thank you, Dr. Wallis. I am
9 Ralph Landry, from NRR.

10 THE REPORTER: Excuse me. Do you have
11 your mike on?

12 MR. LANDRY: Yes.

13 THE REPORTER: There's two switches on
14 there.

15 MR. BOEHNERT: There's two switches on
16 there, Ralph. Make sure both are in the on position.
17 Try it now.

18 MR. LANDRY: Is that better?

19 DR. BANERJEE: Move the thing a little bit
20 to the right or middle.

21 MR. BOEHNERT: Oh, wait a minute. Mine
22 are straight. You don't have it lined up straight.
23 There we go.

24 MR. LANDRY: This okay?

25 MR. BOEHNERT: That's good.

1 MR. LANDRY: You're sure, Paul?

2 MR. BOEHNERT: I'm sure. That's really
3 good.

4 CHAIRMAN WALLIS: But you passed the first
5 two tests. Now, we'll get on with the serious part.

6 MR. LANDRY: Well, that's definitely --
7 that was sure the whole content of what I was going to
8 do. Now, the next speaker will be --

9 (Laughter)

10 MR. LANDRY: I'm Ralph Landry. I'm from
11 NRR and today I'm going to be presenting a summary of
12 the staff's Safety Evaluation Report on the Framatome
13 ANP S-RELAP5 Realistic Large Break LOCA Methodology.

14 Today, I want to go through just a brief
15 review of some of the milestones we reviewed. There
16 are some members here and consultants who were not
17 involved in the early stages. So I'd like to just
18 highlight some of the milestones, not spend a lot of
19 time on that.

20 I'm going to talk a little bit about the
21 SER structure in particular, then give an overview of
22 some of the thermal-hydraulic review. We'll have a
23 review of the uncertainty analysis and a discussion of
24 some of the staff parametric studies that were
25 performed and our conclusions to date.

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1 The staff that have been involved in this
2 review include myself, Sarah Colpo, who has done a
3 great part in looking at parametric studies and
4 looking at some of the internal coding, and reviewed
5 some of the material internal to the code.

6 Tony Attard assisted with review of much
7 of the transfer modeling that's in the code. We had
8 Yuri Orechwa reviewing the uncertainty analysis and
9 statistical approach, and Len Ward, from ISL,
10 Incorporated, assisted us with general overview of
11 thermal-hydraulics in the code.

12 A brief overview of some of the
13 milestones. We received the documentation and the
14 code in August of 2001. Just over a year ago we began
15 this review. We've provided acceptance letter on the
16 code to Framatome in October of 2001.

17 The acceptance letter is merely a
18 statement that, yes, there is sufficient material here
19 to permit us to perform a review. It is not
20 acceptance of the code or acceptance that anything
21 there is correct.

22 It's simply a statement that there is
23 sufficient material to proceed with the review.
24 Framatome made presentations to the staff in October
25 and to the ACRS Thermal-Hydraulic Subcommittee in

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1 January of 2002.

2 We issued the full set of RAIs to
3 Framatome in July of 2002. Framatome prepared their
4 responses in August. We were meeting on the draft SER
5 yesterday and today with the subcommittee, and our
6 intention was to go to the full committee in December
7 of 2002, and to issue the final SER in December.

8 Now, this is assuming that we resolve some
9 of the issues we talked about this morning. The
10 structure of this Safety Evaluation Report, in
11 performing a review of a code of this nature you have
12 to keep in mind that the review we do is not of every
13 single detail in the code, and every single detail in
14 methodology.

15 We simply do not have the staff, the time,
16 the capability to perform a review of that nature.
17 What we do is perform a review of select portions of
18 more of snapshot views of parts of the documentation,
19 parts of the code, parts of the modeling, parts of the
20 uncertainty analysis, assessment and so on.

21 We are not in the position to review every
22 single detail. If we were doing that, that would be
23 performing the quality assurance function, which the
24 applicant must perform on their own. So we have to
25 keep in mind that when we perform this review and what

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1 we report in the SER is a snapshot of parts of the
2 code and parts of the documentation and the
3 methodology that's followed.

4 The SER follows the format that is
5 described by CSAU. This morning Larry O'Dell from
6 Framatome went through step by step the CSAU process.
7 This is the material contained in NEWREG-5249. It
8 defines a 14-step process by which a methodology is
9 presented and determined to satisfy the requirements
10 of 50.46, and determine what the uncertainty is in
11 that methodology.

12 The SER provides an overview of the PIRT
13 structure. We give an overview of the thermal-
14 hydraulic phenomena modeling that we've reviewed.
15 Again, this does not cover everything we review. This
16 is only giving an overview of select parts of our
17 review.

18 If we provided detail of everything we
19 reviewed our SER would be several hundred pages long.
20 So we're trying to be reasonable. And we give an
21 overview of selected assessments. We give an overview
22 of some of the coding examination which was performed
23 and some of the parametric studies which we perform,
24 and we give an overview of the uncertainty
25 determination methodology and the conclusions by the

1 staff.

2 You've heard a great deal today already
3 about the PIRT. So I don't want to go through too
4 much detail on what the PIRT contains. A Phenomena
5 Identification and Ranking Table was developed and
6 included in the methodology report.

7 The omissions of NEWREG-CR-5249 have been
8 included in the PIRT. Those things that were omitted
9 in the standard PIRT developed for the new reg have
10 been fulfilled and included in the PIRT developed and
11 supplied by Framatome.

12 Specifically, the PIRT does address the
13 hot bundle containing the hot rod, as we discussed
14 this morning. The plant calculations are done at a
15 realistic peak linear heat generation rate.

16 The standard PIRT was done at a linear
17 heat generations rate down at around five kilowatts
18 per foot, five to seven to nine, somewhere in that
19 range, and we expect plants to be more in the range of
20 the teens, 12, 14, 15 kilowatts per foot.

21 Calculations have been performed at the
22 realistic and at low containment back pressures. This
23 is an issue which was discussed somewhat this morning
24 and which we do discuss in the SER, and that is the
25 downcomer boiling question that can occur, especially

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1 at low containment back pressures.

2 The PIRT that is presented represents
3 phenomena according to the transient phases, blowdown
4 phase, refill, reflood, post-CHFE transfer phase,
5 reflood heat transfer and rewet. As you also heard
6 this morning, a frozen code version has been provided
7 and has been specified.

8 This was a concern that was raised a few
9 years ago in our code review that we were performing
10 when we discovered that a code that we were reviewing
11 was not frozen.

12 In fact, the code was undergoing major
13 revisions, a major revision in very fundamental
14 aspects, which made it very difficult because we
15 realized at that point that we were reviewing a moving
16 target, and it's very hard to review a moving target.

17 So we've been very, very adamant with some
18 of the vendors that has come in since that point that
19 we will not even begin a review until they assure us
20 that the code we are reviewing is a frozen code
21 version. And Framatome identified and indicated this
22 morning the version of the code which has been
23 supplied for this review.

24 Our SER very specifically states that we
25 have reviewed the S-RELAP5 MOD2 and then identifies

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1 the version of the code. That is to insure that when
2 our SER is picked up and applied, people understand
3 that our review approval is for this specific version
4 of the code and no other.

5 Framatome ANP has provided documentation
6 on the frozen code version, such that evaluation of
7 the code's applicability to the postulated large break
8 LOCA transient scenario could be performed.

9 I will have some more comments on the
10 documentation. I know comments were made this morning
11 regarding documentation. Comments were made based on
12 presentations yesterday, and there's some
13 dissatisfaction.

14 We have pointed out also that there are
15 areas where the documentation needs to be repaired,
16 and indeed, Framatome has committed to make changes in
17 documentation based on some of the things that we
18 discovered.

19 I'd like to turn to some of the thermal-
20 hydraulic models that we've looked at. The heat
21 transferring modeling was evaluated by requesting that
22 Framatome identify the heat transfer correlation used
23 from transient initiation to quench at the hotspot.

24 Specifically, what we are interested in:
25 those of us that have been involved in code work for

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1 a number of years have looked at some of the code
2 results and code modeling techniques and realized that
3 one thing that we don't recall ever seeing was a code
4 modeler take a transient, whatever transient it might
5 be, and follow it from the beginning of the transient
6 to the end of the transient, the heat transfer
7 correlations that are being invoked throughout the
8 transient, what correlations are being brought in and
9 are those correlations being used within their range
10 of validity.

11 And to do that we said, identify to us
12 time-wise throughout the transient what correlations
13 you're using, what are the sources of the data and the
14 range of validity of the correlations and what are the
15 parameters that exist when you're invoking those
16 correlations throughout the transient so that we can
17 see that the correlations are being used properly with
18 correlations that are being used within an accepted
19 range of validity.

20 In doing this, Framatome, as one of the
21 thoughts, provided this diagram which shows for the
22 hotspot the mesh point temperature versus time, and
23 this is looking at a void fraction range over the
24 time.

25 It's not looking at specific void fraction

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1 at a specific time, but what is the average void
2 fraction over a time interval. So we can see that
3 throughout the transient, small time steps were the --
4 where we see major changes in void fracture, what are
5 the void fractures that are occurring at the hotspot.

6 Now, correlated against this in the
7 documentation is a table listing time step, time
8 block, void fraction, heat transfer correlation, the
9 data range of validity for that correlation and the
10 data parameters, the phenomenal parameters that exist
11 in -- during those time blocks for the entire transit.

12 We were able to go through this and then
13 look at the material and say, gee, there are a couple
14 of these correlations that are outside -- or we think
15 are outside the range of validity.

16 We began a series of discussions with
17 Framatome and they were able to come back and show us
18 that through further assessments that they had
19 extended the range of validity of some of the
20 correlations through assessment cases that were run.

21 So we said, okay, those correlations, even
22 though they might appear to be outside their initial
23 range of validity, are within a range of validity
24 because they've been assessed against other data.

25 DR. KRESS: Now, is this for a given break

1 size?

2 MR. LANDRY: This is -- yes. This was --
3 I didn't write down which break size this was. This
4 was the break that resulted in the peak cladding
5 temperature. This is that --

6 DR. KRESS: That was the one that ended up
7 with the heat point.

8 MR. LANDRY: Correct.

9 DR. KRESS: So as you move across in time
10 -- oh. As you move across in time you're looking at
11 different locations in the core? Those are not all
12 one location?

13 MR. LANDRY: No. These are at that one
14 mesh point. This is at the --

15 CHAIRMAN WALLIS: It's all at the peak
16 clad temperature --

17 MR. LANDRY: This is at the mesh point at
18 which the peak clad temperature occurs.

19 DR. KRESS: It finally occurred.

20 MR. LANDRY: So what you're looking at is
21 the temperature trace --

22 DR. KRESS: Of that particular node.

23 MR. LANDRY: -- at that point through
24 time.

25 DR. KRESS: Okay.

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1 MR. LANDRY: We tried to figure out what
2 is the valid way to determine what correlations are
3 being used, and felt that if you take the point at
4 which peak clad temperature or the node at which peak
5 clad temperature occurs from the start to the end of
6 the transient, what correlations are coming in, but
7 then we added onto this.

8 There are other plots and so this is only
9 one. They then showed us plots for that rod, the hot
10 rod, up and down the rod what are the correlations
11 that are occurring at the time of peak cladding
12 temperature, so that you can see -- this is the PCT
13 time.

14 This is the -- this gives us the void
15 fraction. We can go back and check the void fraction
16 and see what correlations are being used there. But
17 we can also look up and down the rod because you know
18 that there is quenching occurring at some point in the
19 rod at that particular time, and what correlations are
20 being used up and down the rod, also, so that you have
21 correlations versus time, or there's a hotspot and
22 correlation versus distance up and down the rod at the
23 time of peak, also.

24 We were trying to get a handle on, in a
25 almost global sense, what is going on in the code at

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1 the highest temperature mesh point. Is what is going
2 on reasonable? Are the correlations that are being
3 used, being used correctly?

4 DR. BANERJEE: Are those different
5 hatchings, just different phases or what is the --

6 MR. LANDRY: The different hatchings are
7 indicated over here in the legend.

8 DR. BANERJEE: Right.

9 MR. LANDRY: They indicate the different
10 void fraction ranges.

11 CHAIRMAN WALLIS: Okay.

12 DR. BANERJEE: The first one goes from
13 zero to one, right? Or does it?

14 MR. LANDRY: That's just in this very
15 narrow time.

16 DR. BANERJEE: Right.

17 MR. LANDRY: In this very narrow time --

18 DR. BANERJEE: They've what?

19 MR. LANDRY: This is the blowdown period.

20 DR. BANERJEE: Right.

21 MR. LANDRY: You're blowing -- you're
22 decompressing the system so you're going from water
23 solid to total steam. After that point, though, the
24 ranges on the void fraction become very narrow.

25 DR. BANERJEE: But what is distinguishing

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1 each hatched area?

2 CHAIRMAN WALLIS: They're going up or
3 down.

4 DR. BANERJEE: They overlap.

5 CHAIRMAN WALLIS: The trend is up or down,
6 it seems to me; are they climbing the mountain or
7 going down the mountain. They're on the top.

8 DR. BANERJEE: I see.

9 MR. LANDRY: But really, it's showing you
10 the way the void fraction is going up and down at the
11 hotspot throughout the transient.

12 CHAIRMAN WALLIS: But it's hardly varied
13 at all. It's between .98 and 1 or something, most all
14 the time.

15 MR. LANDRY: Which is a --

16 CHAIRMAN WALLIS: Very high -- very high
17 void fraction.

18 MR. LANDRY: Which is a very good
19 conclusion that you can see that you have at the
20 hotspot an almost totally voided system for the entire
21 period of the transient until you quench the rod. At
22 this point the void fraction starts dropping very
23 fast, because you're quenching.

24 Quench front is approaching. Once you hit
25 quench you drop very rapidly.

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1 CHAIRMAN WALLIS: Now, is this all the
2 same equation that describes this heat transfer?

3 MR. LANDRY: No. These are -- each of
4 these -- there's a different correlation in each of
5 these --

6 CHAIRMAN WALLIS: In each of these regions
7 a different correlation? But the void fraction's much
8 the same in most of the regions.

9 MR. LANDRY: The void fractions vary a
10 little bit and different correlations are being
11 brought in. We raised a number of questions on the
12 correlations, and as we got into the discussion this
13 morning, discussion of Forslund-Rohsenow, because
14 there are different heat transfer modes occurring in
15 each one of these void sections.

16 MR. CARUSO: This is Ralph Caruso. I'm
17 just going to help Ralph Landry out a little bit.
18 He's got void fraction plotted up there, but there's
19 a lot of other things that are going on. Flow rates,
20 mass flow rates up through the channels are also
21 changing quite a bit, and these also affect the heat
22 transfer readings and the correlations that are used.

23 So although he's just got void fraction
24 here plotted, realize there's a lot of other stuff
25 that's changing at the same time.

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1 DR. BANERJEE: So is there a typical
2 correlation which is being exercised in each of these
3 regions, or is it all Forslund-Rohsenow, all this?

4 MR. LANDRY: No. There are --

5 DR. BANERJEE: So it's different --

6 MR. LANDRY: -- there are a fair number of
7 them.

8 MR. CARUSO: If you look -- let's see.

9 MR. LANDRY: I did not put a listing of
10 all of the correlations up here because that
11 material's proprietary. We wanted to keep the
12 discussion here open.

13 DR. BANERJEE: Okay.

14 MR. CARUSO: I'm looking at one of the
15 RAIs and I've got one, two, three, four, five -- I
16 think about five different correlations coming in and
17 out.

18 DR. BANERJEE: Okay. We can find out
19 details later.

20 MR. LANDRY: You can look in the RAI
21 answers.

22 DR. BANERJEE: Right.

23 MR. LANDRY: This is from RAI No. 2. If
24 you read the response to RAI No. 2 and then Action
25 Item 1 or Action Item 2, you get even more detail of

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1 what is occurring.

2 CHAIRMAN WALLIS: So your documentation
3 has spelling errors in it.

4 MR. LANDRY: Oh, okay. I switched over
5 and instead of using Word Perfect to prepare these I
6 was using one of Bill Gates' products.

7 (Laughter)

8 MR. LANDRY: Which does not do spell-
9 checking. PowerPoint does --

10 DR. BANERJEE: Oh, PowerPoint doesn't.

11 MR. LANDRY: PowerPoint does not do spell-
12 checking for you as you move along. So I'll say a
13 comment that was similar to one said this morning by
14 the applicant when they were asked about a bunch of
15 dark lines in a figure.

16 I think if you look at the mis-spelled
17 words throughout the document, it spells out, "We love
18 Bill Gates." The dominant phase in large break LOCA
19 is reflood, and in particular disperse flow film
20 boiling heat transfer.

21 And we're going to talk more about the
22 reflood in a little bit when Sarah Colpo comes up in
23 some of the studies that she has done. The applicant
24 switched, as you heard this morning, from using the
25 more common Dittus-Boelter correlation to the

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1 Sleicher-Rouse correlation.

2 We spent a time looking at that
3 correlation. We asked for a copy of the paper and we
4 had questions on the uncertainty analysis for that
5 correlation, because everybody knows Dittus-Boelter.
6 It's been around for years.

7 The dispersed flow regime uses Bromley and
8 Forslund-Rohsenow, but interpolates between the two
9 over a particular range.

10 CHAIRMAN WALLIS: Bromley is one of those
11 anomalous correlations that has gravity in it,
12 although this is forced convection?

13 MR. LANDRY: Yes.

14 MR. SCHROCK: Bromley was really analysis.
15 It wasn't correlation, but it was for a different
16 problem.

17 MR. LANDRY: Yes.

18 CHAIRMAN WALLIS: Yes.

19 MR. SCHROCK: Film boiling on a horizontal
20 cylinder.

21 MR. LANDRY: I think Professor Schrock is
22 trying to get me on my soapbox right now.

23 MR. BOEHNERT: But you're not taking the
24 bait, right?

25 (Laughter)

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1 MR. LANDRY: Well, the dispute -- the
2 discussion we had this morning on an application of
3 Forslund-Rohsenow brings up a concern that the staff
4 has, and that's a concern with using the right
5 correlation at the right time and for the right
6 reasons.

7 We went through a long discussion on this,
8 this morning. One of the problems that we see with
9 Forslund-Rohsenow, one, it's a correlation model that
10 was developed for liquid nitrogen in a tube at a very
11 high mass flux and a low void fraction.

12 You see a correlation that is now being
13 applied for water in a channel between rods at low
14 mass flux at very high surface temperatures. The
15 difficulty I have is you're taking a correlation
16 developed for one fluid and applying it to another at
17 a significantly different surface tension,
18 significantly different viscosity, significantly
19 different latent heat vaporization and you're saying
20 that these bubbles -- or excuse me -- these droplets
21 that may be a different size are able to penetrate a
22 thermal boundary layer at a much lower velocity and
23 much less turbulence.

24 This just doesn't make sense. One of the
25 difficulties that we see in the heat transfer models

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1 is a lot -- and everybody uses these. It's not unique
2 to Framatome. We're seeing heat transfer models that
3 are used, that are developed for boiling in a radiator
4 of an automobile.

5 We see models using correlations that are
6 developed for Freon, liquid nitrogen, inside various
7 sized tubes and even capillary tubes, all of these
8 things being applied to flow in a rod bundle.

9 One of the important programs, at least in
10 my view, is to look at the work that you heard about
11 Tuesday afternoon that Dr. Hochreiter is doing at Penn
12 State. He is doing work on reflood heat transfer in
13 a more or less prototypical rod bundle configuration
14 using water at typical flow rates and typical wall
15 super heats.

16 So that information is going to be much
17 more prototypical of the kind of phenomena you would
18 see occurring in a rod bundle under reflood
19 conditions.

20 DR. BANERJEE: Why wasn't FLECHT
21 sufficient? I mean, they have a lot of data and
22 stuff.

23 MR. LANDRY: They have a lot of data, but
24 it wasn't really a heat transfer problem. There are
25 some other problems with FLECHT. There was a

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1 tremendous leakage. When we were doing the review of
2 AP600 we raised a number of questions about use of
3 FLECHT and FLECHT SEASET for levels -- two-phase level
4 swell, because it was so hard to characterize leakage.

5 And the same with the G-2 test and some of
6 the other tests. You can look at these tests and get
7 some data, but are they really fundamental heat
8 transfer research data? We spent a great deal of time
9 and a great deal of effort studying ECC performance.

10 But we're still using a lot of heat
11 transfer correlations that go way, way back and were
12 not developed for this particular problem.

13 MR. SCHROCK: Well, there are some other
14 correlations in the literature for rod bundles, but
15 nobody seems to want to use them in codes.

16 MR. LANDRY: I think there is a certain
17 inertia, industrial inertia that these correlations --
18 everybody's using these.

19 MR. SCHROCK: Very large inertia.

20 MR. LANDRY: People are satisfied with
21 them because we're getting globally reasonable
22 results. We're able to predict a lot of the tests and
23 a lot of the separate effects, integral system tests,
24 et cetera, that we use to validate the codes. So why
25 change?

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1 MR. SCHROCK: These things preceded the
2 codes in many instances. ASME has had a series of
3 monograms, heat transferring rod bundles. I edited
4 the first one of those in 1969. So none of these
5 codes existed in 1969, for example.

6 MR. LANDRY: Well, none of these codes
7 existed when Bromley's work was done, either.

8 MR. SCHROCK: Well, people don't look at
9 what's in the literature enough, I think is the
10 problem.

11 MR. LANDRY: This morning --

12 MR. SCHROCK: If the literature wasn't
13 NRC-generated, it doesn't get the same level of
14 attention.

15 DR. BANERJEE: But Forslund and Rohsenow
16 was not NRC-generated, though.

17 MR. SCHROCK: Well, I'm not making any
18 universal comparisons.

19 (Laughter)

20 MR. LANDRY: This morning, one of the
21 questions that was raised concerned material that had
22 been presented by Joe Kelly a few years ago regarding
23 the Lahey correction. Steve Bajorek of research has
24 talked with Joe Kelly about that.

25 Steve, can you enlighten us a little bit?

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1 DR. BANERJEE: These were the experiments
2 where the interfacial area was measured.

3 MR. BAJOREK: Well, I'll try to, Ralph.
4 I mean, I only saw your slide this morning for the
5 first time. But I think what you were alluding to was
6 the problem with the Lahey bubble-pumping model and
7 the sub-cooled boiling correlations.

8 The problem that's associated with that is
9 that when you try to apply that at relatively low
10 pressures, 40, 50 psi or lower, it cannot really split
11 the heat flux between the sensible heating of the
12 fluid and the latent heat very well.

13 The term that's in question is like a rho-
14 L, a liquid density times an enthalpy difference, a
15 delta enthalpy over a -- on top of a rho-G H-sub-FG.
16 At high pressures it seems to do a reasonable job and
17 do a -- and split the heat flux between heating of the
18 liquid and vapor generation relatively well.

19 However, when you get down at low
20 pressures the rho-L over rho-G dominates and until you
21 get to a -- almost a saturation, all of your energy is
22 going into heating up the liquid.

23 And all of a sudden, what your code does
24 is switch when you get a low pressures to nearly
25 saturation, to taking all of the energy, putting it

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1 into the liquid phase to all into vapor, and your code
2 acts in a very oscillatory fashion, all the heat going
3 to the liquid and then suddenly all the vapor
4 generation, you get very large voids in your
5 calculation, and that instability is what Joe is
6 referring to.

7 MR. LANDRY: Does that answer your
8 question, Sanjoy?

9 DR. BANERJEE: Yes, it's exactly in line
10 with what I --

11 MR. LANDRY: Okay.

12 DR. BANERJEE: -- my understanding is,
13 that it doesn't give you the right split.

14 MR. LANDRY: This morning you heard from
15 Framatome about the decay heat model that they're
16 using. They're using ANS 5.1 1979 model and they're
17 using it in a conservative fashion. We looked at the
18 counter-current flow limit model that is used in the
19 code and felt that the CCFL model was being used fine
20 in the core, but there's no CCFL model in the
21 downcomer.

22 We had a number of questions and spent
23 quite a bit of time speaking with Framatome about the
24 lack of a CCFL model in the downcomer. Our concern
25 was that even though the calculations which they

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1 showed us, showed that they did not have CCFL model --
2 CCFL violation very often in the downcomer, there were
3 a couple of instances in one large plant calculation
4 where they did have CCFL violation, but these were
5 just three short violations of a CCFL.

6 So we felt that it was important that the
7 analyst be alerted and Framatome has agreed to put in
8 the code a flag, so that if CCFL is violated in the
9 downcomer, the analyst will be alerted so that the
10 analyst can determine, is this CCFL violation of such
11 a magnitude that it's going to affect my result, or is
12 it just an instantaneous, very brief violation that's
13 not going to have an affect on the result and it can
14 be ignored.

15 We felt that that is sufficient to simply
16 alert the analyst through the violation of CCFL so
17 that if it is a problem, something can be done. If
18 it's not a problem, it can move along. We did a great
19 deal of looking at boiling in the downcomer, as you
20 heard some talk about this morning.

21 And we've talked about the nodalization in
22 the downcomer. We requested that Framatome go back
23 and renodalize their downcomer from the three node
24 model which they had initially presented, to a six-
25 note and to a nine-node model.

1 In those studies in varying the
2 containment back pressure at the same time, we noticed
3 that there is a less than a 100-degree Fahrenheit
4 change in PCT when you vary the downcomer nodalization
5 back pressure, and the form loss coefficient.

6 So we felt that since the most
7 conservative calculation that they had was the three-
8 node model, that that was acceptable to us. They go
9 to the six-node or nine nodes they go -- they get a
10 lower PCT. So our conclusion was the three-node model
11 which they were using was conservative.

12 Framatome did confirm that they do not
13 include a direct, negative bias and uncertainty
14 methods simulating ECCS bypass, so that they are
15 conservative. This was a concern we had during the
16 review.

17 MR. BOEHNERT: Ralph, what did you mean,
18 they're using ANS 1979 in a conservative manner?

19 MR. LANDRY: They way that the -- the way
20 they've included the actinides, decay heat generation,
21 they've included Plutonium-239, U-238. All the
22 components that they put in are giving a conservative
23 prediction of decay heat. They're not using they're
24 statistical decay heat model.

25 MR. SCHROCK: I understood they make the

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1 assumption that it's all U-235 and infinite
2 irradiation. Is that not true?

3 MR. LANDRY: Yes.

4 MR. SCHROCK: So that's the conservatism.
5 That gives you a higher value than if you have
6 Plutonium contributing.

7 MR. BOEHNERT: Now, if they came in and
8 said they wanted to use ANS 94, would you find that
9 all right?

10 MR. LANDRY: We'd have to re-review it.

11 MR. BOEHNERT: But there's nothing says
12 they can't.

13 MR. LANDRY: If they came in and made the
14 argument, we would review it. I can't say without
15 looking at it.

16 MR. BOEHNERT: No. No. I'm just saying -
17 - yes. I understand.

18 MR. LANDRY: We would review what they've
19 presented.

20 MR. BOEHNERT: Okay.

21 MR. LANDRY: Okay. The uncertainty
22 analysis, I'm going to ask Yuri Orechwa to present to
23 you. After Yuri's presentation we're going to talk
24 about the assessment matrix, and in particular, what
25 we want to talk about is the assessment which we

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1 performed in-house.

2 We looked at the assessment that was
3 provided by the applicant. As I said earlier, because
4 we have to focus on particular parts of the
5 presentation to us, we focus most heavily on our
6 review of the assessment cases, on those that are the
7 latest tests that were run, the SETF, CCTF and UPTF,
8 the NRC sponsored 2D-3D Program.

9 We thought that these were the best data
10 and these are the closest to full scale. So while we
11 looked at the whole assessment that was done, we
12 focused most heavily in our assessment review on the
13 2D-3D assessment cases.

14 We did include spot-checking of the coding
15 and comparison of that spot-check with the
16 documentation, and Sarah will have some words on that
17 later. We found some inconsistencies between --
18 excuse me -- what was coded and what was documented
19 and Framatome has agreed to go back and fix the
20 documentation, because there was documentation errors.
21 We ran --

22 CHAIRMAN WALLIS: Can I go back to that?
23 You mean that the code, what was actually encoded, was
24 not correct?

25 MR. LANDRY: What was encoded was correct.

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1 CHAIRMAN WALLIS: It was the documentation
2 that was wrong?

3 MR. LANDRY: What was written in the
4 documentation was wrong. We included in our review
5 running numerous parametric studies using the S-RELAP5
6 code. Sarah's going to go through those.

7 As was discussed this morning with some of
8 the assessment discussion, Sarah looked at three
9 particular parameters, three sub-routines, which were
10 medium to low priority and one that was a very high
11 priority, according to the PIRT, and found results
12 that are consistent with what we would expect from a
13 high priority phenomenon.

14 CHAIRMAN WALLIS: So you were able to get
15 their code and input text and everything and run it?

16 MR. LANDRY: That's right.

17 CHAIRMAN WALLIS: You had the right
18 platform to run it on?

19 MR. LANDRY: That's right. We were
20 running it on an HP. So I was able to go into the
21 source code, put multipliers in the source code, then
22 recompile the code -- it was in the same compiler --
23 and rerun cases. And Sarah's going to present some of
24 those discussions.

25 This morning there was a lot of time spent

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1 talking about assessment, what is adequate assessment.
2 Unfortunately, what is not done in this country when
3 an assessment is performed is to go to some of the
4 international information that's available.

5 People in this country tend to use certain
6 tests that everybody uses to assess a code. This is
7 particularly troubling because it may be out of a
8 parental view of the assessment.

9 But years ago in Paris while I was working
10 for the Nuclear Energy Agency, Klaus Wolfert and I
11 started a program to determine at that time what was
12 called, how good is good enough, attempted to define
13 what is the proper assessment to perform on a computer
14 code.

15 That work, after I left, was continued and
16 completed under Ralph Caruso while he was in Paris.
17 That work developed massive tables of phenomena that
18 could occur, not only in LOCA but in a number of
19 different transients for PWRs and BWRs, phases that
20 would occur during transience and LOCAs, the phenomena
21 that would occur, the data from all the international
22 projects that could be found, how good are those data,
23 which data directly indicate the phenomena that are
24 being studied and what is the quality of the data.

25 This is a massive effort that is available

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1 to code modelers. And I don't know of any that are
2 using it, at least in the United States. It could
3 easily help out in the discussions like we had this
4 morning of how do you know you've assessed the code
5 enough.

6 How do you know you've assessed properly?
7 By looking at that information that's available and
8 saying, gee, maybe this test that I'm using is not the
9 best test; there is a test in country XYZ that might
10 be better.

11 Now, of course, the difficulty is when
12 you're dealing in the international community, getting
13 the data. The data are not always easily available.
14 One of the complaints -- and you heard part of the
15 complaint this morning -- one of the complaints that
16 has been voiced by the code modelers throughout the
17 world has been the quality of data that are now
18 available.

19 Last May in France when the best estimate
20 code modelers met to discuss the state of best
21 estimate code assessment, virtually every country
22 complained about the same thing. We have all these
23 identified tests and data, but the data are becoming
24 very degraded and very poor.

25 Accessibility of the good quality --

1 qualified data to use for assessment is going downhill
2 fast. Any effort, as Framatome has talked about, of
3 getting data, putting the data on CDs, getting various
4 sets of data from various sources, so that if we have
5 a data set for LOFT test L22, part of it is corrupted,
6 well, if we can get a data tape from somebody else of
7 the same test, maybe that data set is corrupted
8 somewhere else and we can extract the good data from
9 all these different tests and put together a good data
10 set for as many tests as we can before the tapes are
11 all lost. So anyway, that's my soapbox.

12 Next, though, I'd like to turn to a
13 discussion of the uncertainty analysis and turn the
14 floor over to Yuri Orechwa.

15 CHAIRMAN WALLIS: Thank you very much.
16 You'll be back with your conclusions at the end.

17 MR. LANDRY: Of course.

18 (Pause)

19 MR. ORECHWA: Is that going to work?

20 MR. LANDRY: Sure.

21 MR. ORECHWA: Okay. Can you hear me,
22 lady? Okay. What I'm going to discuss is the
23 construction of S-RELAP5, realistic large break LOCA,
24 best estimate analysis methodology. In the words of
25 Bette Davis, fasten your seatbelts, we're in for a

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1 bumpy, bumpy ride.

2 All right. To start, let me remind you
3 what we were supposed to review. In the words of
4 Framatome, the basis of the analysis is the entire
5 methodology, not just the code. I think for the last
6 day or so you've been beating to death the code.

7 Let's talk a little bit more about the
8 methodology. Framatome says the methodology is
9 statistics-based. Okay. Given they're statistics-
10 based, they are going to use a non-parametric
11 statistical approach.

12 I want to touch on all these three points.
13 The framework for this discussion is the following.
14 We can draw the following picture so you get a little
15 bit more of an understanding how this hangs together.
16 The methodology contains the code and data.

17 How are you going to use the code and
18 data? You can use it in two ways. You can go the
19 deterministic way and use Appendix K type analysis.
20 You can go and use best estimate, do a statistical
21 approach with regard to the -- with respect to the
22 data.

23 Having chosen statistical, you have two
24 choices of how to do your statistics, non-parametric
25 and parametric. Within that, you still have two

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1 choices. You can take classical and Bayesian. If you
2 want to bring in all your engineering judgment, you
3 have the Bayesian option.

4 If you take your classical option, shut up
5 about engineering judgment. It's as simple as that.
6 Okay.

7 DR. RANSOM: Aren't you talking about
8 different codes, though?

9 MR. ORECHWA: No.

10 DR. RANSOM: When you talk about Appendix
11 K versus best estimate.

12 MR. ORECHWA: What I'm talking about, I
13 don't care if it's RELAP5 track or anything. Forget
14 the code. Code is going to be a tool. I want to talk
15 in a generic way. The code is going to produce
16 numbers. We're going to evaluate those numbers with
17 respect to data.

18 And I will go through that a little bit
19 later. I hope to make it a bit more inter-ocular.
20 All right. So here is where Framatome is going to be
21 and they will take the classical approach, because the
22 other hasn't been really developed yet.

23 Okay. The next view graph is for you,
24 Graham, so listen up. This was prepared for you.

25 CHAIRMAN WALLIS: Am I allowed to ask

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1 questions, then?

2 MR. ORECHWA: Yes.

3 DR. BANERJEE: Only if they're
4 intelligent.

5 CHAIRMAN WALLIS: Ah, the rules of man.

6 (Laughter)

7 MR. ORECHWA: Okay. Let's talk for a
8 minute -- let's start at the end and just talk about
9 the two difference between the parametric and non-
10 parametric approach. What we're talking about is a
11 tolerance limit.

12 Tolerance limit is a number, 5, .7,
13 whatever. It has three parameters, beta, the fraction
14 of the population of interest, or you can interpret it
15 as a probability, gamma, the confidence level that you
16 have in that probability or fraction of the
17 population, and n, the number of observations in the
18 sample; those three things.

19 What do you do in a non-parametric
20 approach? You start with an assumption. Non-
21 parametric approach and everything starts with an
22 assumption. You're going to hear this over and over
23 again.

24 It says the population is continuous,
25 redistributed, nothing else. It's a continuous

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1 function. No --

2 CHAIRMAN WALLIS: Does it have to be?

3 MR. ORECHWA: Yes, it has to. Because
4 you're going to use order statistics, you cannot order
5 two values which have the same value. So no throwing
6 dice. This is an important assumption. If it isn't
7 true, you can't do this.

8 CHAIRMAN WALLIS: You mean, you can't do
9 it.

10 MR. ORECHWA: No one can. You don't --
11 you can't define an order statistic.

12 CHAIRMAN WALLIS: Well, it seemed to me
13 that if you're asking for a --

14 MR. ORECHWA: Don't seem. You can't
15 define an order statistic.

16 CHAIRMAN WALLIS: -- you're asking for a
17 95th percentile.

18 MR. ORECHWA: Wait for the percent.

19 CHAIRMAN WALLIS: Then all you need is the
20 95th percentile exists, and it doesn't mean to say
21 that the rest of the distribution has to be continual.

22 MR. ORECHWA: You start -- you have to go
23 through the proof. You start with the assumption of
24 a continuous function, okay?

25 CHAIRMAN WALLIS: Okay. Well, let us

1 agree to start with an assumption.

2 MR. ORECHWA: Statistical theory then
3 tells you that there is a functional relationship
4 between these three numbers. So you have not taken a
5 sample yet. They don't know what the data is,
6 nothing, but given the fraction of the population and
7 the confidence level, I can compute the end as to how
8 many samples I should take.

9 So I haven't done anything yet. I'm still
10 sitting at home. I haven't gone anywhere. Okay.
11 Once I have n , then I go take my sample. I order my
12 values and I get my winner. So you're starting with
13 a choice of what your beta and gamma, what your
14 probability and what your confidence is.

15 In the parametric method, what do you do?
16 The assumption in the parametric method is that the
17 population distribution is known. I put quotes on it
18 because we never know the distribution. We have -- we
19 know something roughly.

20 To know the distribution, statistical
21 theory says you go out and you get some data. How
22 many data points do I take? That I choose, a priori.
23 It's a hypothesis. So say I need five or 50. I don't
24 derive that.

25 I go out and get data. Based on that

1 data, I estimate a distribution, say normal, a vector
2 of means and variance, co-variance matrixes. There
3 are no co-variances here. I don't know what the
4 distribution is.

5 They're only here and they came from the
6 data. So in the parametric method you're starting
7 with the data.

8 DR. BANERJEE: So you can derive from that
9 the distribution if you know --

10 MR. ORECHWA: You derive the distribution.
11 You take the sample. You derive the parameters of the
12 distribution. That's why it's parametric. Once you
13 have the parameters, based on this distribution you
14 say, for a 95 confidence what is going to be beta.
15 You compute. Given that, you say, I want this
16 confidence level.

17 CHAIRMAN WALLIS: So in the parametric
18 method you need more information because you have to
19 estimate --

20 MR. ORECHWA: Up front.

21 CHAIRMAN WALLIS: -- you have to estimate
22 the distribution.

23 MR. ORECHWA: Yes.

24 CHAIRMAN WALLIS: So if you did both of
25 them with the same problem you'd expect your answers

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1 to be compatible and reasonably descriptive --

2 MR. ORECHWA: No.

3 CHAIRMAN WALLIS: -- of the same problem.

4 MR. ORECHWA: No. You have -- you're
5 starting with --

6 CHAIRMAN WALLIS: I don't expect to get a
7 different answer.

8 MR. ORECHWA: -- far less information.
9 You were starting with nothing.

10 CHAIRMAN WALLIS: Yes. But if you want --
11 yes. But then you look at data afterwards. You can
12 always look at data when, you know, you have the data
13 afterwards.

14 MR. ORECHWA: Oh, I see what you mean.
15 The data should come close, yes.

16 CHAIRMAN WALLIS: What does it tell you
17 about, and it should be consistent.

18 MR. ORECHWA: The thing will be
19 consistent.

20 CHAIRMAN WALLIS: Right.

21 MR. ORECHWA: But you have far less
22 information when in a non-parametric method. See, the
23 trick is this -- it's in the end. Here you are, it's
24 predetermined what end you're going to choose for
25 this. Here, you need to choose it and then go out and

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1 compute.

2 DR. BANERJEE: Usually, you have to have
3 enough data to get the higher order moments to get the
4 distribution like --

5 MR. ORECHWA: For this.

6 DR. BANERJEE: Usually, the skewness and
7 the peakedness is needed, as well, to get the proper
8 distribution for the parametric approach. So you need
9 quite a bit of data.

10 MR. ORECHWA: Yes. Once you have your
11 data you can do whatever you want.

12 DR. BANERJEE: Yes. But you need a lot of
13 data to get a good estimate.

14 MR. ORECHWA: Well, I don't know. That
15 depends how good your data is. The point is, it's not
16 the quality of the data; it's you have to go get data
17 first. And you have to decide how much data with
18 almost no information except maybe some thought in a
19 dream or something.

20 Here, you choose what you want and it
21 tells you how many data you need. Okay. So that's
22 the story. All right. Thank you very much. All
23 right. Let's change --

24 CHAIRMAN WALLIS: Which of those ways is
25 the straight and narrow and which is the primrose path

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1 of dalliance?

2 (Laughter)

3 CHAIRMAN WALLIS: Either way is
4 acceptable, right?

5 MR. ORECHWA: Of course.

6 CHAIRMAN WALLIS: Okay. Good. There's no
7 judgment.

8 MR. ORECHWA: No, there is no judgment in
9 this.

10 CHAIRMAN WALLIS: Okay. Good.

11 MR. ORECHWA: But it's just, you have to
12 realize what information is being carried through and
13 how you're arriving at it. Okay. And in different
14 cases it might be -- you know -- in some cases you may
15 not be able to even do one of the non-conservative --
16 it's just that type of thing.

17 But there is no panacea in either of them.
18 That's the issue here. Okay. Let me now try
19 something out on you guys. All right. We're going to
20 attack the methodology itself. Again, I'm not going
21 to solve any codes.

22 The code is basically not the issue here.
23 What I want to do is give a formal solution to the
24 problem. What is the problem? The objective is to
25 estimate the performance figure of merit, peak

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1 cladding temperature, oxidation, whatever, at some
2 thermal-hydraulic conditions.

3 I mean, that's what RELAP does. That's
4 what basically it solves. The tool is RELAP or some
5 other codes. What I want to focus on is what are the
6 ingredients in the methodology. We have measured
7 results of a test.

8 We have the computed results of the test.
9 We have measured results of a LOCA. We don't have
10 this. If we had this, we wouldn't be here. This is
11 what we want. But we have computed the results, and
12 we could compute anything.

13 So you can just go out and compute. How
14 do we get this? Let me just -- the notation I'm going
15 to use. On this side we have whether the parameter is
16 measured or calculated. These are the thermal-
17 hydraulic conditions.

18 Are they tests or are they LOCA? By LOCA,
19 I mean we have a manifold which is all LOCA and in
20 between there are test specs spattered around. Okay.
21 Now, in order to solve this, I'm going to solve it
22 formally, like mathematicians do formal, you know.

23 My advisor used to call it Polish
24 mathematics because at that time in transfer theory
25 there were two Polish guys. They worked in bannock

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1 space and the answer was always the resolvent on the
2 source equals the resolvent operator, which we all
3 know is λI minus inverse. And that was the
4 answer.

5 But I'm going to do Polish mathematics for
6 that reason. Let me bring the sum total of my
7 education -- I need to bring the sum total of my
8 education to this -- bear on this problem.

9 CHAIRMAN WALLIS: That's a big package,
10 then.

11 MR. ORECHWA: You will find out what it
12 is. My high school teacher, my algebra high school
13 teacher told me, it's all a matter of expressing what
14 you don't know in terms of what you do know. That's
15 principle one.

16 Then I went on to university with this
17 principle and I was not a very serious student, but I
18 had the good fortune to go to a university where
19 mathematics was taken very serious, and teaching was
20 taken very serious.

21 And in my -- I think it was second year
22 algebra class, something to do with Jordan canonical
23 forms or whatever. I don't remember. Teacher proved
24 the theorem, goes through the theorem and then we're
25 discussing kind of the results of it and implications,

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1 and the student asks the question, and the question
2 was basically conjecture.

3 Well, professor says, okay, let's just see
4 if we can prove this. So he writes down, if blah,
5 blah, blah, then such and such and such. And then he
6 starts proving, proving, proving, and the thing is
7 just not going anywhere.

8 It just isn't happening. So then he turns
9 around and says, now you shall mathematics in action.
10 He goes up, changes a word in the if statement, goes
11 back to the proof, QED falls right out. So the key
12 is, you got to get the right assumptions up there.

13 CHAIRMAN WALLIS: So he worked back from
14 the answer.

15 MR. ORECHWA: That's right. So what do we
16 need here? What did I take away from that? See, the
17 teaching was so good you could pick things up by
18 osmosis, even for -- what I'm going to assume is that
19 in our manifold of LOCA conditions that the test data
20 is dense, okay, in the mathematical sense that it's
21 dense.

22 So whenever you're at some place, some
23 LOCA place, you're close to a test. It's like if you
24 -- it's like a cherry pie, okay. The tests are the
25 cherries spread out. Then -- okay. Then I went to

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1 graduate school.

2 So we still can't connect this. Now, we
3 have a -- we know what we're supposed to do. We have
4 an assumption. How do we --

5 CHAIRMAN WALLIS: I'm still waiting to
6 know what insight you got when you came to the NRC
7 after all this schooling.

8 (Laughter)

9 MR. ORECHWA: I went to graduate school
10 and what a rude awakening in graduate school. These
11 guys really expected you to do something. It's not
12 just messing around like that. And you're up against
13 the wall with this analytic expression and you learn
14 very quickly, well, you expand in Taylor series.
15 Okay. And then finally --

16 CHAIRMAN WALLIS: Well, you waited to
17 graduate school before you heard about Taylor?

18 MR. ORECHWA: Of course. I had to do
19 something. So and then Feinman (phonetic) says you
20 should never consider anything beyond first order and
21 you always listened to him, of course. Only losers go
22 and work in higher orders.

23 CHAIRMAN WALLIS: So you've at last
24 discovered the differential calculus, huh?

25 MR. ORECHWA: Right. So --

1 (Laughter)

2 CHAIRMAN WALLIS: Well, we've got to get
3 to the point of this, Yuri.

4 MR. ORECHWA: So the point of this is the
5 following. Now, what tools do we have? We have that
6 the tests are dense in LOCA space and we have a Taylor
7 series, first order Taylor extension. We can expand
8 this, the LOCAs about the tests. Okay.

9 And we get an expression. If we take the
10 ratio of that expression we get our -- and throw out
11 all higher terms and all that, we can get the
12 following relationship. All right. You can do that
13 for homework.

14 Now, you may laugh, Graham, but I'd like
15 to know what is in the solution algorithm of RELAP
16 that goes beyond the assumption of density and Taylor
17 approximation, or can be formulated from that. You're
18 integrating in time.

19 You're going from one thermal-hydraulic
20 condition. You want to know what it is from T to T
21 plus delta-T. How do you get -- you have to solve it
22 at those other thermal-hydraulic conditions. All you
23 do generally is do a thermal -- Taylor expansion.

24 So I don't think it's that far, making
25 those assumptions from what you do fundamentally at

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1 the most basic level.

2 MR. LANDRY: Except when you change flow
3 regimes.

4 MR. ORECHWA: Yes, flow regimes. But
5 given a flow regime, I mean, when you're solving the
6 equation at a node for one point, they're doing
7 nothing else. So we're talking about the basic
8 characteristics of the whole thing.

9 Now, okay. So here we have what we
10 wanted, okay, and we have three terms. And I'd like
11 to interpret these terms. And here's where you're
12 going to learn that I did learn something when I came
13 to NRC.

14 Okay. This is the calculation of the
15 parameter calculated of LOCA. This is what RELAP
16 calculates for one shot. Okay. I'm going to assume
17 that this has been beaten to death. All the models
18 are good and all the whatever it is.

19 Everything is fine. It comes up with an
20 answer close to it. Let me look at --

21 DR. BANERJEE: Dr. Orechwa, are you going
22 to take it away?

23 MR. ORECHWA: No. I'm going to come back
24 to it. I want to first discuss this, okay.

25 DR. BANERJEE: Say there's a vector

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1 anywhere else.

2 MR. ORECHWA: Yes. It's a big, big
3 vector. It has lots of these. It's thermal-hydraulic
4 conditions, velocities, densities, voids, et cetera,
5 et cetera, whatever defines your thermal-hydraulic
6 condition.

7 DR. BANERJEE: Right.

8 MR. ORECHWA: Whatever you need in order
9 to compute the cladding temperature.

10 CHAIRMAN WALLIS: So your first slide --
11 your last slide was talking about the sensitivity of
12 P measured LOCA to changes in theta?

13 MR. ORECHWA: Yes. Right. Let me -- now,
14 if we look at what is the difference between scaling
15 and validation. If we are at fixed thermal-hydraulic
16 conditions and we take measurements at those
17 conditions and we do a calculation, we're doing
18 validation. Okay.

19 If we are looking at measurements, at test
20 conditions and the LOCA conditions, we're going from
21 one thermal-hydraulic condition to the next, okay.
22 That's scaling. All right. At least that's what I
23 call it. If -- so we're here, P, at theta.

24 Here we are P at theta plus delta theta.
25 Okay. That is, we need to get from this thermal-

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1 hydraulic condition to this, we need to know the
2 derivative. That is the quantity that's necessary, to
3 go from point A to point B.

4 Here we are at the same theta. You don't
5 need anything. So if you look back on the previous
6 slide -- if I can get it up there -- okay, this term
7 is just a ratio at the same thermal-hydraulic
8 conditions, okay, and these are ratios.

9 So we need the -- I mean, not ratios.
10 These are derivatives. We need to know at the places
11 where we have data we need to know the derivative of
12 the quantity. This is -- it's the same place, the
13 same thermal-hydraulic conditions, but how do they
14 change in the measurements; how does it change.

15 CHAIRMAN WALLIS: Now, theta is an n-
16 dimensional variable.

17 MR. ORECHWA: Yes. It's n-dimensional.
18 You're right.

19 DR. BANERJEE: So is that a summation,
20 like --

21 MR. ORECHWA: I don't want to go there,
22 okay. Let's just stick to heuristic.

23 DR. BANERJEE: Okay.

24 MR. ORECHWA: I'm trying to show what form
25 it was in.

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1 CHAIRMAN WALLIS: I'm trying to figure out
2 what your formula is. I'm having trouble with the
3 formula.

4 DR. BANERJEE: But don't go away from
5 that.

6 CHAIRMAN WALLIS: We need to understand
7 what you're doing there.

8 MR. ORECHWA: What I'm saying is, let's
9 define this, what you do -- what I'm doing is the next
10 slide, what I learned at NRC.

11 CHAIRMAN WALLIS: All right.

12 DR. BANERJEE: But don't go away.

13 CHAIRMAN WALLIS: Don't go away from that.

14 MR. ORECHWA: Well, I'll bring it back,
15 but can I bring this up?

16 CHAIRMAN WALLIS: You seem to be claiming
17 that you --

18 MR. BOEHNERT: Yes, go ahead.

19 CHAIRMAN WALLIS: -- can do something
20 about predicting the LOCA just from DP/Dtheta --

21 MR. ORECHWA: No. Wait. Wait. Wait.
22 Wait. Wait. Wait.

23 CHAIRMAN WALLIS: -- during --

24 MR. ORECHWA: Wait. Wait. Wait. Wait.
25 Wait. Wait. Don't get carried away. Don't get

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1 carried away.

2 CHAIRMAN WALLIS: Well, you -- no, you
3 have to answer it. You keep flashing up your key
4 place and then take it away. You can't play that
5 game.

6 MR. ORECHWA: All right. I was going --

7 DR. BANERJEE: Keep it on the other one.

8 MR. ORECHWA: Yes, that's okay. I'll
9 please him; just leave it.

10 CHAIRMAN WALLIS: You're claiming that
11 what you know about --

12 MR. ORECHWA: What I'm claiming --

13 CHAIRMAN WALLIS: -- what you know about
14 the --

15 MR. ORECHWA: -- formally, where's the --
16 if -- in order to know what we want to know at LOCA
17 conditions --

18 CHAIRMAN WALLIS: Plus what happens in a
19 real LOCA.

20 MR. ORECHWA: A real LOCA. We calculate
21 what happens.

22 CHAIRMAN WALLIS: Right.

23 MR. ORECHWA: At the real LOCA. We
24 correct this information by looking at the ratio at
25 this ratio.

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1 CHAIRMAN WALLIS: That's an assumption.

2 MR. ORECHWA: No.

3 CHAIRMAN WALLIS: Yes, it is.

4 MR. ORECHWA: This is all -- what did
5 these guys show for the last few days.

6 CHAIRMAN WALLIS: It's assumption and
7 similarities.

8 MR. ORECHWA: This is --

9 CHAIRMAN WALLIS: Assumption of
10 scalability, then.

11 MR. ORECHWA: No. This is the
12 uncertainty. This is past versus -- past calculated
13 versus measured at a test.

14 CHAIRMAN WALLIS: How does the test --

15 MR. ORECHWA: Scaling, I said, is you go
16 from -- to get further out to the next, to the next
17 thermal-hydraulic condition.

18 CHAIRMAN WALLIS: Yes, but you --

19 MR. ORECHWA: You start at a test.

20 CHAIRMAN WALLIS: You first assume
21 scalability in your first four factors.

22 MR. ORECHWA: No. No.

23 CHAIRMAN WALLIS: Yes, because you're
24 relating P measured LOCA. You're saying the
25 correction factor for P measured LOCA to P calc is the

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1 same as for P measured test for P calc, plus some
2 sensitivity to delta theta.

3 MR. ORECHWA: Nonsense.

4 CHAIRMAN WALLIS: Well, you're trying to
5 explain it so we understand it doesn't do any good if
6 we don't understand it.

7 MR. ORECHWA: Well, I'm trying to explain
8 it. You have to be receptive --

9 CHAIRMAN WALLIS: Yes. So you have to be
10 patient.

11 MR. ORECHWA: -- to my explanation. Okay.

12 CHAIRMAN WALLIS: No, that's not the way
13 education works. We have to understand it.

14 MR. ORECHWA: But that's a calculus -- not
15 a correlation --

16 CHAIRMAN WALLIS: Well, if we understood -
17 - don't understand it, we can't do anything with it at
18 all. Anyway, I understand this figure. That doesn't
19 say anything. Let's go to the -- does the equation
20 say anything. That's what I'm trying to find out.

21 MR. ORECHWA: Okay. Here's the equation
22 in pieces, okay?

23 CHAIRMAN WALLIS: Okay.

24 MR. ORECHWA: This -- the calculation of
25 the LOCA with the applicability, the question is, can

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1 you do that, do you -- is my code good enough to get
2 close to the answer. We know it is slightly off;
3 let's say slightly off.

4 Formally, you would correct that by
5 comparing a test, the measurements of the test to a
6 calculation of the test. Formally, you would do that.
7 What would you compare in order to show scalability?
8 Like I said, scalability, you're going from some
9 thermal-hydraulic conditions to another.

10 To get from one to the other you need to
11 know the derivative from -- at where you're starting.
12 That's this picture that you don't like.

13 CHAIRMAN WALLIS: Well, scaling to me
14 means going from one size, like a test, to another
15 size.

16 MR. ORECHWA: Right.

17 CHAIRMAN WALLIS: And I don't understand
18 how -- $DP/D\theta$ in a test or $DP/D\theta$ coded for a
19 test tells you anything about the real LOCA because
20 it's at a different scale. It doesn't say anything
21 about --

22 MR. ORECHWA: The real LOCA is the point -
23 - look, can't you understand, there is a manifold.
24 There's a manifold with a bunch of --

25 CHAIRMAN WALLIS: Well, you don't seem to

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1 understand my question.

2 MR. ORECHWA: Yes, I do, but --

3 CHAIRMAN WALLIS: Well, then you listen to
4 the question.

5 MR. ORECHWA: -- and I'm telling you --

6 CHAIRMAN WALLIS: You listen to the
7 question, please, and listen to the question. The
8 third bullet you have DP/Dtheta measured test, which
9 is a function of the test, right? You have DP/Dtheta
10 calculated test, which is a function of the test.

11 MR. ORECHWA: Right.

12 CHAIRMAN WALLIS: But you don't understand
13 -- I don't understand how something measured at a
14 scale or calculated at a scale, low scale, can't tell
15 you directly information about what happens without
16 scaling.

17 MR. ORECHWA: At a different --

18 DR. KRESS: You have an assumption that
19 all these data points bunch around the real answer.

20 MR. ORECHWA: That's right. It's dense.

21 DR. KRESS: And they sort of --

22 MR. ORECHWA: That's the whole assumption
23 of density.

24 DR. KRESS: That's your dense assumption
25 in there and you just have to look at it as a bunch --

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1 MR. ORECHWA: It's a formal argument and
2 the point is that in scaling you're going to need a
3 little bit more than just a ratio. You need to know
4 how you -- because you're going to a different place
5 than where the tests are.

6 CHAIRMAN WALLIS: Sensitivity to theta.

7 MR. ORECHWA: Right.

8 CHAIRMAN WALLIS: Sensitivity to changes
9 in theta.

10 MR. ORECHWA: And this is exactly. These
11 two terms, if you ratio them, it's like elasticity in
12 economics.

13 CHAIRMAN WALLIS: Well, again, you see, my
14 problem is that this equation here is only a function
15 of the lower scale. It only measures things at the
16 lower scale. $DP/D\theta$ at the lower scale, whether
17 it's tests or measurement, it doesn't tell me what
18 $DP/D\theta$ is at the high scale.

19 MR. ORECHWA: Look, the point is, what
20 type of information do you need in scaling? In
21 scaling you need derivative information. For
22 uncertainty, you just need the ratio to compute the
23 bias and the distribution of the bias in order to do
24 the correction.

25 CHAIRMAN WALLIS: I'm not sure if it's

1 derivative.

2 MR. ORECHWA: In this case --

3 CHAIRMAN WALLIS: It could be that at the
4 higher scale some other phenomenon happens.

5 MR. ORECHWA: No. Forget --

6 DR. BANERJEE: No. I think your
7 assumption is there's a one to one mapping from the --

8 CHAIRMAN WALLIS: We've already assumed
9 that it's good scaling.

10 DR. BANERJEE: -- test into the LOCA
11 scaling.

12 CHAIRMAN WALLIS: We've already assumed
13 it's good scaling.

14 DR. BANERJEE: I don't think that bias
15 ratio will hold. You can divide P measured by P calc,
16 I know.

17 MR. ORECHWA: This is one component, what
18 I'm saying.

19 DR. BANERJEE: No, that's okay, but the
20 left-hand side, if you go to the previous equation,
21 the right-hand equation -- if you wrote -- if you
22 divided the left-hand side by P calc LOCA, all it
23 means is that the distortion is the bias. If you
24 measured --

25 MR. ORECHWA: That's right.

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1 DR. BANERJEE: Is a distortion of the
2 bias, but it assumes there is a mapping from these to
3 that. And what Graham is saying, suppose there's a
4 nonlinearity here.

5 MR. ORECHWA: The mapping is taking care
6 of this.

7 DR. BANERJEE: Yes, right.

8 CHAIRMAN WALLIS: Right.

9 MR. ORECHWA: But there is a --

10 DR. BANERJEE: Where there is a mapping,
11 but that assumes there is a mapping.

12 MR. ORECHWA: There is a mapping, exactly.

13 DR. BANERJEE: Yes.

14 MR. ORECHWA: That's why you're dense and
15 the mapping is the Taylor expression.

16 DR. BANERJEE: The question he's asking is
17 that it can be phenomenon which is not there.

18 MR. ORECHWA: Yes, that's right. And then
19 you --

20 DR. BANERJEE: In which case, you cannot
21 map.

22 MR. ORECHWA: Right. Just listen. The
23 issue is uncertainty. The question is, where are the
24 uncertainties coming from.

25 CHAIRMAN WALLIS: But it's not a question

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1 of scaling.

2 MR. ORECHWA: You mean, scaling is not
3 something that is an uncertainty in all this business?

4 CHAIRMAN WALLIS: No. I say that the
5 question, scaling question is whether or not your
6 phenomena and the test are the same, and equate -- the
7 same equation as on the first test.

8 MR. ORECHWA: Are you going to accept
9 this? Given my formalism, what Framatome is doing, in
10 my view, they're -- this is their big RELAP, S-RELAP
11 calculation. They go through a bunch of uncertainty
12 analysis with separate effects tests.

13 The discussion of scaling is about five
14 pages and it says there is none. This is one.

15 CHAIRMAN WALLIS: Okay. Does your
16 equation give any insight into whether there is or is
17 not scaling?

18 MR. ORECHWA: My equation says that you
19 have -- I'm not saying what there is. I'm telling you
20 what to look at. I'm saying you got to look at the
21 derivative of the parameter of interest in relation to
22 the thermal-hydraulic parameters, in principle.

23 CHAIRMAN WALLIS: Which is -- that's a
24 sensitivity --

25 MR. ORECHWA: How you do that is a

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1 different question.

2 CHAIRMAN WALLIS: It's a sensitivity
3 study.

4 MR. ORECHWA: I'm giving a formal argument
5 and I gave a formal relationship where all these three
6 things come in, your base calculation, your
7 uncertainty analysis and the uncertainty associated
8 with the scaling. Okay.

9 These should be addressed if you're going
10 to talk about uncertainty with regard to a code, in my
11 view. Okay. Please. I won't go into scaling. I
12 don't want to go down that road.

13 CHAIRMAN WALLIS: So you're saying that
14 Framatome should --

15 MR. ORECHWA: Graham, you won't follow me.

16 CHAIRMAN WALLIS: -- you're going to want
17 to require that Framatome evaluate these DP/Dthetas in
18 some way?

19 MR. ORECHWA: No.

20 CHAIRMAN WALLIS: No?

21 MR. ORECHWA: I want them to evaluate
22 scaling a little bit more than in five pages, given
23 all the work that's done.

24 CHAIRMAN WALLIS: How do you want them to
25 evaluate scaling?

1 MR. ORECHWA: That's not my problem. I'm
2 only a reviewer.

3 CHAIRMAN WALLIS: Why are you telling me
4 all this stuff about DP/Dtheta if it isn't relevant?

5 MR. ORECHWA: I'm saying that if you --
6 the ratio of two -- just one point. Okay.

7 CHAIRMAN WALLIS: We're going to move onto
8 the next slide.

9 MR. ORECHWA: The derivative, you have to
10 have more information about the test than just the
11 data. That's the whole thing, and you just want to
12 throw scaling out. All right. Any --

13 CHAIRMAN WALLIS: I think scaling is an
14 important question and it should be evaluated in a
15 rigorous way.

16 MR. ORECHWA: Anyway, anything else,
17 Graham?

18 CHAIRMAN WALLIS: Well, I'm still eager to
19 learn, but I'm not sure --

20 MR. ORECHWA: That I'm the proper teacher?

21 CHAIRMAN WALLIS: -- what I'm learning.

22 MR. ORECHWA: Or the proper --

23 CHAIRMAN WALLIS: So maybe we should go on
24 to your next slide.

25 MR. ORECHWA: Yes, all right. Let me just

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1 get organized here for a second. Okay. So where are
2 we? All right. Let's go now to the answers, all
3 right?

4 DR. BANERJEE: So let's assume that the
5 expression you wrote was correct.

6 MR. ORECHWA: Formally correct.

7 CHAIRMAN WALLIS: Formally correct.

8 MR. ORECHWA: I emphasize the --

9 DR. BANERJEE: So what is the consequences
10 of that?

11 MR. ORECHWA: The consequences are if
12 you're looking at -- if you are checking data, okay,
13 that if you're uncertainty, the first uncertainty with
14 regard to bias is just a ratio of the values at the
15 thermal-hydraulic conditions, if you are trying to
16 correct for scaling, involved in that expression are
17 derivatives.

18 These always contain a lot more
19 uncertainty, the over-analyzed data. And so by just
20 saying that they don't matter to me is implausible.

21 DR. BANERJEE: So what you're saying is
22 that the bias is amplified in some way by --

23 MR. ORECHWA: By scaling.

24 DR. BANERJEE: -- by these other
25 derivatives there.

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1 MR. ORECHWA: In principle it is. This is
2 usually -- it's much more difficult to you, deal with
3 derivatives of the data than with the data itself.

4 DR. BANERJEE: So the sensitivity of the
5 calculations and the sensitivity of the tests, of the
6 experiments --

7 MR. ORECHWA: Yes.

8 DR. BANERJEE: -- at the test scale have
9 to be added in some way to increase the bias.

10 MR. ORECHWA: That's right, how do the
11 tests connect. Remember, the assumption is that the
12 tests are dense in the manifold of all the parameters
13 over which we consider LOCAs may have. All right. So
14 then in that context, with that assumption that it's
15 dense, we can do certain things.

16 Whether you have in reality that kind of
17 data and whether you can make those statements, that's
18 a completely different issue.

19 DR. BANERJEE: So all you've done is a
20 Taylor series expansion about --

21 MR. ORECHWA: About the test.

22 DR. BANERJEE: -- the measurement.

23 MR. ORECHWA: Right.

24 DR. BANERJEE: Test and calculation at
25 test.

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1 MR. ORECHWA: Right, because we don't have
2 the -- we are interested not at the test, but the --

3 DR. BANERJEE: Then why didn't you also do
4 a Taylor series expansion of the calculations at LOCA,
5 then?

6 MR. ORECHWA: Because you -- what is your
7 reference point? You say I know the tests. You're
8 interested in what you calculate. So you know, when
9 you expand, what are you going to expand about? You
10 expand about what you know.

11 DR. BANERJEE: Right. You know the test,
12 but you also have the calculations at test conditions.
13 You have measurement at test conditions, calculations
14 at test conditions, and both of these you have done
15 tests --

16 MR. ORECHWA: You also expand the test --
17 you expand the terms about the test condition. So you
18 take the derivative at the test conditions.

19 DR. BANERJEE: Yes.

20 MR. ORECHWA: See, so you need more
21 information at the test --

22 DR. BANERJEE: I guess if you wrote that
23 expression as the quotient on the left-hand side it
24 would make more sense, because then you are looking at
25 the distortion of the bias.

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1 MR. ORECHWA: Well, fine. I look at it
2 differently.

3 DR. BANERJEE: Yes.

4 MR. ORECHWA: Okay. I'm looking at it, a
5 correction to --

6 DR. BANERJEE: Well, I can see how you
7 come to that expression.

8 MR. ORECHWA: Okay.

9 DR. BANERJEE: Yes.

10 MR. ORECHWA: The point is to look at what
11 the information content is of that expression, and it
12 basically follows what is it, the same terms that we
13 use in CS whatever the methodology.

14 MR. BOEHNERT: CSAU.

15 MR. ORECHWA: CSAU methodology.

16 DR. KRESS: Part of the trouble is your
17 delta theta may be very large, and Taylor --

18 MR. ORECHWA: Well, that's a computation,
19 yes.

20 DR. KRESS: -- series breaks that -- yes.

21 MR. ORECHWA: You're not going to compute
22 anything like that.

23 DR. KRESS: No. No.

24 MR. ORECHWA: That's not the point.

25 DR. KRESS: But in principle this would be

1 a way to look at it.

2 MR. ORECHWA: But this is a way of looking
3 what type information do you want and what does it
4 mean, the type of information. Okay.

5 CHAIRMAN WALLIS: Well, I'm very -- I
6 would think you would want to express delta P measured
7 LOCA as a function of delta theta.

8 MR. ORECHWA: All right. If you want to,
9 Graham, you can --

10 CHAIRMAN WALLIS: I don't see any delta on
11 the P measured LOCAs.

12 MR. ORECHWA: -- you can express it any
13 way you want.

14 CHAIRMAN WALLIS: Okay.

15 DR. BANERJEE: Anyway, what he is saying
16 there is the change -- there's an increase in the bias
17 that --

18 CHAIRMAN WALLIS: Well, he must have a
19 delta P measured LOCA. I mean, I think what he's
20 saying is that you need to look at the variations in
21 these DP/Dtheta in order to tell how sensitive your P
22 measured LOCA is to your delta theta.

23 MR. ORECHWA: The LOCA --

24 CHAIRMAN WALLIS: I don't see any delta P
25 measured LOCA here. So I'm not quite sure what I'm

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1 seeing.

2 DR. BANERJEE: Because he doesn't have a
3 delta P.

4 DR. KRESS: He doesn't have that. He
5 can't --

6 DR. BANERJEE: He is not -- he is
7 expanding about the test scaling.

8 MR. ORECHWA: LOCA is anything outside the
9 test in the manifold of the thermal-hydraulic
10 parameter.

11 DR. BANERJEE: Which is why I said you
12 should express the left-hand side of the --

13 CHAIRMAN WALLIS: Well, I guess if we're
14 not going to use it we should move away from this
15 equation.

16 MR. ORECHWA: But I -- you know -- it's a
17 cautionary tale.

18 CHAIRMAN WALLIS: Is he going to use it?

19 DR. KRESS: I don't know.

20 CHAIRMAN WALLIS: I don't think so.

21 MR. ORECHWA: All right. Let's get to the
22 answers.

23 CHAIRMAN WALLIS: Yes -- we'll think about
24 it.

25 MR. ORECHWA: All right. Food for

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1 thought, Graham.

2 CHAIRMAN WALLIS: All right.

3 DR. KRESS: We'll think about it.

4 MR. ORECHWA: Good.

5 DR. BANERJEE: He's used the binomial
6 expansion, as well, just to the first.

7 DR. KRESS: He just took the first term,
8 then.

9 CHAIRMAN WALLIS: We'll see what we can do
10 with it.

11 DR. BANERJEE: I think we can do that.

12 MR. ORECHWA: It's a homework problem.
13 Let's go.

14 CHAIRMAN WALLIS: It's a homework problem,
15 yes. Okay. So now, we're getting back to Framatome.

16 MR. ORECHWA: Framatome, and what
17 Framatome said. Okay. Initially, in their initial
18 submission they gave, this was the bottom line. The
19 methodology, which uses S-RELAP5 data, it uses a
20 statistical approach and that statistical approach is
21 non-parametric.

22 And they came up with this and I already
23 about a year ago discussed this with you. We went
24 over it, that the results based on 59 cases is okay if
25 you are only considering one variable, PCT. If you

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1 want to make a probabilistic statement about the
2 output variables, 59 is enough -- not enough.

3 It's just basically, you need more
4 information, okay? And remember that you're starting,
5 this is a derived quantity. The F that I showed the
6 relation between the beta, gamma and n is different
7 slightly for a different number of outputs.

8 Okay. So this finally after many, many
9 months of back and forth and et cetera, et cetera,
10 Framatome kind of backed off and they appealed to
11 Regulatory Guide 1.157 in the following statement,
12 which they always write.

13 What I bolded here is the words I want to
14 emphasize what this thing is about, no matter what it
15 says. It talks about probability and it talks about
16 criteria over and over. Probability and criteria. If
17 you now look at the currently -- where is it --
18 current submission of Framatome they want us to
19 accept, at least that's what the last information that
20 I got, is the following, that there are still three
21 criteria.

22 There are still 59 samples. Fifty-nine
23 samples, 95/95 PCT is fine. This they say, given
24 these 59 samples, where we make this statement, it
25 happens that the result for the -- what is it --

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1 maximum nodal oxidation is this, and it compares very
2 favorably with the limit.

3 Same thing here, that this is a result and
4 this is favorable. Let me -- there is no -- where is
5 the word "probability" here? This is an example of
6 59. This is not statistics. Somebody ran 59 cases
7 and got a result.

8 If they run 59 cases again they're going
9 to get a different result. This is not probability.

10 DR. KRESS: But each of those 59 cases
11 represent to some extent the full distribution.

12 MR. ORECHWA: Then okay. Let's do it.
13 Let me show you what the answer -- we'll look in the
14 back of the book.

15 DR. KRESS: Okay. You got to look for the
16 answer.

17 MR. ORECHWA: If we look in back of the
18 book we get this: "Number of runs 59, number of
19 criteria, .95/.95, 95/95. In order -- remember how
20 non-parametric statistics goes. It starts over here.
21 For using the relationship for this we need 124 runs.

22 Given that Framatome doesn't want to get
23 off of 59, if I choose my confidence level at 95, my -
24 - this is the probability. If I choose my
25 probability, this is the confidence.

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1 CHAIRMAN WALLIS: That is true, apart from
2 the fact that they submitted these graphs and the
3 statistical distributions showing how far away you
4 were from the 17 percent with the total observation
5 that PCT appeared to be a far more stringent
6 criterion, based on all these runs, than these other
7 criteria.

8 Therefore, there was a very high
9 probability that if you met the PCT criterion, you're
10 going to meet the other ones because in order to get
11 to 17 percent oxidation you'd have to be way off scale
12 in terms of the results. So that was additional
13 information that they submitted.

14 DR. KRESS: Yes. That's what I was
15 saying, that they --

16 MR. ORECHWA: But you can't use that
17 information if you're going to do non-parametric
18 statistics.

19 CHAIRMAN WALLIS: But you've got to use
20 new information if it's relevant.

21 MR. ORECHWA: If it's relevant? How do
22 you get the probability out of that information?

23 CHAIRMAN WALLIS: Well, I think --

24 DR. KRESS: The curve you get for --

25 MR. ORECHWA: No. No. Wait --

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1 DR. KRESS: It's an approximation of the
2 distribution, to some extent.

3 MR. ORECHWA: Fine. What I'm telling you
4 is the methodology on page 1, what they said, what it
5 -- what they're claiming, we will use a methodology
6 which is primary over the -- even over the code.

7 CHAIRMAN WALLIS: Well, let's go to --

8 MR. ORECHWA: We will use statistics, we
9 will use non-parametric statistics. We will arrive at
10 an answer using those.

11 CHAIRMAN WALLIS: Well, you're --

12 DR. KRESS: We agree with that -- we agree
13 with you that that's not -- in principle that's wrong.

14 MR. ORECHWA: Okay. That's all.

15 DR. KRESS: Yes, we'll agree with that.
16 But we also agree that the new information can be used
17 to justify the 59 runs is sufficient for all three.

18 CHAIRMAN WALLIS: For instance, let's look
19 at this table --

20 MR. ORECHWA: Why not --

21 CHAIRMAN WALLIS: -- your number 124
22 assumes that these phenomena are independent.

23 MR. ORECHWA: Doesn't assume anything.

24 CHAIRMAN WALLIS: Oh, yes, it does.

25 MR. ORECHWA: It does not.

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1 CHAIRMAN WALLIS: If they are tightly
2 correlated --

3 MR. ORECHWA: It assume --

4 CHAIRMAN WALLIS: -- as you are -- if peak
5 clad temperature and oxidation are exactly dependent,
6 one on the other, if you're in the 95th percent --

7 MR. ORECHWA: Graham, get that out of your
8 head.

9 CHAIRMAN WALLIS: Listen to me. Listen to
10 me. Well, I'm going to put it on the record and
11 you're going to be quiet.

12 MR. ORECHWA: Fine. Put it on the record.

13 CHAIRMAN WALLIS: Right. That if peak
14 clad temperature and oxidation are exactly a function
15 of each other, you can draw straight -- you can plot
16 on a graph one against the other and you get one
17 straight line, then if your results are in the 95th
18 percentile at peak clad temperature they would also be
19 95th percentile of oxidation level.

20 Then in that case you only need 59 runs
21 and you succeed with both of them. If they're
22 independent you need more runs; depends upon how
23 they're related to each other.

24 MR. ORECHWA: Let me go on the record.
25 You didn't learn your lesson on square one. You --

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1 CHAIRMAN WALLIS: But that's so general it
2 doesn't tell me anything at all.

3 MR. ORECHWA: It doesn't -- it tells you
4 exactly. You get your 50 n runs based on knowing
5 nothing about the distribution, nothing except that
6 it's continuous. You're bringing in information after
7 the fact, after you've chosen n.

8 DR. KRESS: That's right.

9 MR. ORECHWA: That's right, but there is
10 a method of doing that. You can't go on and bring in
11 information and change this thing.

12 CHAIRMAN WALLIS: The same -- this
13 information which is brought after doing the runs.

14 MR. ORECHWA: This --

15 CHAIRMAN WALLIS: The correlations.

16 MR. ORECHWA: -- this is what you're
17 starting with, nothing. That's the whole thing about
18 non-parametric statistics. Why is it non-parametrics?
19 No parameters. What is correlation? It is a
20 parameter in the distribution that you don't know when
21 you're starting out. Get that through your head.
22 (Polish phrase.)

23 CHAIRMAN WALLIS: But after you have done
24 the runs you learn something. You happen to learn --

25 MR. ORECHWA: Yes. Then you use phase-in

1 methods. You update.

2 CHAIRMAN WALLIS: Well, if you --

3 MR. ORECHWA: But what are you updating
4 then?

5 CHAIRMAN WALLIS: That's what we're doing.

6 MR. ORECHWA: Then you got to do the
7 statistics properly. They said they're going to do
8 statistics. There are methods.

9 CHAIRMAN WALLIS: Well, I think -- I agree
10 with you. I think it would be very good if instead of
11 this kind of qualitative argument, we could have a
12 more rigorous statistic argument. But I think you'll
13 find that when you do that, that the number of runs is
14 decreased --

15 MR. ORECHWA: Well --

16 CHAIRMAN WALLIS: -- from your value.

17 MR. ORECHWA: What?

18 CHAIRMAN WALLIS: That I think it would be
19 useful if Framatome --

20 MR. ORECHWA: But you got to do it.

21 CHAIRMAN WALLIS: -- instead of
22 representing these qualitative arguments based on some
23 curves, could actually put some numbers in a
24 statistical way on -- to buttress their conclusions.
25 I think that would be very helpful.

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1 MR. ORECHWA: Look at --

2 CHAIRMAN WALLIS: That's a useful
3 argument.

4 MR. ORECHWA: I agree that the data that
5 has been presented is probably okay, but they are not
6 -- they're presenting a sort of a good feel type.
7 They're not presenting a probability.

8 CHAIRMAN WALLIS: That's right. That's
9 why I agree. I agree.

10 MR. ORECHWA: Which is what Reg Guide
11 calls.

12 CHAIRMAN WALLIS: It would be very useful
13 if they would do that, but they will not -- if they
14 use that information they will not conclude that they
15 need 124 runs.

16 MR. ORECHWA: They're going to have to --
17 that's right, because what they're going to have to do
18 is parametric statistics and they're going to choose
19 n before that.

20 CHAIRMAN WALLIS: That's a useful idea.

21 MR. ORECHWA: This is a whole point, that
22 these two things are like night and day. It's like
23 choosing, what is it, forward and backward
24 differencing. You're doing the same thing, but you
25 can end up in very different territories, analogous.

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1 But the regulation or whatever it is, it
2 says probability of the criteria. It doesn't say,
3 feel good because I got a number that is small.

4 CHAIRMAN WALLIS: It just says --

5 MR. ORECHWA: We're going to go to another
6 reactor and what are you going to get then?

7 DR. BANERJEE: There's a point you made,
8 though, which is sort of quite interesting, which is
9 that they have assumed implicitly, I think, a one to
10 one scaling, the slide you showed there.

11 MR. ORECHWA: Yes, but that's outside of
12 this, my argument with Graham, though.

13 DR. BANERJEE: That's irrelevant, whether
14 it is outside, but you showed the slide.

15 MR. ORECHWA: Okay.

16 DR. RANSOM: That's the question I had.
17 What is going to happen to this other influence
18 coefficient type of thing? Why did you present that?
19 Do you have some conclusion based on your slide five?

20 DR. BANERJEE: Yes.

21 MR. ORECHWA: My conclusion is --

22 DR. RANSOM: In which you presented the --

23 MR. ORECHWA: -- that in my view that
24 there are certain ways -- that certain things have not
25 been looked at that would contribute to uncertainty.

1 DR. RANSOM: Are you proposing a way to
2 evaluate these derivatives?

3 MR. ORECHWA: Absolutely not.

4 DR. RANSOM: No.

5 MR. ORECHWA: I'm just saying that there
6 is an area that -- you know -- I don't have the
7 solution.

8 DR. BANERJEE: What you showed was a slide
9 that -- you showed two slides. One is a slide which
10 said that implicit in the arguments of Framatome are
11 scaling is one, and they've based it on some full-
12 scale tests.

13 MR. ORECHWA: Right. Right.

14 DR. BANERJEE: And there are other aspects
15 which are not, and but it may not be that all aspects
16 are full-scale. And then you proposed a sort of a
17 formal relationship for bias which at least allowed
18 you to get a better idea about the scaling. Now, you
19 don't want to stand behind that equation you showed?

20 MR. ORECHWA: What I tried to show
21 formally, what type of information is important if
22 you're going to consider scaling.

23 DR. BANERJEE: Right. And that --

24 MR. ORECHWA: And that now -- and I stand
25 by that that type of information is important. Now,

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1 how you do it --

2 DR. BANERJEE: That's besides the point,
3 yes. But what you showed was I think that just
4 because you have a certain bias based on your test
5 experiments, some of the test experiments would be
6 full-scale, doesn't mean that the LOCA bias
7 measurements to calculations will be the same.

8 That's basically what you showed, but that
9 you have to look at the sensitivities of both your
10 test scale measurements and your test scale
11 calculations.

12 MR. ORECHWA: Right.

13 DR. BANERJEE: Is that correct?

14 MR. ORECHWA: Right. Right.

15 DR. BANERJEE: Or right, I mean?

16 MR. ORECHWA: That's right. That's right.
17 Let me suggest something. I'll stick my neck out on
18 this. I haven't thought it completely through. So
19 Graham, don't jump on my ass right now. I think that
20 the part of scaling, if you look at in response --
21 I'll set this down -- is analogous a little bit to R
22 squared in regression, I think. It's at least
23 analogous, not one form.

24 DR. BANERJEE: There may only be four or
25 five values of theta that actually affect --

1 MR. ORECHWA: Right. Right. No, this
2 could be -- maybe none of them do. Maybe it is one.
3 I don't know. Maybe it's fine.

4 DR. BANERJEE: But whether this applies to
5 Framatome --

6 MR. ORECHWA: But that's not --

7 DR. BANERJEE: -- the problem is not the
8 issue here.

9 MR. ORECHWA: My presentation, other than
10 the result, okay, of 59 cases and PCT and like that,
11 that's Framatome. The rest is a generic -- are
12 genetic issues, how to deal with uncertainty. But
13 when you say you're going to take a statistical
14 approach, you make certain decisions.

15 When you come to parametric, non-
16 parametric, it's a crossroads. One you go down one
17 you got to follow it. You can't mix the two. If you
18 want to bring in information, you go and do the
19 Bayesian.

20 That's a completely different story again.
21 If you are going to follow statistics, so --

22 CHAIRMAN WALLIS: So I think it --

23 MR. ORECHWA: I'm telling you the way it
24 is. You want to apply -- you want to whittle it down.
25 That's -- you know -- you're -- but I go on the record

1 to tell you what the story is.

2 CHAIRMAN WALLIS: Yes. But I think we're
3 saying that the statistical probabilities that you
4 estimate are not independent of what you learn about
5 how these three outputs are related to each other.

6 MR. ORECHWA: That's right. But then you
7 have to do the analysis.

8 CHAIRMAN WALLIS: That's right. That's
9 what -- I agree.

10 MR. ORECHWA: Accordingly to come up with
11 probability.

12 CHAIRMAN WALLIS: I think we're agreeing.
13 It would be very useful if instead of just saying,
14 look, it's .8 percent compared with 17 percent, the
15 affect could have been put on the basis of some
16 probability.

17 MR. ORECHWA: I mean, that's what the Reg
18 Guide asks for.

19 CHAIRMAN WALLIS: Right.

20 MR. ORECHWA: Okay.

21 CHAIRMAN WALLIS: So I think we --

22 MR. ORECHWA: But I mean, my conclusion --

23 CHAIRMAN WALLIS: -- I think we've
24 appreciated that from your presentation.

25 MR. ORECHWA: My conclusion is, let's look

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1 at the statistics that they are presenting and what
2 does it result in. It does not result in -- you know
3 -- the key thing is, 95 insures that greater
4 probability that the other criteria will not, if. The
5 thing is, it's if then.

6 CHAIRMAN WALLIS: But if it were that they
7 could look at the actual -- infer some probability
8 distribution for nodal oxidation, from the 59 points
9 that they do have, and if they can then use a
10 statistical argument which has numbers on it, then you
11 might be satisfied, right?

12 MR. ORECHWA: Well, 59 -- take 59 cases
13 and do it the classical, statistical, parametric way.
14 You should --

15 CHAIRMAN WALLIS: Right. Okay. So I
16 think it's about time to take a break now?

17 MR. ORECHWA: Yes, please. I've got to --

18 CHAIRMAN WALLIS: Listen to anyone else?
19 Do you have any other question, Vic, maybe? Sanjoy?
20 So we could take a break until five past 3:00.

21 Thank you very much, Yuri.

22 (Whereupon, the foregoing meeting went
23 off the record at 2:52 p.m. and went back
24 on the record at 3:07 p.m.)

25 CHAIRMAN WALLIS: Let's come back into

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1 session to hear from Sarah Colpo.

2 MS. COLPO: Is this one working?

3 CHAIRMAN WALLIS: I don't know. It's best
4 if you use the mike which you carry around. Do you
5 have a place you can put it?

6 MS. COLPO: No, that's the thing.

7 DR. KRESS: Then you have to do this.

8 CHAIRMAN WALLIS: Then you have --

9 DR. KRESS: Doesn't it hang around your
10 neck? No.

11 CHAIRMAN WALLIS: It doesn't hang around
12 your neck?

13 DR. BANERJEE: Might strangle you.

14 MS. COLPO: Yes, that's what I'm worried
15 about.

16 CHAIRMAN WALLIS: Okay. Well, speak into
17 the other one. If you have to stand up maybe you can
18 just grab it and walk around with it.

19 MS. COLPO: Okay. All right. My name is
20 Sarah Colpo. I'm a reactor engineer in the Reactor
21 Systems Branch of NRR. And my role for this effort
22 was to review the 2D/3-D assessment and also to do a
23 code documentation comparison.

24 And I did some parametric studies where it
25 was my job to investigate the importance of some of

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1 the parameters in the code and report what I found to
2 other members of the team. I want to be clear here
3 that it was not within the scope of my review to make
4 decisions about what to do with this information.

5 DR. BANERJEE: Do we have a handout?

6 DR. KRESS: Yes. You didn't get one?
7 Looks like this. Did you get a handout?

8 DR. BANERJEE: No. Sarah, will you be
9 using this form?

10 MS. COLPO: I will. Only a couple times,
11 but I will be using it.

12 (Pause)

13 MS. COLPO: Okay. In my review of the
14 writeup of the 2D-3D assessment, I compared the
15 writeup to the plots that Framatome ANP provided to
16 see if what they said made any sense.

17 When it didn't make any sense at all for
18 me I spoke with senior engineers until I understood
19 what was going on, and then went from there. The
20 bottom line for me from that review was that the codes
21 were mostly conservative.

22 The results were mostly conservative, but
23 I didn't -- I guess being new to this game I have a
24 hard time seeing them as realistic, because I guess I
25 have different expectations since I'm new, I guess.

1 CHAIRMAN WALLIS: Your expectations are
2 for a closer comparison with data to be realistic, or?

3 MS. COLPO: Yes, that's what I was
4 thinking.

5 CHAIRMAN WALLIS: You were surprised by
6 the degree of scatter or?

7 MS. COLPO: Yes. You know, and like I
8 said, I'm new. So you know, this may be leaps and
9 bounds better than what was around before, but just,
10 I had maybe different expectations. There was one
11 case where the code was not conservative when
12 Framatome ran a UPTF test.

13 It ended up that there were large
14 oscillations in the pressure and in the lower plenum
15 level in mass. So Framatome suggested that the large
16 oscillations were due to the level tracking model,
17 which is in the bottom node of the lower plenum model.

18 They thought they'd go ahead and turn that
19 off and when they did the oscillations dampened, but
20 the mass and level in the core were still much lower
21 than the data. So to investigate that, they
22 implemented a 2D lower plenum model.

23 The results improved. However, in that
24 case the levels in mass in the core was
25 nonconservative. So even though the -- looking at the

1 way that they've chosen to model it, it was mostly
2 conservative, there were occasions where it wasn't.

3 I have to say that Framatome and the RAI
4 response said that they don't have the intention of
5 modeling the lower plenum as a 2D part of their
6 methodology.

7 CHAIRMAN WALLIS: I'm wondering what we
8 should conclude from this.

9 MS. COLPO: Well, that their 1D is good
10 enough.

11 CHAIRMAN WALLIS: It's not good enough or
12 is good enough? They think it's good enough?

13 MS. COLPO: They think it's good enough.

14 DR. RANSOM: 1D where?

15 DR. BANERJEE: Lower plenum?

16 DR. RANSOM: Lower plenum.

17 DR. BANERJEE: Were you -- did you -- when
18 you say conservative, you meant that the predictions
19 in the core were lower in level or something than the
20 experiments?

21 MS. COLPO: Were --

22 DR. BANERJEE: Is that what you meant by
23 conservative?

24 MS. COLPO: Right, that they weren't
25 making assumptions that were the wrong directions.

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1 CHAIRMAN WALLIS: No. The results are
2 conservative, presumably.

3 MS. COLPO: Pardon me?

4 CHAIRMAN WALLIS: Not the assumptions.
5 It's the results; you found at the core that the level
6 was predicted to be higher than measured or something?
7 Is that what you mean by conservative?

8 MS. COLPO: Or --

9 CHAIRMAN WALLIS: The other way around?

10 MS. COLPO: -- or the other way around,
11 yes.

12 CHAIRMAN WALLIS: The other way around is
13 conservative?

14 MS. COLPO: Right.

15 DR. RANSOM: There was too much
16 entrainment of water being carried out of the vessel
17 or?

18 MS. COLPO: Right.

19 CHAIRMAN WALLIS: So then you passed on
20 your observations to the more experienced members of
21 this team and --

22 MS. COLPO: The senior engineer.

23 CHAIRMAN WALLIS: -- they had to decide
24 whether or not to reach some conclusion or how to
25 reach conclusions?

1 MS. COLPO: Right. I didn't have that
2 difficult task. That was beyond my scope of
3 responsibility.

4 CHAIRMAN WALLIS: It's a little difficult
5 for this group to reach conclusions, so -- because we
6 haven't seen this in the degree of detail that you
7 have. So is this written up somewhere?

8 MS. COLPO: It's in the -- I can't
9 remember which documentation chunk it's in, but --

10 CHAIRMAN WALLIS: I don't know if the
11 individual staff reviews ever get through a
12 documentation that's accessible to ACRS. Maybe we
13 will ask. We will ask Mr. Landry what he concluded
14 from what you told him.

15 May we ask you now, Ralph?

16 MR. LANDRY: I think let's go through and
17 hear the whole presentation first.

18 CHAIRMAN WALLIS: She's going to do the
19 whole thing first. Okay. Okay. We'll come back to
20 you.

21 MR. LANDRY: Because you have to look at
22 the entire package of the RAIs and the responses to
23 the RAIs to see where we ultimately concluded that --

24 CHAIRMAN WALLIS: Okay.

25 MR. LANDRY: -- the realistic large break

1 LOCA methodology was conservative overall in its
2 predicted capability.

3 MS. COLPO: All right. So the next thing
4 I worked on was a spot-check of the code and the
5 documentation for consistency. I looked at things, I
6 mean, from just as basic as typos up to, you know,
7 were the units correct. Were the equations matching
8 with what was in the documentation?

9 And what I found was that there were
10 occasions where the documentation didn't match the
11 code, and that's not to say that the code was wrong,
12 but the documentation was wrong. And Framatome --

13 CHAIRMAN WALLIS: It seems to me very
14 strange that the code is always right and it's always
15 the documentation that's wrong.

16 MS. COLPO: Well, I picked the wrong
17 choice of --

18 CHAIRMAN WALLIS: I would think you'd
19 write the equation first and then put it in the code.

20 MS. COLPO: Well.

21 CHAIRMAN WALLIS: Seems to be the other
22 way around. You write the code and then you figure
23 out what the equation must have been.

24 DR. RANSOM: Well, I wonder if it's
25 possible that different people did the writeup from

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1 the development side.

2 CHAIRMAN WALLIS: That's probably it.

3 It's almost certain.

4 MR. LANDRY: If I may. Ralph Landry
5 again. The code is written from calculation notebooks
6 and developmental materials. Afterwards, the
7 documentation is prepared for the code. The
8 documentation is not prepared and then the code taken
9 from the documentation.

10 This has been an ongoing problem that
11 we've had in the past with the National Laboratories
12 back in the early days of the code, that the code
13 should be written. And it was very difficult to get
14 documentation prepared on what was in the code.

15 And somewhere errors get introduced into
16 the documentation because they're working from hand
17 notes, hand calculations, calculation notebooks and
18 the code, to then write and prepare the documentation
19 of what is in the code.

20 So this is not a surprise that there are
21 errors in documentation, but not in the code. But if
22 we look at the code then we discover the documentation
23 doesn't match exactly.

24 MR. SCHROCK: What is the reference for
25 what is correct? Or how do you know when you look at

1 the code whether it's right or wrong?

2 MS. COLPO: Well, what I did was ask
3 questions. If there was something that appeared in
4 the equations that didn't appear in the documentation
5 I asked the general question, explain this parameter,
6 and then it can go either way.

7 Well, is it wrong in the code or is it
8 wrong just in the documentation? Did that answer your
9 question?

10 MR. SCHROCK: I'm not quite sure.

11 MS. COLPO: Okay.

12 MR. LANDRY: Virgil, what we end up doing
13 with the RAIs is give the applicant the opportunity to
14 explain to us which is correct, rather than the staff
15 go out and determine which is the correct.

16 The onus is on the applicant to explain
17 which is correct, and we can then look at the response
18 and look at literature and say, are they describing
19 the correct correlation that we are familiar with from
20 the literature. And can we then conclude that, yes,
21 they're right, the documentation is wrong.

22 MR. SCHROCK: How do you guard against the
23 possibility that they agree with one another, but are
24 in fact wrong?

25 MR. LANDRY: That the code and

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1 documentation are the same?

2 MR. SCHROCK: Are in agreement, but --

3 MR. LANDRY: But they're both incorrect?

4 MR. SCHROCK: -- but are incorrect. Yes.

5 MR. LANDRY: That was one of the reasons
6 we started to do this spot-checking. The committee
7 has requested the staff numerous times to look at
8 individual lines in the coding and make sure things
9 were coded right.

10 So we started down this path and found in
11 some of the subroutines that there were lines of
12 coding which did not agree with the documentation. We
13 did not go back and start checking the individual
14 lines then against literature when both were in
15 agreement to see that, yes, this was coded right.

16 As I said earlier, we have to do a
17 snapshot review. We have to pick out particular items
18 to look at and determine, are they correct or not.

19 MR. SCHROCK: Okay. So the bottom line
20 is, you don't claim it's exhaustive. It's --

21 MR. LANDRY: No. No.

22 MR. SCHROCK: -- we've got some measure of
23 errors that are discovered.

24 MR. LANDRY: This was to give us a
25 snapshot view of, can we spot-check and see something

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1 was done correctly. And in our spot-checking, which
2 Sarah did, Sarah found a number of instances where she
3 said, why does this -- what's in the code show
4 something different than this in the documentation,
5 and Framatome would come back then and say, because
6 such and such.

7 DR. KRESS: The other problem would
8 probably get uncovered by your comparisons with tests,
9 for examples, and by your cross-checking with another
10 code to see if you get the same kind of results, if
11 you had both wrong, document and the code; if
12 something's wrong in there, is in the wrong
13 correlation, for example.

14 MR. LANDRY: Right.

15 DR. KRESS: Or wrong form on it, then it
16 would show up in some of your other tests, probably.

17 MR. LANDRY: Yes. And well, that can give
18 you a gross error.

19 DR. KRESS: Yes.

20 MR. LANDRY: Some of the really find
21 errors that may not show, but that is another way and
22 that's another reason why we do confirmatory
23 calculations, and another reason why we did some of
24 the stuff that Sarah's going to talk to, if she can
25 get to it, looking at some of the parameters in

1 parametric studies that she did with the code.

2 CHAIRMAN WALLIS: But presumably,
3 sometimes you do look at the original document. You
4 have all these papers and you're interested in
5 Forslund-Rohsenow particularly --

6 MR. LANDRY: Right.

7 CHAIRMAN WALLIS: -- I would imagine you
8 can't help looking at the equation that's in the
9 published paper, and probably noticing when the
10 documentation is not the same.

11 MR. ATTARD: Yes. Dr. Wallis, my
12 understanding -- Tony Attard from Reactor Systems. I
13 did that exact thing when Sarah first brought a couple
14 of these questions. I went back to the sources and
15 various textbooks actually, and what happened quite
16 a number of times is that the expression in -- or the
17 equation in the submittals was written slightly
18 different than what it was in the textbook, okay.

19 And that was enough to kind of just throw
20 things off a bit. But in reality there was just a
21 parameter change from one to the other. So we did
22 check that at the equation level.

23 MS. COLPO: All right. The next thing I
24 looked at in what I'm spending probably the rest of my
25 time here talking about is the parametric studies.

1 What they did was focus their review on the most
2 significant parameters.

3 I varied FWDRAG, VISCOL and post-DNB
4 subroutines. FWDRAG calculate to the wall drag terms.
5 VISCOL calculates the water liquid density or
6 viscosity, I mean. And post --

7 CHAIRMAN WALLIS: Excuse me. These wall
8 drag terms are what they've been calling the loss
9 coefficients? Or are they something else?

10 MS. COLPO: I'm not sure.

11 CHAIRMAN WALLIS: Well, they are a
12 generalized friction factor loss or the places where
13 they don't have loss coefficients? Or what are the
14 FWDRAG? They're wall friction, but most of your --
15 many of your components have a K loss factor rather
16 than a wall friction or both of them or --

17 A PARTICIPANT: They got both.

18 CHAIRMAN WALLIS: They got both. Okay.
19 So you're not varying the loss coefficients. You're
20 varying the friction drag.

21 DR. BANERJEE: You mean, the total
22 frictional drag and the total losses are about the
23 same in magnitude going around the circuit or what?
24 No -- yes. You said they were very similar.

25 DR. MARTIN: In the --

1 MR. BOEHNERT: You need to get the mike,
2 I'm sorry, to get you on the record.

3 DR. MARTIN: In the momentum equation --

4 DR. BANERJEE: Right.

5 DR. MARTIN: -- the formulation, there's -
6 - the order of magnitude obviously is different.

7 DR. BANERJEE: What is the relative order
8 of magnitude?

9 DR. MARTIN: Well, I guess it depends on
10 what you're looking at. If you're in a straight pipe
11 but no formula, it's at -- well, at zero.

12 DR. BANERJEE: Right. But in the typical
13 circuit.

14 DR. MARTIN: Typical circuit.

15 DR. BANERJEE: Right. Pick one that you
16 did a calculation for, one of your cases, anyone.

17 DR. MARTIN: I would say they're on the --
18 if you're going through a component like a bend it can
19 be on the same order of magnitude. They're not -- you
20 know -- they're not talking about ten to the six type
21 things, and you're probably only talking about ten to
22 the three. It's probably less than that, ten to two.

23 CHAIRMAN WALLIS: What do you mean by ten
24 to the three?

25 DR. MARTIN: They can vary kind of in that

1 -- I mean --

2 CHAIRMAN WALLIS: Oh, by a factor of
3 1,000?

4 DR. MARTIN: At the most maybe 100, if you
5 have -- as long as you have something. And I'm just -
6 - and I'm gauging that based on looking at output,
7 where they -- you know -- we'll have --

8 DR. BANERJEE: So let's say that --

9 DR. MARTIN: -- a list of what the F-wall
10 F and form F, we have those outputs and I'm just going
11 on experience there and looking at the output and
12 seeing numbers that are kind of in the ballpark, but
13 sometimes they may be off by 100.

14 DR. BANERJEE: Well, you want to compare
15 K with 2FL divided by D, right, their equivalent?

16 DR. MARTIN: Yes. FL over D and --

17 DR. BANERJEE: Yes, 2FL by the end of the
18 -- or 4 by D if you wish -- against K. And let's say,
19 take a couple of typical cases, we come in from the
20 code leg, go down the down-comer into the lower
21 plenum, what is the relative magnitude of those two in
22 typical terms, K versus 2FL by D?

23 DR. MARTIN: Well, you'll have a friction
24 loss along the walls everywhere.

25 DR. BANERJEE: Right.

1 DR. MARTIN: Just what we've talked about.
2 We'll apply the form loss, or basically our guideline
3 is we will go to IDLECHECK or Crane or something to
4 determine the form losses. So certainly, when the --
5 at the cold leg to the down-comer there is a
6 calculated form loss there that's put in there.

7 Then you won't have anything unless
8 there's a geometry change, you know, up the area of
9 the down-comer will vary again at the appropriate
10 junction. There'll be something there.

11 DR. BANERJEE: No. I'm just trying to get
12 a feel for it.

13 DR. MARTIN: And I'm saying it's --

14 DR. BANERJEE: What's the relative
15 magnitude of these?

16 DR. MARTIN: -- it's going to be very
17 close, but you know, depending what you have, it may
18 be -- you know -- up to 100 DIP off.

19 DR. BANERJEE: Let me make a statement and
20 see if it's correct, then. Except in the core, form
21 losses dominate frictional losses. Is this correct or
22 not?

23 DR. MARTIN: Yes, when you have them. I
24 mean, in straight pipes you're not going to have them,
25 right. I mean, they're --

1 DR. BANERJEE: Yes. But let's say for a
2 circuit, leaving aside the core, if I make the
3 statement, form losses will dominate over frictional
4 losses, is that correct for the whole circuit or not?

5 DR. MARTIN: I'll agree with you.

6 DR. BANERJEE: Okay. In the core it's the
7 other way around. Okay.

8 MS. COLPO: Okay. In these parametric
9 studies the FWDRAG subroutine had the most significant
10 affect on the peak cladding temperature, and given
11 that that was the case, the FWDRAG was the subroutine
12 that I chose to focus my parametric studies on.

13 DR. KRESS: Now, FWDRAG is a subroutine?

14 MS. COLPO: It's a subroutine that
15 calculates the --

16 DR. KRESS: How do you parametrizie the
17 subroutine with --

18 MS. COLPO: Well, what I did was, the --
19 I went into the code and at the very bottom where it
20 computes the wall drag term. I introduced a
21 multiplier.

22 DR. KRESS: Oh, I see. Okay.

23 MS. COLPO: Of -- well, depending on which
24 case we're talking about, of two or ten or .1.

25 DR. KRESS: You went to the bottom line

1 result.

2 MS. COLPO: Right. Right.

3 DR. RANSOM: Normally, the code calculates
4 one for the liquid and one for the vapor.

5 MS. COLPO: I did them both.

6 DR. RANSOM: You did them both. I had one
7 more question: why you selected these particular
8 parameters?

9 MS. COLPO: Well, I -- to tell you the
10 truth, I chose VISCOL because I've always -- just my
11 own personal choice that I've always thought liquid
12 viscosity seemed to be a pretty important parameter.
13 And so that was my own curiosity.

14 I chose the wall drag because I just think
15 it would be important, and I chose post-DNB because I
16 just thought it seemed like it would be an important
17 one; nothing more than that.

18 MR. SCHROCK: So VISCOL essentially --

19 DR. RANSOM: So of you chose interface
20 drag you probably found a really big affect.

21 MS. COLPO: Actually, I believe somebody
22 has already looked at interface drag, interfacial
23 drag. Is that correct, Ralph?

24 MR. LANDRY: It's been looked at but we
25 haven't looked at it with this code.

1 DR. RANSOM: I was just curious why, you
2 know, you chose the parameters you did and I guess
3 just to see what the sensitivities were?

4 MS. COLPO: Right.

5 CHAIRMAN WALLIS: The interface drag makes
6 quite a difference in the things like pool swell and,
7 you know, entrainment and carryover.

8 MS. COLPO: Well, unfortunately, I didn't
9 choose that one. I could certainly do that.

10 DR. BANERJEE: This is just a frictional
11 drag. So you -- because you were interested in the
12 core, primarily, I take it?

13 MS. COLPO: Yes.

14 DR. BANERJEE: Okay. So you didn't change
15 any of the loss factors.

16 MS. COLPO: No.

17 MR. LANDRY: Keep in mind that we were
18 trying to keep this fairly easy to understand. This
19 was -- for this type of review this was a first shot
20 at doing something of this nature. So we were trying
21 to keep it at a range where we understood what was
22 going on and where we thought we could see an affect.
23 We wanted to see what would happen with the code.

24 DR. RANSOM: Well, the other one would be,
25 were the ranges that you chose consistent with the

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1 non-parametric studies that they made using the
2 statistical approach?

3 MR. LANDRY: No. We chose ranges to try
4 to make an affect.

5 DR. RANSOM: I mean, were they bigger or
6 smaller or -- is that correct?

7 MS. COLPO: I didn't even look at the
8 statistical --

9 R. RANSOM: What Framatome did?

10 MS. COLPO: Yes.

11 DR. RANSOM: Or what they used for their
12 multipliers or range?

13 MS. COLPO: I just, like Ralph said, I
14 just picked ones to see where I would get an affect,
15 or if there would be an affect at all.

16 MR. LANDRY: Every time we do this we get
17 a little smarter. So we're --

18 DR. RANSOM: No, I'm not objecting to
19 doing it, but I'm wondering, what do you make of it.

20 MR. LANDRY: Yes. We wanted to see an
21 affect, and from this we have some ideas. And next
22 time we review a code we have further ideas where to
23 go.

24 CHAIRMAN WALLIS: Yes. See, you're --
25 this is a good step and you're learning as you go

1 along.

2 MR. CARUSO: There is a strong element of
3 staff development associated with this.

4 CHAIRMAN WALLIS: We're interested to have
5 you describe the picture that's up on the screen.

6 MS. COLPO: Well, I'll be happy to tell
7 you all about that. What this plot shows, and going
8 back to the statement that I chose different
9 subroutines to look at, and found that FWDRAG has the
10 most significant affects.

11 As you can see, the peak clad temperature
12 was higher for FWDRAG. It occurred more than 100
13 seconds later than the --

14 CHAIRMAN WALLIS: But that was with
15 FWDRAG, what, ten times as much or something?

16 MS. COLPO: Right.

17 CHAIRMAN WALLIS: Ten times as much?

18 MS. COLPO: Right.

19 CHAIRMAN WALLIS: Okay.

20 MS. COLPO: And it just looks like a
21 different transient. It doesn't quench at the same
22 time the other ones do. So I thought FWDRAG's the one
23 to look at.

24 DR. RANSOM: Well, did you multiply FWDRAG
25 just in the core or through everywhere, everywhere

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1 it's used?

2 MS. COLPO: Wherever it's used, that's
3 where it would come up, because in that bottom line
4 where it has the final -- this is what the wall drag
5 is, I just put a multiplier in, two, ten, .1 and so
6 on.

7 CHAIRMAN WALLIS: But then the other ones
8 that those black, red and blue, those are for VISCOL
9 changes or something?

10 MS. COLPO: VISCOL and post-DNB.

11 CHAIRMAN WALLIS: Oh, those are a factor
12 of ten on both of those things?

13 MS. COLPO: Actually, there is a factor of
14 two or three on those. Now, the reason that I put up
15 the ten was that I also did the same two or three on
16 the FWDRAG and it had a significant affect, too. So
17 I wanted to emphasize on this slide that it had the
18 most significant affect.

19 And I guess if I had put the same
20 multipliers in you would have still seen the same
21 idea. It's just accentuated here a bit more. Anymore
22 questions on that?

23 MR. SCHROCK: Is viscol simply the liquid
24 viscosity? Did I understand that --

25 MS. COLPO: The water liquid viscosity,

1 correct.

2 MR. SCHROCK: And you put a multiplying
3 factor of three on that?

4 MS. COLPO: Two and three.

5 MR. SCHROCK: Two and three.

6 MS. COLPO: Yes. Actually, I did more
7 than that. I started out with .5, you know, to see.
8 It wasn't a whole lot of difference.

9 MR. SCHROCK: It's not --

10 MS. COLPO: I just kept playing with it
11 until I saw something happen.

12 CHAIRMAN WALLIS: Well, the title says,
13 "PCT independent of location."

14 MS. COLPO: Right.

15 CHAIRMAN WALLIS: Does that mean that you
16 fixed the place where you raise the temperature or?

17 MS. COLPO: What that means is that this
18 was run with the Westinghouse three-loop model that
19 Framatome ANP gave us.

20 CHAIRMAN WALLIS: Right.

21 MS. COLPO: And there was a script that
22 could go through and look anywhere in the core and
23 pick the highest peak cladding temperature.

24 CHAIRMAN WALLIS: Ah, that's what it
25 means, is that this -- it searches for the peak clad

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1 temperature, independent of where it may be?

2 MS. COLPO: Yes.

3 CHAIRMAN WALLIS: That's what the typo
4 means? Okay.

5 MS. COLPO: Right.

6 DR. KRESS: Are you --

7 CHAIRMAN WALLIS: So you're --

8 DR. KRESS: I'm sorry.

9 CHAIRMAN WALLIS: -- so you're finding the
10 real peak clad temperature.

11 MS. COLPO: Right.

12 CHAIRMAN WALLIS: Yes.

13 DR. KRESS: But when you vary viscosity
14 aren't you just going for a wild ride?

15 CHAIRMAN WALLIS: Maybe it's also an
16 interface drag.

17 DR. BANERJEE: You vary the Reynolds
18 number.

19 CHAIRMAN WALLIS: And all kinds of things.

20 DR. BANERJEE: You vary the Reynolds
21 number, too.

22 CHAIRMAN WALLIS: Maybe it's also an
23 interface drag.

24 DR. BANERJEE: Maybe. I don't know. I'd
25 have to look at the formulation.

1 MS. COLPO: Framatome, like I said,
2 provided the staff with the Westinghouse three-loop
3 large break LOCA model, and I ran a base case with
4 this model and then inserted the multipliers of two
5 and ten in the FWDRAG subroutine of the code and
6 recompiled and reran the plant deck.

7 Those results were interesting and
8 prompted some further investigations, and I'll show
9 them on the next slide. But just to say right now
10 that for further investigation Framatome also provided
11 the input deck for the FLECHT SEASET test 31504.

12 I ran a base case with that model and
13 inserted multipliers of .1, two and ten into the
14 FWDRAG subroutine of the code, recompiled and reran
15 the FLECHT SEASET model, and this study will be the
16 focus of the rest of my presentation.

17 Of course, one of the differences between
18 the two cases is the PWR case is a model of the whole
19 primary coolant system. Whereas, the FLECHT SEASET
20 test is basically just a lower plenum and a core and
21 an upper plenum and that's it.

22 So it really focuses the investigation on
23 what happens when you increase or decrease the wall
24 drag in the core.

25 DR. RANSOM: Do you know if in the FLECHT

1 SEASET case they had boundary conditions of just
2 pressure? Or did they have a velocity boundary
3 condition?

4 MS. COLPO: They had pressure, temperature
5 and velocity, and I'll get to that. I have a
6 nodalization diagram that shows that. These are the
7 results from running the PWR cases. The heavy black
8 line is the base case with no multiplier or just one
9 as the multiplier on FWDRAG.

10 The blue line is the case modified to
11 calculate ten times the wall drag. As you can see,
12 the peak clad temperature is increased with increasing
13 wall drag. This is explained by saying that the wall
14 drag retarded reflood by slowing down the progress of
15 the clench front.

16 Also, the ten times wall drag case looks
17 like a totally different transient and it resulted in
18 over 100 degree higher peak clad temperature occurring
19 later, and once again, doesn't quench before the end
20 of the calculation.

21 So because of these results I was
22 interested in running some cases where reflood would
23 be the focus, and that's what I was just talking about
24 in running the FLECHT SEASET model runs.

25 This slide shows the FLECHT SEASET cases

1 that I ran with the model provided by Framatome. The
2 bottom green line, I just wanted to interject
3 something here. It didn't show up on the slide right
4 here, but the bottom green line shows the liquid
5 viscosity multiplied by a factor of ten.

6 And for some reason it didn't show up on
7 either my overhead plot or the plots that I printed
8 out for handouts for you all. So this one, this
9 bottom green line, this is actually ten times the
10 liquid viscosity.

11 CHAIRMAN WALLIS: That's interesting,
12 because ten times viscosity in the turbulent region
13 looks as if it's almost like four times the wall drag,
14 which doesn't seem quite right for the usual exponent
15 on Reynolds number.

16 But maybe it's changing something else
17 like the bubble rise velocity or something. So it's
18 hard to tell.

19 DR. BANERJEE: What are the other lines?

20 MS. COLPO: The other lines there are
21 these -- I'm not sure if I'm pointing correctly. This
22 is two times the wall drag, one time the wall drag, or
23 basically no multiplier, and 0.1 times the wall drag.
24 And those are the different peak clad temperatures
25 that you get running those cases.

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1 DR. BANERJEE: And the lowest one is ten
2 times the wall drag?

3 MS. COLPO: The lowest one is the ten
4 times.

5 DR. BANERJEE: So in this case the peak
6 clad temperature went down with increasing order?

7 MS. COLPO: Yes, which is interestingly
8 enough, just the opposite of what we saw in the PWR
9 case.

10 DR. RANSOM: The pressure boundary
11 condition, although that's what you'd expect because
12 you're reducing the flow rate, apparently.

13 CHAIRMAN WALLIS: Well, then you expect it
14 to get hotter if you reduce the flow rate.

15 MS. COLPO: Well, FLECHT SEASET, this test
16 had a constant velocity input, .972 inches per second
17 reflood rate constant.

18 DR. RANSOM: Oh, the velocity.

19 MS. COLPO: Right.

20 CHAIRMAN WALLIS: Constant velocity.

21 MS. COLPO: Right.

22 CHAIRMAN WALLIS: Oh.

23 MS. COLPO: They're putting it in as a
24 constant velocity, constant reflood rate.

25 DR. RANSOM: Oh, I see.

1 CHAIRMAN WALLIS: And that's reducing the
2 Reynolds number.

3 DR. BANERJEE: Reducing it, okay.

4 CHAIRMAN WALLIS: So the best thing we
5 could do is call this run molasses.

6 (Laughter)

7 DR. RANSOM: This viscosity, I guess,
8 would go into the heat transfer coefficient
9 calculation, as well?

10 MS. COLPO: Pardon me?

11 DR. RANSOM: Well, it would go into the
12 heat transfer coefficient calculation, as well as the
13 wall drag?

14 MS. COLPO: The --

15 DR. BANERJEE: This is the wall drag.

16 DR. RANSOM: If this is the property
17 routine.

18 MS. COLPO: This is the wall drag.

19 CHAIRMAN WALLIS: Except for one case.

20 MS. COLPO: Except for the one case.

21 DR. RANSOM: The one case, right.

22 MS. COLPO: The one bottom green line case
23 that I just put on there for comparison, say, to show
24 that the wall drag multiplied by ten had more of a
25 significant affect than --

1 DR. RANSOM: Oh, yes.

2 MS. COLPO: -- ten times the water
3 viscosity.

4 CHAIRMAN WALLIS: It's very strange,
5 because if you had an enormous wall drag you wouldn't
6 have any flow, presumably, or what would happen?

7 DR. BANERJEE: If she's injecting --

8 CHAIRMAN WALLIS: You're forcing the flow.

9 MS. COLPO: Right.

10 CHAIRMAN WALLIS: Right.

11 MR. LANDRY: I think if you let Sarah go
12 through an explanation.

13 CHAIRMAN WALLIS: Okay.

14 MR. LANDRY: Because we did a lot of head-
15 scratching on what was going on in this.

16 CHAIRMAN WALLIS: Yes, we can do that.
17 Maybe we should move on and then --

18 MS. COLPO: Okay.

19 CHAIRMAN WALLIS: -- see what we learn at
20 the end, yes.

21 MS. COLPO: Well, this plot definitely
22 prompted me to dig in and figure out what was going
23 on. I wanted to show you a nodalization diagram. I
24 promise I'm not going to try and draw any control
25 volumes on this thing.

1 And I wanted to let you know also that
2 this was generated by SNAP. So SNAP does work. As I
3 mentioned before, there's -- the lower plenum had 40
4 psi and 123 degrees F, and in this junction here into
5 the heated portion, the heated core region, there's a
6 constant reflood rate of .972 inches per second.

7 So that was just constant throughout the
8 test. Then you have the unheated core region and then
9 the upper plenum, which also had I believe it's --
10 what is it -- 40 psi and 400 degrees F.

11 MR. SCHROCK: The injected water is always
12 123?

13 MS. COLPO: Yes.

14 CHAIRMAN WALLIS: Well, it keeps the
15 liquid in there, right?

16 MS. COLPO: This is just a picture of the
17 core, the heated core region with its 20 axial nodes
18 and the elevations that correspond to each of the
19 nodes or the volumes. The integral mass flow in, mass
20 flow out and carry out fraction was the same for all
21 of the runs.

22 There was no change when we changed the
23 multipliers. Integral mass flow in. I'm not sure
24 that you all have these plots in.

25 MR. BOEHNERT: We don't have those.

1 MS. COLPO: Right. Because there wasn't
2 really anything to show except for everything was the
3 same.

4 DR. BANERJEE: Well, you were forcing the
5 in flows -- forcing velocity.

6 MS. COLPO: Right. So okay. Here, I get
7 to use my two overheads. Okay. What you can see on
8 these clads is of the steam output rate and the liquid
9 outflow rate is that a higher wall drag produces a
10 higher steam outflow, and a lower liquid outflow.

11 The one-tenth of the base case wall drag
12 produced the highest liquid outflow and the lowest
13 steam outflow rate. What we're seeing is more water
14 is being held in the lower core section, which boils
15 and produces more steam, and that's substantiated
16 further by the next few slides.

17 CHAIRMAN WALLIS: I guess these steam flow
18 oscillations are why Larry Hochreiter has his damping
19 vessel in his new experiment.

20 DR. BANERJEE: It's also due to Unow's
21 (phonetic) boiling calculation.

22 MS. COLPO: This slide shows a plot of the
23 differential pressure at the lower one foot of the
24 core. And as you can see, the larger wall drag again
25 is seen to retain the most liquid in the lower core

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1 region. Okay. You're going to love these.

2 (Laughter)

3 MS. COLPO: All right. What you're seeing
4 here --

5 CHAIRMAN WALLIS: Modern art, it looks
6 like.

7 MS. COLPO: Yes. It is something more
8 beautiful than modern art, even. What they show is
9 the void fraction in the core, and what these -- these
10 different lines show the void fraction as you move up
11 in the core, so.

12 DR. RANSOM: In this particular case does
13 it start out full of liquid and then it's boiling off
14 or?

15 MS. COLPO: No. No. It's getting filled
16 up.

17 CHAIRMAN WALLIS: It's full of steam.

18 DR. RANSOM: Oh, is this void fraction or
19 is this liquid fraction?

20 MS. COLPO: It's a void fraction. If you
21 can see --

22 CHAIRMAN WALLIS: They all start at the
23 top. They all start at the top and come down.

24 MS. COLPO: Well, I think the very first
25 one started at the bottom and went up.

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1 CHAIRMAN WALLIS: No.

2 MS. COLPO: No?

3 CHAIRMAN WALLIS: Looks to me that they
4 all start --

5 MS. COLPO: Start at the top and go down
6 to the bottom.

7 CHAIRMAN WALLIS: They all start at the
8 top, yes.

9 MS. COLPO: Right.

10 CHAIRMAN WALLIS: It's dry at the start.

11 MS. COLPO: Right.

12 DR. RANSOM: Oh, I see. Right. Okay.
13 It's filling up with liquid, yes.

14 CHAIRMAN WALLIS: Oh, I think we're going
15 to have to ask Ralph Landry what he concludes from
16 this, too.

17 DR. BANERJEE: And you said we've love
18 them, so is it the art we love or is there something
19 we should know from here?

20 MS. COLPO: Well, it's partially the art.
21 The thing that you should notice from this is that in
22 the point -- 0.1 multiplier case you see the -- in the
23 upper regions of the core, which is as we move this
24 direction, in the upper regions of the core you're
25 getting a lower void fraction than you do with ten

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1 times the wall drag.

2 It's staying -- the void fraction is
3 staying higher. So that's what I saw in comparing
4 these two.

5 MR. SCHROCK: How do you interpret where
6 you are in the core on this?

7 MS. COLPO: So and now -- now, this is why
8 I said you'd love it, because basically it's just --
9 each of these lines represents a level in the core.
10 So as you --

11 MR. SCHROCK: We don't have the legend
12 yet. Okay.

13 MS. COLPO: As you kind of progress this
14 direction --

15 MR. SCHROCK: Go across. I see.

16 MS. COLPO: -- through the plat, it's
17 lines representing higher levels in the core. Did
18 that make sense?

19 MR. SCHROCK: Yes, liquid is eventually
20 getting up there.

21 MS. COLPO: Right.

22 MR. SCHROCK: Yes. The blue one sort of
23 in the middle, is it the same location?

24 MS. COLPO: Yes. All of them, I made sure
25 that the same color lines would match the same

1 locations, which meant I had to do it over once or
2 twice, actually. Okay. Let's see. This is another
3 indication of less water being carried out of the core
4 in the high wall drag case.

5 And these are my last sets of slides, more
6 lovely ones I'm sure you'll appreciate. Okay. So
7 these show the flow regimes for the .1 and the ten
8 multiplier cases. And what I tried to do is point --
9 see, when you ask the code for the flow regimes it
10 basically pops out numbers which correspond to meeting
11 some flow regime.

12 So that's what's plotted out, is the
13 numbers. And then I tried to indicate by pointing
14 arrows to like, say, this one right here and --

15 CHAIRMAN WALLIS: Excuse me. This is at
16 some particular point, because presumably the --

17 DR. BANERJEE: Different colors are
18 different locations.

19 MS. COLPO: Yes.

20 CHAIRMAN WALLIS: The colors are different
21 locations?

22 MS. COLPO: Just the same as in the void
23 fraction that we were just looking at.

24 CHAIRMAN WALLIS: So how do we know -- oh,
25 different levels being different flow regime,

1 different heights on the flow regime. Okay. Okay.

2 MS. COLPO: So yes.

3 CHAIRMAN WALLIS: So four is a bubbly and
4 five is a slug and --

5 MS. COLPO: Right. I believe so, yes.
6 Right. Four is a bubbly. Five is a slug.

7 CHAIRMAN WALLIS: I didn't know they had
8 such a sophisticated flow regime map, FLECHT SEASET.

9 DR. BANERJEE: No. They inverted and
10 uninverted, the same fluid uses.

11 MR. BOEHNERT: Isn't some of this a matter
12 of judgment, though, about what regime to use?

13 DR. BANERJEE: There's a map.

14 MR. BOEHNERT: Yes.

15 DR. BANERJEE: What else?

16 MR. BOEHNERT: Those lines were to be
17 fuzzy.

18 MR. SCHROCK: Let's see. What is an
19 inverted slug?

20 MS. COLPO: The slug inverted?

21 DR. BANERJEE: Big chunks of liquid flying
22 upwards.

23 (Laughter)

24 MR. LANDRY: What we see the code doing is
25 selecting the flow regime. And in fact, we're seeing

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1 the affect here of inverted annular flow and that's
2 for the low flooding rate, or the low wall drag case
3 that Sarah ran, a very strong affect of going into an
4 inverted annular flow regime.

5 Where we're blanketing the rods with steam
6 we're getting a high mass flow through, but the mass
7 flow is not penetrating the annular region and cooling
8 the rods. So even though we supposedly have a lower
9 flooding rate for carrying out a lot of liquid, we're
10 not doing it effectively.

11 CHAIRMAN WALLIS: I'm a little concerned
12 about it, having so much inverted slug in this, which
13 is a strange flow regime anyway.

14 DR. BANERJEE: It's very oscillatory. You
15 see it in reality.

16 CHAIRMAN WALLIS: You've got hunks of
17 liquid.

18 DR. BANERJEE: It's not like real slug,
19 so, but boy, just up and down.

20 MR. LANDRY: Now, you have to put what
21 Sarah was doing into perspective, that we were not
22 doing it to verify the code or assess the code. We
23 were trying to understand what the code was doing.
24 And by doing this calculation set for a big plant
25 calculation we had -- we confirmed our feeling that

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1 wall drag is going to be a strong affect.

2 Viscosity is going to be a lower order
3 affect. When we looked at the FLECHT SEASET, though,
4 we were very surprised because it seemed to be going
5 the opposite of what we thought should be happening.

6 And what began as just doing some
7 calculations ended up a pretty in-depth analysis that
8 Sarah had to do, because she had to then go back and
9 figure out why is this inverting what I expect to see.

10 And it's only by tracing through what the
11 code was doing with selecting the flow regime map,
12 matching up with the flow conditions, that we're able
13 to see that, well, this thing is going into a flow
14 regime that seems to be carrying out fluid or liquid,
15 but it's doing it inefficiently as far as heat
16 transfer is concerned.

17 And then when we started to think about
18 it, okay, yeah, that is reasonable and it does fit,
19 because we're fixing the flooding rate.

20 DR. BANERJEE: The pressure was higher at
21 the bottom, right?

22 MR. LANDRY: Right. Right.

23 CHAIRMAN WALLIS: So this --

24 DR. BANERJEE: How much higher was it, do
25 you know? Do you remember?

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1 MR. LANDRY: Sarah had that.

2 CHAIRMAN WALLIS: Well, it's varied,
3 depending on the wall drag.

4 DR. BANERJEE: Yes, that's what I mean.

5 MR. LANDRY: Right. The wall drag alters
6 the pressure distribution throughout the channel,
7 alters the flow regime.

8 MS. COLPO: Is this the one you were
9 looking for?

10 DR. BANERJEE: Right. Right.

11 CHAIRMAN WALLIS: So what you're gaining
12 from this is -- because of some confidence that the
13 code is giving results which make some sense
14 physically when you vary some things and you explain
15 why it's doing what it's doing? Is that what you gain
16 from this?

17 MR. LANDRY: Correct. As I said, this was
18 not done to confirm the validity. We were trying to
19 understand what the code is doing.

20 CHAIRMAN WALLIS: Sort of exploring,
21 exploring.

22 MR. LANDRY: It was more exploratory.

23 CHAIRMAN WALLIS: Maybe in the future when
24 you do more of this you could focus on some key areas
25 where something might be -- have some significance

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1 relative to code assessment or a safety evaluation or
2 something?

3 MR. LANDRY: Right. That's what Ralph
4 Caruso indicated earlier in the presentation, that
5 this is all a part of the staff's own learning curve.
6 We've learned something from this and when we get
7 another code, which we have another code coming in for
8 review already, we've learned something here and we
9 can carry through and we can explore a couple other
10 areas now and have some ideas for our next code
11 review.

12 DR. BANERJEE: Wall drag is a pretty good
13 thing to try because you can get fuel with very
14 different roughness and crud formation and all sorts
15 of stuff, you know, and the fact that it's so
16 sensitive to it is quite interesting, I would say.

17 MR. LANDRY: So our -- from this, our
18 conclusion is that this was a very good exercise. It
19 was a good exercise in understanding the code. It was
20 a very good exercise for us in working with the code.
21 We've been able to get into the code and fix our own
22 minds, has the coding been done correctly, or the
23 spot-checking we did.

24 Do we see which -- a couple of parameters
25 that we feel are important, are they important? Does

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1 this confirm in our minds the importance of a couple
2 of key parameters as indicated by the PIRT? So
3 overall, we're quite pleased with this work.

4 It is a beginning for us and we hope to
5 have the opportunity to continue with additional codes
6 in this manner.

7 MS. COLPO: I'll say I definitely learned
8 a lot in going through this exercise through the
9 studies.

10 MR. LANDRY: Okay.

11 DR. RANSOM: I was going to ask you, did
12 the code fail at all?

13 MS. COLPO: Not at all.

14 DR. RANSOM: No problems?

15 MS. COLPO: No problems.

16 DR. RANSOM: Robust.

17 CHAIRMAN WALLIS: Are we ready to move on
18 to Ralph's summing up? Thank you very much.

19 MR. LANDRY: I don't know if all that last
20 remark, if Vic meant to say rats, or yea. I don't
21 know if he was disappointed or happy.

22 CHAIRMAN WALLIS: He seemed somehow
23 surprised that the code didn't fail.

24 (Laughter)

25 MR. LANDRY: Okay. Some of the

1 conclusions that we arrived at in our SER, we
2 concluded that the review of the documentation code
3 and input models submitted by Framatome ANP, that the
4 S-RELAP5, realistic large break LOCA methodology is
5 structured consistent with the guidelines of the CSAU
6 methodology, methodological process.

7 It addresses the licensing requirements
8 for a variety of similarly designed nuclear power
9 plants. And in particular, we concluded that this
10 applies to the three-loop and four-loop Westinghouse
11 designs and the two by four combustion engineering
12 design with bottom-up quench, bottom -- or lower
13 plenum injection plants.

14 Methodology, the model applies to bottom
15 reflood plants only. In other words, we do not
16 believe that this applies to the upper head injection,
17 upper plenum injection plants, plants for which a top-
18 down quench occurs.

19 If that occurs we feel that there has to
20 be further review of the methodology and the modeling.
21 The modeling does not determine whether long-term
22 cooling has been satisfied, as this is determined by
23 individual licensees as part of the application of a
24 methodology, or as part of a design basis established
25 by the licensee.

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1 If the licensee's design basis has already
2 addressed long-term cooling, this is primarily a
3 hardware issue. Unless there is some reason that this
4 methodology would change the conclusions already in
5 place, we do not see a need for talking about long-
6 term cooling with respect to realistic large break
7 LOCA methodology.

8 CHAIRMAN WALLIS: So you think --

9 DR. RANSOM: Ralph, is there any interest
10 in BMW plants or is that --

11 MR. LANDRY: This has not been assessed
12 for application to the once-through steam generator
13 design.

14 DR. RANSOM: So that's not being
15 considered now?

16 MR. LANDRY: No. That may be -- Framatome
17 now -- what was seen -- or it was Exxon, then it was
18 Advanced Nuclear Fuels. Then it was Siemens, it's now
19 Framatome also owns what used to be BMW. So at some
20 point in time Framatome may very well want to apply
21 this to the rest of the fleet of Framatome hardware.

22 At that point this would have to be re-
23 viewed for application to once-through steam
24 generators. That's why we've been very specific.
25 What they've asked for is applicability to three- and

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1 four-loop Westinghouse design; in other words, U-tube
2 seeded (phonetic) generator, a recirculating steam
3 generator, and to the combustion engineering two by
4 four design.

5 MR. MALLAY: This is Jim Mallay. As I
6 mentioned this morning, our next effort over the next
7 five to eight years will be apply the realistic --
8 well, I should say the S-RELAP5 platform to BWR
9 analysis. We currently do not have plans to apply it
10 to the BMW units.

11 CHAIRMAN WALLIS: Can we look at your
12 first bullet? You conclude from review of the
13 documentation, code and input models submitted by
14 Framatome is structured consistent with the
15 guidelines. That's a very weak sort of statement.

16 That simply says they tried to follow the
17 rules. Doesn't say it's good. It doesn't say --

18 MR. LANDRY: Well, they've concluded that
19 they satisfied the requirements.

20 CHAIRMAN WALLIS: Well, of the process,
21 but it doesn't mean to say that they met -- they went
22 -- they took the exam, but did they pass?

23 MR. LANDRY: This morning and earlier
24 today we've discussed an issue which we are now
25 examining.

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1 CHAIRMAN WALLIS: They passed everything
2 else?

3 MR. LANDRY: They passed until we decided
4 -- until we understood fully what was being said with
5 regard to selection of the worst (phonetic) break
6 size.

7 CHAIRMAN WALLIS: I'm very surprised, see.
8 You've said the documentation, code and input models
9 is what led you to your conclusion. I would have
10 turned it around completely and said, in spite of the
11 documentation --

12 (Laughter)

13 CHAIRMAN WALLIS: -- code and input
14 models, our assessment -- our assessment -- of the way
15 the overall code works when compared with the data
16 leads us to conclude that it's a good code. I don't
17 think you can conclude anything from what's claimed in
18 approximate equation in some documentation. That
19 doesn't tell you if it works or not at all.

20 MR. LANDRY: Well, what we're saying, Dr.
21 Wallis, is everything combined --

22 CHAIRMAN WALLIS: Yes.

23 MR. LANDRY: -- leads us to the
24 conclusion.

25 CHAIRMAN WALLIS: But please, please state

1 that your assessment -- isn't it your assessment that
2 has to be the key decision driving process? The
3 documentation -- because so many assumptions are made
4 in it and because it's so much -- so many ad hoc
5 methods are introduced to make things happen, it is a
6 hodge-podge.

7 And the only real test of its usefulness
8 and its acceptability has to be that it works as a
9 package. Isn't that -- would you disagree with that
10 statement?

11 MR. LANDRY: I don't want to be so
12 negative about any aspect. When we assess -- when we
13 determine acceptability or for approval, we look at
14 the entire package and consider the entire package.
15 The documentation, maybe it's poor; maybe it's not.

16 We look at the code itself. We look at
17 the input models that work. We look at the code and
18 the input models to work with them. And that's what
19 I think you're referring to as our assessment. By
20 working with the code, the input models and the
21 documentation we get an overall feel and we look at
22 what is required by the regulations.

23 CHAIRMAN WALLIS: So when you read the --

24 MR. LANDRY: When we put it all together
25 we say, yes or no. We don't say, in spite of crummy

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1 documentation we have run a case that says it's okay.
2 We have to say when we take the entire package
3 combined --

4 CHAIRMAN WALLIS: Well.

5 MR. LANDRY: -- we are satisfied that they
6 meet the regulatory requirements.

7 CHAIRMAN WALLIS: Let me say it another
8 way, and then I'll come back to the other one. Even
9 if the documentation looked good, I mean, even if you
10 couldn't question the derivation of the equations and
11 the assumptions made and so on, even if the
12 documentation looked really fantastic and good, I
13 think you'd still say, you know, that's all very well,
14 that's theory; you've got to show that it works.

15 And I would think that showing that it
16 works has to be the key part of it all.

17 MR. LANDRY: That's an important part.

18 CHAIRMAN WALLIS: Isn't that really the
19 case?

20 MR. LANDRY: Yes. And that -- today we're
21 mixing what the applicant has shown with what we have
22 learned, the code itself. The old days we would
23 simply base it on the documentation and what the
24 applicant or the vendor would show to us, because we
25 would not work with the code.

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1 So today, we have the advantage of not
2 only having to look at the documentation and say,
3 well, the documentation leaves a lot to be desired.
4 We don't -- we've looked at all the assessment. We've
5 worked with the code. We've looked at the internals
6 of the code.

7 When we take the whole package together we
8 make a judgment as to acceptability. So I prefer to
9 not be negative about any one aspect. I prefer to
10 take the position that because of the whole package
11 we're able to draw a conclusion.

12 CHAIRMAN WALLIS: So when you saw the
13 momentum equations you cheered and said, wonderful.

14 MR. LANDRY: Don't put words in my mouth.

15 CHAIRMAN WALLIS: But you're saying, you
16 know, the documentation and the input model submitted
17 seem to be put up here as being the key thing.

18 MR. LANDRY: No. When we take it all --

19 CHAIRMAN WALLIS: I can't believe that's
20 the case.

21 MR. LANDRY: No. I keep trying to say,
22 when we take everything together -- I could have put
23 that in the reverse order and this order was just
24 that. Writing these items down, it wasn't intended to
25 infer --

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1 CHAIRMAN WALLIS: Right.

2 MR. LANDRY: -- this is key, this is
3 lesser, this is least.

4 CHAIRMAN WALLIS: I think my view is that
5 the assessment has to be key, and maybe -- I don't
6 know if you've got time to tell us a bit more about
7 how you were satisfied with the assessment.

8 It seems to me that your manipulating the
9 code was interesting, but it didn't really address the
10 question of whether or not this code's adequate for a
11 large break LOCA. It showed that you can run the
12 code.

13 You can do parametric studies, but it
14 didn't really address the key issue of having to do
15 with nuclear safety or adequacy of the code. And I
16 suppose if the code hadn't worked, you know, it taught
17 you something.

18 The assessment has to be at a deeper level
19 than that. So what was this deeper level of
20 assessment that really convinced you to give this an
21 okay?

22 MR. LANDRY: Well, when we look at the
23 assessment cases we look at the breadth of the
24 assessment that's been performed. Has the code been
25 assessed against separate affects test? Has the code

1 been assessed against integral systems test?

2 Has the code been assessed over a range of
3 sizes? What -- just ignore the whole question of
4 scale right now. Has there been a sufficient range of
5 sizes or tests that are used for comparison and for --
6 ranging from separate effects through integral systems
7 to big full-size, if it was available?

8 When we look at the entire package of
9 assessment we can say, okay, for this test the results
10 are not as good as we would like to see. There's
11 something here that is happening that the results are
12 not real good.

13 But when we look at the overall proponents
14 for all of the assessments together, we get a nice
15 feeling that the code is performing well against this
16 whole range.

17 Today, the assessments that are being done
18 are trying to cover -- this isn't talking just about
19 Framatome -- today the assessments that are being done
20 are trying to cover an adequate range from separate
21 affects that model or emphasize particular phenomena,
22 to full -- to integral systems to full-size, where
23 possible.

24 When we look at those assessments we want
25 to insure that there is as complete a coverage as

1 possible. We're also now becoming more and more aware
2 of the difficulties that applicants, vendors are
3 having in obtaining good quality data over the entire
4 range.

5 And we're becoming maybe a little more
6 sensitive to this degradation that I talked about
7 earlier, that the entire code community around the
8 world is complaining about now.

9 It's going to be very interesting in the
10 future to see results from tests like those that Larry
11 Hochreiter is doing, to see more data in a more
12 prototypic condition, fluid, hardware-wise, et cetera,
13 for use against -- use with modeling and testing of
14 the codes.

15 CHAIRMAN WALLIS: Does this statistical
16 and uncertainty approach help a great deal in
17 assessing whether a code should be accepted or not?

18 MR. LANDRY: Personally, I think it does
19 help because by doing comparisons with separate
20 affects tests, phenomenological tests, a code can --
21 a code-user or a code-developer can determine, are the
22 correlations and models in the code predicting the
23 phenomena correctly?

24 If not, what are the biases plus and
25 minus? Do enough of those add the biases to enough of

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1 the phenomenological models and then go back -- or
2 before doing that, go out and calculate a large
3 medical assistance test, now see where the differences
4 are, add your biases in and see what the code does as
5 a calculation against the integral systems test?

6 Does the code -- did the biases now come
7 in and give a very good prediction of the integral
8 systems test? It does? Okay. Now, we can go out and
9 we can understand more about the uncertainty in the
10 code and do a prediction in a more realistic nature
11 for a full-size plant.

12 I think this helps a great deal. I think
13 this helps understand what the code is doing and say,
14 yes, this code is calculating phenomena correctly, or
15 we understand where there are biases in the
16 phenomenological calculation, so that when we get a
17 result we have more faith in the result than a
18 methodology that's so deterministic that we say, well,
19 we don't understand a lot of these things in the code
20 so we're going to slap on something that's incredibly
21 conservative to guarantee that our result is
22 conservative, no matter what's wrong in the code.

23 CHAIRMAN WALLIS: Well, most things you
24 hear about assessment of the old way of assessment
25 seemed to be you make some runs and you look at some

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1 data and you draw some wiggles and squiggles and see
2 if the data are somewhere near the wiggles and
3 squiggles.

4 And that's a very qualitative sort of
5 expert judgment approach. I thought that we were
6 trying to replace that with something more logical,
7 mathematical, statistical by saying, let's take this
8 bunch of data, let's see what that tells us about the
9 uncertainties in the code.

10 Let's use the data to establish some
11 numerical assessment in the form of probabilities and
12 so on with those uncertainties, and then let's
13 synthesize this together and relate in some way to
14 full-scale -- full -- what do you call it -- system
15 tests.

16 And presumably, you need to get some
17 uncertainty assessments out of the system tests. But
18 now, you've got a quantitative way of saying how good
19 the code is because you've got some statistical way of
20 evaluating it.

21 The old way of just looking at data points
22 and curves have always made me nervous, because I
23 wasn't sure of what I was really learning from that.
24 But if you can extract some meaningful statistical
25 information and use it, that seemed to me a tremendous

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1 step forward.

2 MR. LANDRY: And that's what the bias
3 analysis does.

4 CHAIRMAN WALLIS: I mean, I'm surprised
5 you didn't emphasize that more in your conclusion.
6 You didn't say anything about it at all. You just
7 said documentation code input models. I would think
8 it's the assessment and the statistics and the logical
9 evaluation of uncertainties which is the key to
10 evaluating the code.

11 MR. LANDRY: This SER is a draft. We do
12 intend to go back and modify it. You received some
13 time ago another draft SER --

14 CHAIRMAN WALLIS: Which was different.

15 MR. LANDRY: -- which was different
16 because at that point we were involved in some very
17 difficult discussions, and following those discussions
18 we resolved problem areas that we had. So we were
19 able to go back and rewrite the SER.

20 We sat down and completely rewrote the SER
21 to try to get closer to the methodology that was being
22 used in support of the methodology, and explain what
23 was being done with the realistic large break LOCA
24 methodology and why it was acceptable.

25 This is going to be fine-tuned. Through

1 the discussions of the last two days we know there's
2 some other areas to go back and tune what we've
3 written and explain further where we need to do
4 further explanation in our SER.

5 As I said earlier at the outset, what we
6 have done in the review is a snapshot look at the
7 methodology, and out of that we've written an SER
8 that's a snapshot. If we had written down everything
9 that we did it would be massive.

10 So we -- but seeing where the questions
11 are that experts on the subcommittee identified, we
12 can see where we can go back now and further explain
13 in the SER what we have done and why we believe it's
14 acceptable.

15 CHAIRMAN WALLIS: Which will be done
16 before the full committee meets in December?

17 MR. LANDRY: It will be done in -- we have
18 an issue that we need to resolve.

19 CHAIRMAN WALLIS: So what the full
20 committee sees in December is not going to change
21 significantly afterwards?

22 MR. LANDRY: We would hope not. We're
23 going to go back and work on the SER some more.

24 DR. KRESS: Your remaining issues, the
25 statistical variation in the pipe size. Other than

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1 that you would have said this thing is ready to go.

2 MR. LANDRY: Right.

3 DR. KRESS: It's okay.

4 MR. SCHROCK: But you have a statement
5 about that in the current draft which is puzzling to
6 me, because as I read it I get the impression that you
7 are ready to disapprove what they are saying about
8 probability. And then you turn around and say that
9 they're consistent with the CSAU approach.

10 MR. LANDRY: No. Go through to the top of
11 that section on uncertainty analysis and you'll see in
12 bold letters a statement that that entire section is
13 being replaced. That's because that -- there's an old
14 section from when we were having discussion, which
15 Yuri talked about earlier, of the former approach and
16 the current approach of Framatome.

17 We have a new writeup for that that will
18 be substituted for that writeup. So that -- what I
19 was trying to indicate on there without just leaving
20 a big hole was, here's the writeup we had, but ignore
21 it because we're going to change that entire section.
22 It's going to be pulled and a whole new section put
23 in.

24 DR. RANSOM: I've got a couple questions.

25 DR. KRESS: Do you want us to express our

1 opinion on this statistical variation in the pipe size
2 in a letter or something or did you --

3 MR. CARUSO: Not yet.

4 DR. KRESS: You'd rather look into the
5 policy issues first?

6 MR. CARUSO: We would rather discuss this
7 before we ask for your advice.

8 DR. KRESS: Okay.

9 DR. RANSOM: I've got a couple questions.
10 One, did you rerun any of the assessment calculations
11 that Siemens provided that you could then assure
12 yourselves, I guess, that those are what they say they
13 are?

14 MR. LANDRY: Well, Sarah rerun the FLECHT
15 SEASET test --

16 DR. RANSOM: Right. But what about like
17 LOFT and --

18 MR. LANDRY: -- 31504, I believe it was,
19 and reran the three-loop --

20 DR. RANSOM: PWR, right.

21 MR. LANDRY: -- PWR. Those gave us the
22 base cases for the further work that she did. But as
23 far as going back and rerunning the other cases, no.

24 DR. RANSOM: The other question is, did
25 you run some of those cases with your code, you know,

1 with the licensing audit code that the NRC has? It
2 would be interesting to see what the comparison is
3 between the NRC's version and the Siemens version.

4 MR. LANDRY: Well, the version that we
5 have right now is RELAP5 lot 3.2.2 or 3.3 gamma. I
6 don't --

7 DR. RANSOM: Yes, whatever. I mean --

8 MR. LANDRY: -- I'm not sure exactly which
9 modeling.

10 DR. RANSOM: -- would that be of interest?
11 That presumably is your audit tool, right?

12 MR. LANDRY: Yes. But we did not go back
13 and run it for comparative purposes.

14 MR. CARUSO: Actually, what I'd like to
15 do, I think, next time around is use TRAC-M.

16 DR. RANSOM: Well, or use TRAC-M. It's
17 whatever you want to use.

18 MR. CARUSO: And I believe we just
19 received a copy of a SNAP tool which will do a
20 translation between a RELAP deck and a TRAC-M. So that
21 may make it a lot easier to do these in the future.
22 There's a lot of effort to putting together a deck
23 from scratch.

24 And we don't have any -- I'm not sure if
25 there are any TRAC-M decks available for some of these

1 facilities. I'm not sure what's available at this
2 point.

3 MR. LANDRY: You have to keep in mind also
4 that RELAP5 MOD 2 deck is now running RELAP5 MOD 3
5 without conversion.

6 MR. CARUSO: Right.

7 MR. LANDRY: So we would have to do the
8 conversion and then we would have to do some final
9 checking or Q/A to make sure that their MOD 2 point
10 whatever it is deck was converted properly to run on
11 MOD 3.

12 DR. RANSOM: Well, you surely have LOFT
13 decks, don't you? I mean, because I think the thing
14 of most interest would be to compare it to something
15 where you do have it done.

16 MR. LANDRY: Yes.

17 DR. RANSOM: But I guess you haven't done
18 that yet. But the other thing is, Bill Nutt showed me
19 a curve that I don't know if you're willing or can
20 show it here, but it seemed to me it's the kind of
21 thing that would be very much of interest to this
22 committee, as well as, you know, the full ACRS
23 committee. And I'm not sure what their status is. Is
24 that possible or?

25 CHAIRMAN WALLIS: Can we see it after

1 we've finished questioning Ralph? I wanted to go back
2 to the first of Sarah's -- you said that she --

3 MR. LANDRY: You can.

4 CHAIRMAN WALLIS: -- she did do these 3D-
5 2D-3D tests and then she seemed to be uncertain about
6 what to conclude. She sort of said, well, they're
7 mostly conservative. This is -- could something --
8 couldn't something more be wrung out of that by
9 running those -- she actually ran the code on these
10 tests, right?

11 MS. COLPO: No.

12 MR. LANDRY: No, she examined.

13 CHAIRMAN WALLIS: Oh, she examined how
14 they had run the code on these.

15 MR. LANDRY: Yes.

16 CHAIRMAN WALLIS: I'm sorry. I thought
17 she had -- so she hadn't run the codes.

18 MR. LANDRY: Right.

19 CHAIRMAN WALLIS: Okay.

20 DR. KRESS: The key to this whole thing,
21 Ralph, is how they properly assess the uncertainties.
22 And then everything there is in terms of assessment of
23 statistical method and then what follows from it.
24 Were you very well satisfied with the way they
25 assessed the uncertainty in the code?

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