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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

SUBCOMMITTEE ON MATERIALS AND METALLURGY

+ + + + +

WEDNESDAY

JANUARY 16, 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., Peter Ford,
Chairman, presiding.

COMMITTEE MEMBERS:

F. PETER FORD, Chairman, ACRS, Member

MARIO V. BONACA, Member, ACRS

WILLIAM J. SHACK, Member, ACRS

STAFF PRESENT:

NOEL F. DUDLEY

1 ALSO PRESENT:
2 EDWIN HACKETT
3 SHAH MALIK
4 MARK KIRK
5 DAVID BESSETTE
6 ALAN KOLACZKOWSKI
7 ALI MOSLEH
8 JACK ROSENTHAL
9 TERRY DICKSON
10 BRUCE BISHOP
11 FRED SIMONEN (on the phone)
12 ROY WOODS

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

(8:34 a.m.)

CHAIRMAN FORD: I reconvene this meeting.

Where we got yesterday, we pretty well got back onto track, I think, Ed, as far as everything. And today we're going to concentrate primarily on the example I believe. Oh, I'm sorry. I have to read this again.

The meeting will now come to order. This is the meeting of the ACRS Subcommittee on Materials and Metallurgy. I am Peter Ford, Chairman of the Materials and Metallurgy Subcommittee. The other ACRS members in attendance are Mario Bonaca and Bill Shack.

The purpose for the meeting of this Subcommittee is to review the status of the Pressurized Thermal Shock Technical Basis Re-evaluation Project. In particular, the staff will present the initial results of the reactor vessel failure frequency of Ocone Unit 1 as calculated by the FAVOR probabilistic fracture mechanics code.

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

Mr. Noel Dudley is the Cognizant ACRS Staff Engineer for this meeting. The rules for

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1 participation in today's meeting have been announced
2 as part of the notice of this meeting previously
3 published in the Federal Register on December 19,
4 2001.

5 A transcript of this meeting is being
6 kept, and will be made available as stated in the
7 Federal Register Notice. In addition, a telephone
8 bridge has been set up to allow individuals outside
9 the meeting room to listen to the proceedings.

10 It is requested that speakers first
11 identify themselves and speak with sufficient clarity
12 and volume so that they can be readily heard. We have
13 received no written comments or requests for time to
14 make oral statements from members of the Public.

15 We will now proceed with the meeting and
16 I call upon Mr. Ed Hackett of the Office of Nuclear
17 Reactor Regulations to begin. Ed?

18 MR. HACKETT: Thank you, Peter. I'm glad
19 to be back again for Day Two to get into the detailed
20 example. Let me start by introducing the table. I'm
21 Ed Hackett. I'm Assistant Chief of Materials Branch
22 in the Office of Research.

23 And joining me at the table from my right
24 are Roy Woods and Alan Kolaczowski and their focus is
25 PRA. Mark Kirk, ably manning the Powerpoint station

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1 here for the visuals and fracture mechanics is Mark's
2 expertise, PFM, as is Shah Malik and Dave Bessette.
3 And Professor Ali Mosleh from the University of
4 Maryland are over there to my left.

5 A couple of items, I guess, of admin
6 business here, just to re-orient everyone, we are
7 schedule-wise, I think to vii, which is, on the
8 original schedule, which is the example problem.

9 We originally slated to launch into that
10 late yesterday. We didn't quite get there so that's
11 going to be the main focus of today.

12 Another item I will mention is the
13 Chairman and I talked yesterday about the need for a
14 letter or at least the idea that the Committee may
15 want to write a letter because if nothing else, it
16 turns out, I guess, history shows it's been a while
17 since the Committee wrote a letter regarding this
18 project.

19 So, at this point, I think we would
20 probably appreciate any feedback that the Committee
21 might want to give in that regard.

22 One item of unfinished business that, you
23 know, Mark was working on getting a few slides here
24 ready, or Mark and Dave Bessette, one item we left as
25 kind of an open item that looks like we may be ready

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1 to address at least partially today is Dr. Ford asked
2 yesterday about benchmarking the validation of the
3 RELAP code.

4 David said yesterday that there were some
5 experiments performed at APEX where there was some --
6 benchmarking may not be the right word, but there was
7 some comparison, at least, with the RELAP code.

8 And that information is available so we
9 were going to propose to start there --

10 CHAIRMAN FORD: Good.

11 MR. HACKETT: -- And hopefully get through
12 that quickly.

13 CHAIRMAN FORD: Excellent.

14 MR. HACKETT: I'm thinking is this 15
15 minutes worth or something on that order?

16 CHAIRMAN FORD: Probably 5 minutes.

17 MR. HACKETT: Okay.

18 (Laughter.)

19 MR. HACKETT: Oh, and there are slides?

20 MR. KOLACZKOWSKI: We want to address
21 there were some issues raised about seeing a little
22 bit more why main steam line break is going away. And
23 so I created a few slides that -- and in the example
24 in an appropriate place, I think we can diverge a
25 little bit and address that.

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1 Unfortunately we don't have it on the
2 computer although we could get it on maybe. But we do
3 have pass-outs and it's already passed out.

4 MR. HACKETT: Okay, we'll fit that into
5 the example problem then, too. So with that, I'll
6 turn it over to Mark and Dave.

7 MEMBER BONACA: Just a note, that's a very
8 good point. You know I've been reflecting since
9 yesterday and certainly one of the things that comes
10 to my mind is how do we get from you know five and ten
11 to the amount of six or wherever we were to where we
12 are now which is a big jump.

13 And so I was trying to organize in my mind
14 the main contributors to that. And I think that so,
15 you know, in all those instances where you see
16 measured contributions to this reduction, it would be
17 worthwhile to focus and pay some attention.

18 MR. KOLACZKOWSKI: I understand.

19 MEMBER BONACA: Yes, thank you.

20 CHAIRMAN FORD: Dave Bessette.

21 MR. BESSETTE: So what I'm going to show
22 here is some results that we obtained from our AP600
23 work. We went through quite an extensive validation
24 of RELAP during the AP600 program which lasted all
25 told six years or so. Included extensive experiments.

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1 So we went through quite a large effort to
2 validate and assess RELAP. The types of transients we
3 ran, of course, are quite similar to what we're
4 dealing with in the PTS space, basically primary
5 system LOCAs. Next.

6 And so the phenomena are the same, the
7 dominant phenomena are the same. This is a comparison
8 of what a two-inch break from one of the ROSA tests.
9 ROSA is the large facility located in Japan. It's the
10 largest cylindrical test facility in the world. Very
11 well instrumented.

12 This is a pressure trace from a two-inch
13 break of the, in this case it's a pressure balance
14 line. This is quite similar to a cold leg break.
15 This shows the pressure comparison.

16 This is typical of the kind of comparisons
17 we get in pressure between the RELAP and data. The
18 comparisons are normally, you know, of this fidelity.

19 What you see in the left -- when you get
20 the part of this you're particularly concerned with is
21 up to about the first or second vertical dotted line.
22 Next.

23 CHAIRMAN FORD: Sorry, those dotted lines,
24 may be a bit out of focus. What does it say?

25 MR. BESSETTE: So it, so, see an accosted

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1 AP600, you have the ADS system, automatic
2 depressurization system.

3 CHAIRMAN FORD: Okay.

4 MR. BESSETTE: Which are valves, it starts
5 with valves on top of the pressurizer. So, again,
6 when that valve opens, it looks like a stuck open SRV.
7 In fact, that's how we ran the -- in the -- our APEX
8 experiments, we simulated a stuck open SRV with one of
9 these ADS valves from the AP600 days. Next.

10 This is comparison between RELAP and data.
11 The dotted line is RELAP and the solid is data of the
12 inlet temperature. Of course it's -- unfortunately
13 this data is kind of sanitized because this is based
14 on proprietary Westinghouse proprietary information so
15 you don't see the actual scales.

16 But you can see for that for a core inlet
17 temperature, again the comparison -- the core inlet
18 temperature is going to -- the comparison, the core
19 inlet temperature is going to be the same as downcomer
20 temperature because of the nature of the RELAP. So
21 you can see that the comparison is rather good.

22 CHAIRMAN FORD: So sorry, David, if you
23 could just back off one second. What's the
24 experimental set up? It's a pipe?

25 MR. BESSETTE: This facility is an

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1 integral facility. It's basically it's a two-loop
2 arrangement. So it has a full integral system, with
3 a vessel, loops, steam generators, pressurizer.

4 CHAIRMAN FORD: Okay.

5 MR. BESSETTE: So it's a complete
6 representation of director coolant system.

7 CHAIRMAN FORD: Okay. So where are these
8 temperatures and pressures?

9 MR. BESSETTE: Well, the pressure was a
10 system pressure. This temperature is taken at the
11 core inlet.

12 CHAIRMAN FORD: Okay.

13 MEMBER BONACA: Now, just a question I
14 have. The model you used for the Ocone analysis for
15 the PTS work, is it set up the same way as the one
16 that was tested here?

17 MR. BESSETTE: Same way.

18 MEMBER BONACA: Yes.

19 MR. BESSETTE: We used consistent
20 nodalization across all the experimental facilities.

21 MEMBER BONACA: Okay.

22 MR. BESSETTE: Next? Is there any more?
23 So basically, like I said, in terms of the system
24 pressure and downcomer temperature are fairly global
25 parameters. And basically you can get pretty good

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1 agreement between the RELAP and data, providing you
2 match the break flow between the RELAP calculation and
3 the experiments.

4 CHAIRMAN FORD: Yes.

5 MR. BESSETTE: And, of course, one of the
6 variables in this, of course, you heard that the focus
7 of the PTS risks turns out to be LOCA. And during the
8 PTS study, we did do a spectrum of breaks from between
9 one inch and eight inches.

10 And also we varied the break location
11 between the hot side of the plant, the hot leg and the
12 cold leg, so that was part of the uncertainly
13 evaluation.

14 MEMBER SHACK: Did I understand your
15 comment correctly that those results have actually
16 been adjusted by adjusting the break flow rate to
17 match that in the experiment?

18 MR. BESSETTE: Well, during the AP600
19 testing is when we installed the Henry-Fowski break
20 flow in order to get better agreement with the data.

21 MEMBER BONACA: Oh, okay.

22 MR. BESSETTE: Of course Henry-Fowski
23 break flow is almost 30 years old itself but -- so
24 it's not a new model but we did reimplement it in
25 RELAP.

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1 MEMBER SHACK: Because it basically gave
2 better agreement with --

3 MR. BESSETTE: It gave better agreement.

4 MEMBER BONACA: And that's one of the
5 parameters you did sensitivities on?

6 MR. BESSETTE: Yes, that's right, yes. Is
7 that it? I think that's all I had to say.

8 CHAIRMAN FORD: Now what about these
9 experiments which were done at the APEX facility?

10 MR. BESSETTE: Yes, I didn't bring, I
11 hadn't prepared any viewgraphs of those because I'm
12 still -- those results are fairly recent. I'm still
13 trying to digest the results. But the results are
14 similar to what I showed you from this ROSA test.

15 CHAIRMAN FORD: Okay. Under the thermal
16 hydrolysis, would that amount, would those two graphs
17 that you showed us, is that enough information between
18 observation and theory to validate the RELAP code?

19 MR. BESSETTE: No, I haven't showed you
20 the complete picture which, of course, is much more
21 extensive. It's always a very complex -- it's a
22 highly involved process to validate and assess that
23 the code -- so it's -- you have to do a much more
24 extensive analysis than just this one example I've
25 shown here.

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1 MR. HACKETT: I guess one of the things we
2 could take as an action, Dave, would be -- is there a
3 -- you discussed yesterday, I think there's a suite of
4 problems that have gone into benchmarking RELAP
5 before, is that described in a publication or NUREG
6 that we could forward to the Committee?

7 MR. BESSETTE: Yes, because every time we
8 release a new version of RELAP, we include a
9 generalized assessment that includes at least 50 or
10 more specific comparisons between RELAP and various
11 experimental data covering various separate effects
12 phenomena and our integral system tests.

13 It's documented -- the code documentation
14 is a multi-volume set. One volume is devoted to the
15 developmental assessment.

16 CHAIRMAN FORD: I guess maybe a question
17 for you, Ed, you know it's fairly obvious that the
18 findings you've got so far are, to put it mildly, are
19 fairly earth-shattering. I mean, they're fundamental
20 to the whole way we're going to treat PTS in years to
21 come.

22 And yet the -- and even though I don't
23 understand all of the fracture mechanics aspects, I
24 have a good gut feeling that they are valid.
25 Therefore, the whole thing hinges on the input to the

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1 PFM model.

2 And after all the binning, the things that
3 go on the PRAs it is, you know, it's fairly
4 structured. But the inputs to the model, to the PFM
5 model come from the thermal hydraulics code. And
6 therefore it's going to depend critically on the
7 veracity of that code.

8 How do you feel, as Project Leader? Is
9 there enough -- do you feel happy in your gut that the
10 input you're getting is good?

11 MR. HACKETT: I'm more like you. This is
12 not my technical area.

13 CHAIRMAN FORD: Yes.

14 MR. HACKETT: So I agree with your
15 statement, though, that it's absolutely critical to
16 the project. I don't think we've yet done, in this
17 session, any justice to validation of the RELAP code.

18 So I guess we need to pursue the best way
19 to proceed on that.

20 And I don't think it's because it doesn't
21 exist. It sounds like it's just that we don't have
22 that information put together in a form to present at
23 this point.

24 So we either need to pick that up at
25 another meeting or maybe and/or get you documentation

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1 of the validation of the code.

2 CHAIRMAN FORD: Yes.

3 MR. HACKETT: It's certainly not my area
4 of expertise. But I do agree with the statements that
5 is absolutely critical to do that.

6 CHAIRMAN FORD: Has there been any
7 sensitivity studies to -- if the code was off by, for
8 whatever reason, modeling assumptions, etc., etc., if
9 it was off, how much would it have to be off to make
10 any significant changes to those frequency RT diagrams
11 you showed at the very beginning? How sensitive are
12 we to these numbers?

13 MR. HACKETT: I don't believe those types
14 of evaluations have been run but I turn to David or --

15 MR. BESSETTE: Well, we did a lot of
16 sensitivity studies. You can see we ran a total of
17 300 RELAP calculations. And a lot of those were
18 sensitivity studies to look at the sensitivity to
19 downcomer temperature --

20 CHAIRMAN FORD: Right.

21 MR. BESSETTE: -- Of these, we identified
22 what we believed to be the dominant modeling features,
23 boundary conditions to the problem, dominant physical
24 models within RELAP.

25 And we did sensitivity studies to see how

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1 important these parameters were to our key parameters
2 here, downcomer temperature and system pressure.

3 So a lot of that work was motivated by
4 that, you know.

5 CHAIRMAN FORD: Yes.

6 MR. BESSETTE: Because a lot of those
7 sensitivity studies were motivated by that.

8 MEMBER BONACA: And sensitivity studies
9 that are really focused on the code alone. I was
10 wondering if, for example, you have a system cool
11 down, okay, that's your best estimate calculation that
12 you're making with the code.

13 And assume that you have an assessment of
14 the range, okay, how much greater a cool down could
15 you have --

16 MR. BESSETTE: You know --

17 MEMBER BONACA: -- Okay, assuming from
18 RELAP5, okay assuming that there's a band of
19 uncertainty. And that's really the question you're
20 concerned about, you know, could it be a much more
21 severe cool down than what we are representing here?

22 MR. BESSETTE: No.

23 MEMBER BONACA: I'm sure that -- no, let
24 me finish. This new cool down, this higher cool down
25 that you could potentially expect because of

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1 uncertainties may be part of another bin that you
2 already realized for which you have assigned a
3 different frequency however.

4 MR. BESSETTE: See what, yes --

5 MEMBER BONACA: Is there any sensitivity
6 you can measure relating to the frequency range
7 sensitivities that -- because that's really the issue
8 that I'm concerned about.

9 That we have a cool down that could be
10 associated with a more severe cool down for the
11 certain transients that in the analysis would be
12 associated with a lower frequency. Therefore, you
13 have a higher cool down but a lower frequency and so
14 it washes away and it shouldn't. I'm not sure that --

15 MR. BESSETTE: What I -- see I knew going
16 into this that what was going to dominate the results
17 was the sequence identification. And the sensitivity
18 studies we did confirmed that to be true, that the
19 temperatures and pressures were dominated by operator
20 actions for most of these events.

21 And that's why you see what the residuals
22 we have here are primarily LOCAs where the operator
23 doesn't have much of a role.

24 The other sequences, these secondary side
25 transients, the outcome is dominated by the operator

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1 actions and the plant controls.

2 So -- and this was confirmed by the
3 sensitivity studies so that resulted in a lot of our
4 effort going toward the binning process, providing
5 additional RELAP calculations. We greatly expanded
6 the number of RELAP cases that we ran as we went along
7 because of the fact that the outcome is dominated by
8 operator actions and not by the RELAP modeling itself.

9 CHAIRMAN FORD: If I could suggest, you
10 know, time's going on here. Let us table this
11 particular topic. Obviously, you could go into this
12 quite deeply and maybe it's a topic for the thermal
13 hydraulic subcommittee.

14 MR. HACKETT: What occurs to me, at least,
15 and may be there are more, but there are at least two
16 issues. There's validation of RELAP as a code in
17 general, which it sounds like the Committee needs to
18 hear more about however we decide to do that.

19 CHAIRMAN FORD: Yes.

20 MR. HACKETT: And then above and beyond
21 that, there's application to PTS scenarios.

22 CHAIRMAN FORD: Right.

23 MR. BESSETTE: And how it does there. And
24 that may be a lesser, something we're able to do to a
25 lesser degree but that needs to be addressed also

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1 obviously like this comparison with the APEX tests.

2 So at least one thing that comes to mind
3 is we could volunteer an additional presentation to
4 the Committee at some point to be scheduled that
5 hopefully does not have to be a day and a half but,
6 you know --

7 CHAIRMAN FORD: Oh, absolutely, yes.

8 MR. HACKETT: -- But maybe a couple of
9 hours to go into that and hopefully provide some
10 documentation in advance.

11 CHAIRMAN FORD: That would be a good idea.
12 So what I'd suggest is let's take it as read that the
13 thermal hydraulics code is okay for the time being.

14 And then let's go forward here. But we'll
15 come back and address that.

16 MR. HACKETT: Okay, that sounds good.

17 CHAIRMAN FORD: Right.

18 MR. HACKETT: So what we'll do is get
19 ready to launch into the example problem here. I'll
20 talk about that in a second. A couple of other things
21 I thought I would mention while, you know, we have the
22 gathering of folks we have in the room.

23 There will be a full Committee reprise of
24 this session on a much reduced basis, probably I think
25 no more than an hour or two on February 7 for those

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1 who are looking at marking calendars. And my
2 understanding is that's scheduled, Noel, from 2:45 to
3 4:30 on February 7th so we'll do that.

4 We are also planning in March most likely
5 on previewing the staff recommendations on the risk
6 acceptance criteria which, again my recollection is
7 that's due in a SECY paper to the Commission by the
8 end of March.

9 And I think it would be a good idea from,
10 the discussions we've had over the last day, to have
11 feedback from the Committee on that before we go
12 forward.

13 CHAIRMAN FORD: Now do you want that in
14 March, the beginning of the March meeting? Or the
15 beginning of the April meeting?

16 MR. HACKETT: Probably the March meeting
17 is what -- I need to check specifically on schedules
18 right now.

19 MR. BESSETTE: We would need the documents
20 at the minimum two weeks before.

21 MR. HACKETT: Okay.

22 MR. BESSETTE: We'd like it four weeks
23 before but that I think --

24 MR. HACKETT: That it becomes a shock to
25 Cunningham's branch.

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1 MR. BESSETTE: -- is very unreasonable.
2 No, no, no, we'll do this in the middle of the
3 example.

4 MR. HACKETT: Yes, that will be in middle
5 of the example.

6 MR. BESSETTE: Okay.

7 MR. HACKETT: So those were sort of two
8 items of administrative business. Then just to
9 summarize what we were coming to after a lot of
10 background discussion yesterday is to try to walk
11 through an example of how this actually works, which
12 is what we're going to do now.

13 For the Oconee plant and that starts in
14 your package on Slide 119 and Alan Kolaczowski was
15 going to start the lead for that discussion.

16 MR. KOLACZKOWSKI: Okay.

17 MR. HACKETT: Alan?

18 MR. KOLACZKOWSKI: Okay.

19 MR. HACKETT: Let me add one thing before
20 Alan -- I left out a key individual at the table from
21 our side, and that's Mr. Terry Dickson. I might add
22 none of this would be possible without Terry. He's
23 worked, you know, like the equivalent of five guys to
24 get the FAVOR code together, which is the integrating
25 piece for this entire project. So, sorry about that

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1 oversight previously.

2 MR. KOLACZKOWSKI: Okay. Again, you've
3 seen at a high level, if you will, yesterday, much
4 about the process and how we tried to interact between
5 the PRA aspect of the analysis in the thermal
6 hydraulic and finally the PFM and then combining at
7 the end.

8 And I'm sure there was a lot to absorb
9 yesterday and there's probably still some questions in
10 your mind and maybe we can at least some of those
11 questions hopefully go away by actually looking at one
12 of the dominant scenarios that is coming out of the
13 Ocone analysis right now which has to do with a
14 transient that -- under those transient conditions,
15 let's say we do get a demand of a safety relief valve
16 and that valve sticks open and then subsequently
17 recloses sometime later in the scenario.

18 It's a very challenging scenario from the
19 operator's perspective in that well, of course, at
20 least initially, while the SRV is stuck open, you
21 essentially have a small LOCA going on in the primary
22 system and so that's causing a cool down of the down
23 comer wall, etc.

24 So we're getting the temperature gradients
25 of concern. But then what will be obviously unknown

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1 to him until he begins to see some evidence of that is
2 that at some point in the scenario, the SRV does
3 reclose.

4 And, in fact, if you look at -- and there
5 are not a lot of SRVs stuck-open events in the
6 industry but there are a few. And if you look at the
7 data, it does suggest that when such a valve sticks
8 open, in fact, the likelihood that it will reclose
9 sometime later in the scenario is quite high as a
10 matter of fact.

11 When that happens, of course, then the
12 system does not take very long, because you are
13 probably injecting at full flow rate, at least in the
14 case of Oconee, when that valve recloses, suddenly the
15 system goes solid and it does not take very long.

16 And you'll see the pressure plots a little
17 bit later here in the example. So suddenly the
18 operator's going from what was a cool down under
19 saturated conditions to a cool down with solid
20 conditions.

21 And the operator has to act very quickly
22 to try to avoid a severe or at least a long time
23 period over which there is a repressurization event.
24 And the status of the system changes very, very
25 suddenly.

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1 And, as I say, it's quite a challenging
2 situation for the operator.

3 So needless to say, we get the cool down
4 and then we get a repressurization. It is a very
5 severe event, I think, from a fracture mechanics point
6 of view. And Terry will certainly probably have more
7 to say about that.

8 So not surprising, the frequencies are not
9 all that low of this kind of an event. So with the
10 frequency not being all that low, and then on top of
11 that, it's very challenging from a fracture mechanics
12 point of view, the CPF and CPI, that is conditional
13 probability of crack initiation and then subsequent
14 failure, is relatively high compared to other
15 sequences.

16 So it is among the dominant scenarios from
17 the Ocone analysis. We're going to kind of quickly
18 go through that and go through the PRA/T-H fracture
19 mechanic steps just like we've done yesterday but
20 focused on this particular example.

21 And that's what we're going to do. And
22 hopefully it will clarify some of the things we talked
23 about yesterday. Perhaps raise a few more questions
24 and, if so, we'll try to address that.

25 I will, at an appropriate point in here

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1 when I get to the human liability part, I will digress
2 a little bit. We created a few slides last night
3 which I believe you've been handed out an additional
4 copy of those slides that I want to digress a little
5 bit and actually go to the main steam line break and
6 talk about the human error for that one.

7 So I will digress from the example a
8 little bit at the appropriate point.

9 This just summarizes pretty much what I
10 said. We're really going to be talking about three
11 bins sort of at the same time because they are really
12 just flavors of the same kind of scenario. And you
13 can see there that bin 109 is the case of a stuck open
14 pressurizer SRV.

15 In this particular bin, it's the case
16 where we've assumed that the valve recloses at a
17 little less than two hours into the scenario. There
18 was a reason why we selected that. We can get into
19 that if you wish.

20 And the operator fails to control the
21 repressurization. For whatever reason, the operator
22 never does address the fact that the plant has gone
23 solid.

24 And we're sitting there riding on the PORV
25 and we kind of do that forever. And he never brings

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1 the pressure back down within the allowable pressure
2 temperature cool down curves.

3 Bin 112 is the case where we essentially
4 have the same event, SRV sticks open, recloses at a
5 little less than two hours into the event.

6 However, the operator, upon recognizing
7 that the throttling criteria for high pressure
8 injection have been met and even though it's not quite
9 this simple, let me just say the throttling criteria
10 for Oconee are primarily once we have achieved five
11 degrees subcooling back in the primary system or
12 higher and that we've got pressurizer level restored
13 somewhere around 100 inches or so, or higher.

14 Once those two conditions are met and it
15 is an and situation, then the operator, at that point,
16 is allowed by procedure to begin to throttle injection
17 back.

18 Now again, this pressurize would be
19 happening so quickly that he is going to try to
20 severely throttle the HPI back because he's trying to
21 avoid this huge pressure spike that's happening
22 because the plant system is going solid on him.

23 In the case of bin 112, he successfully
24 does that within one minute after the throttling
25 criteria have been met.

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1 And 113 is just an intermediate stage
2 where the same event but for whatever reason, workload
3 issues, whatever it might be, he has been delayed and
4 does not throttle the injection until 10 minutes into
5 the event.

6 Those three bins were sent to the fracture
7 mechanics portion of the analysis. And so they looked
8 at what the conditional probability of failure of
9 crack initiation, excuse me, of crack initiation and
10 failure of the vessel would be under those three
11 distinct scenarios. So they are three different
12 scenarios.

13 And the operator is playing the role
14 basically on what the pressure does and how long it
15 stays high versus comes back down.

16 MEMBER BONACA: I have a question. So it
17 severely closes in 100 minutes, in all scenarios.

18 MR. KOLACZKOWSKI: In these three bins.
19 Now we had some other bins --

20 MEMBER BONACA: I understand, I
21 understand.

22 MR. KOLACZKOWSKI: -- That had a different
23 time. That's correct.

24 MEMBER BONACA: So he does not recognize
25 he had a stuck open SRV.

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1 MR. KOLACZKOWSKI: No, he recognizes he
2 has a stuck open SRV, but unlike the PORVs, of course,
3 these are the ASME code safety release valves --

4 MEMBER BONACA: Oh, these are safety
5 release.

6 MR. KOLACZKOWSKI: -- There is no
7 isolation capability. There's nothing he can do about
8 it.

9 MEMBER BONACA: Okay. I understand.

10 MR. KOLACZKOWSKI: They're going to stay
11 open and that's all he can do.

12 MEMBER BONACA: Right.

13 MR. KOLACZKOWSKI: He's going to watch it
14 and try to deal with the event the best he can. But
15 there's no way to isolate this.

16 MEMBER BONACA: But did you look at a PORV
17 as much as --

18 MR. KOLACZKOWSKI: Yes, we also looked at
19 the PORV. Now at Oconee, the PORV is very small.

20 MEMBER BONACA: Yes, okay.

21 MR. KOLACZKOWSKI: They have a single
22 PORV. It's one inch. Even if it opens, the plant
23 almost like doesn't cool down. So it's been looked
24 at.

25 MEMBER BONACA: All right.

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1 MR. KOLACZKOWSKI: Now when we get to
2 Beaver Valley or somebody else that has huge PORVs,
3 it's going to be a different story.

4 MEMBER BONACA: I mean the likelihood of
5 opening the safety -- I'm sure the initiating
6 frequency is very low.

7 MR. KOLACZKOWSKI: Yes. I think the
8 chance that the valve would even be demanded and then
9 sticks open, I don't remember -- don't quote me on
10 this but it seems to me it's somewhere in the 10^{-3} per
11 year range. It's fairly low. But there have been a
12 enough events, even in the 90's, that you can begin to
13 get a handle on what that probability is. Next slide.

14 I'm going to tell a story here. At the
15 beginning. I hope we conveyed to you yesterday it
16 isn't like that we knew ahead of time we were going to
17 need 140 bins and we ran them all. And then we
18 started binning sequences. That was not the case.

19 We took a cut at what kinds of thermal
20 hydraulic runs we were going to need at the beginning
21 of the project. I think the initial number of bins
22 that we had was somewhere around 40 some odd. I don't
23 remember exactly.

24 MR. MALIK: 36.

25 MR. KOLACZKOWSKI: What was that? It was

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1 actually even 36 I guess at one time. I think this
2 was an additional one at some point.

3 But the point is, at one time in the
4 analysis, early on in the analysis, the best bin that
5 we had that would fit an SRV stuck open and recloses-
6 type of scenario was this bin 41.

7 You can see what bin 41 was when we ran it
8 with the RELAP code was an SRV stuck open, it recloses
9 at 100 minutes, but there was no operator actions
10 model. So in other words, worst case kind of
11 situation.

12 So it recloses, it repressurizes. If the
13 pressure stays up forever at the PORV set point and we
14 had such a thermal hydraulic run available.

15 MEMBER SHACK: But that's bin 109 isn't
16 it?

17 MR. KOLACZKOWSKI: Well, it eventually
18 will be, it eventually will be. I'm going to take you
19 how bin 41 eventually became 109, 112 and 113.

20 At this point in the analysis, we only had
21 one bin, bin 41. Now nearly all of the initiators and
22 the subsequent event trees, which describe the
23 possible scenarios that can occur after those
24 initiators, nearly all of those initiators and event
25 tree scenarios had scenarios that we placed into this

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1 bin 41.

2 Now I'm just going to show you one tree
3 and try to demonstrate what the initial binning looked
4 like with the next slide. Now I know this is a little
5 hard to read up here on the screen so you may want to
6 refer to your hard copy where it's probably a little
7 bit more readable.

8 But this happens to be the reactor trip
9 tree and, again, remember there was a loss of main
10 condenser tree, loss of instrument air tree, etc.,
11 etc.

12 So this is only one tree of many. But
13 they all had a similar construction that looked like
14 this. And you'll notice that early in the event tree,
15 we ask what is the status of the PORVs and the SRVs?
16 Have they been demanded? • And if so, did any of them
17 stick open?

18 If you follow the highlighted path down in
19 the tree, it represents the case where yes, the SRV
20 has, indeed, stuck open.

21 And later on we ask does it ever reclose?
22 And the branch kind of going up there under the
23 SRV/ISOF event, which is asking whether the stuck open
24 SRV recloses or not? Yes, it has successfully, in
25 fact, reclosed.

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1 So that's really the beginning of the
2 scenario that we are interested in. Now, after that,
3 there are a number of questions asked about the status
4 of turbine bypass valves. And how many are demanded?
5 And do they stick open? Do they get isolated either
6 by the operator or by themselves, etc.?

7 And you'll notice that I've highlighted
8 all of the branches, which means that at this point,
9 what we're basically saying is -- what I'm
10 highlighting, by the way, are the sequences that were
11 originally put into this bin 41.

12 Which, remember, is nothing more than an
13 SRV sticks open, recloses in 100 minutes and the
14 operator does nothing at all.

15 You'll notice that regardless of what's
16 happening with the TBV states, turbine bypass valves
17 states, we still binned all those sequences into bin
18 41.

19 The reason being is that, and obviously
20 this isn't shall I say exactly true, but an
21 approximation is that once the SRV is stuck open, the
22 SRV is large enough and represents a large enough
23 break to the system that the cool down rate in the
24 primary system is being largely driven by that SRV.

25 And, for the most part, the primary has

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1 decoupled from the secondary. And so almost -- no
2 matter what's happening over on the secondary side,
3 even if we have a stuck open turbine bypass valve as
4 well, the cool down rate would not drastically change
5 because it's all being driven by the break over on the
6 primary.

7 And the primary isn't really seeing the
8 secondary very much. Now I will grant you that if
9 there are four turbine bypass valves stuck open as
10 well, which is this lower branch, this is zero stuck
11 open, this is one, this is two and I think this is
12 three or more or something like that, on that lower
13 branch there, I'll grant you if there are four turbine
14 bypass valves stuck open, the primary probably will
15 see some additional cool down rate as a result of
16 that.

17 On the other hand, we'll think of what the
18 frequency of that would be. It would be very, very
19 low. And so, in fact, even if we have miss-binned
20 that sequence and there should have been another bin
21 of SRV sticks open and there are four TBVs stuck open,
22 we would probably end up throwing that scenario away
23 on frequency anyway. And so it really almost doesn't
24 matter where be bin it.

25 So while it is a non-conservative binning,

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1 we have binned all those cases into bin 41 thus far.
2 Because we're saying, again, that the response of the
3 plant is largely driven by the SRV being stuck open.

4 Now, the tree continues. And at the end
5 of each one of those branches that you saw on the
6 first page, this portion of the tree is tacked on to
7 the end of those. So, in reality, there's not just
8 one page of this, there's multiple pages of this.

9 You can see that everything on this
10 portion of the tree as highlighted is still going into
11 bin 41. And what this tree is asking is what's the
12 status primarily of the feed conditions to the steam
13 generators? Are we on main feed? Are we on emergency
14 feed? Have we actually had to go to condensate feed?

15 And, if so, are we over feeding the steam
16 generator? Are we controlling it properly, etc.?
17 Again, for the same reasons, because the primary is
18 primarily decoupled from the secondary, it almost
19 doesn't matter what the feed is doing. The primary is
20 being driven by that stuck open valve.

21 So we can bin all of these possible
22 combinations of feed along with the SRV stuck open
23 into just the SRV stuck open bin because the thermal
24 hydraulics suggest that the plant response is being
25 driven largely by the fact that the SRV is stuck open.

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1 And not by the fact that we might be overfeeding one
2 steam generator as well.

3 So at the end of those, yet tacks on
4 another portion of the tree, which is the last page.
5 And here is where we're asking the status. Has high
6 pressure injection started in this event, which, of
7 course, it clearly should because we've got a LOCA
8 going on?

9 There are a few questions that address
10 what the status of the RCPs are. In this particular
11 case, it is highly likely that the operator will trip
12 the reactor coolant pumps because he has a LOCA
13 condition, he's lost subcooling and his procedures and
14 his training would tell him he should, in fact, trip
15 the RCPs. But we do ask the possibility that he has
16 not, just in case.

17 And I want to also focus your attention to
18 the next to the last event to the right where we ask
19 has the operator throttled the HPI when appropriately
20 he's supposed to do so?

21 At this point in time, because we only had
22 the one bin in which we said operator does nothing,
23 there was no distinction made as to whether the
24 operator successfully throttled or not.

25 And so for the time being, whether he

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1 throttles or not is still all in bin 41, the worst
2 case situation. But now we're going to have to take
3 that bin and essentially separate it out and recognize
4 the operator may throttle and that probably means that
5 we've got to put the successful throttling scenarios
6 into another bin. And that's what we're about to do.

7 Any questions to this point?

8 (No response.)

9 MR. KOLACZKOWSKI: Okay. I've already
10 made these points. Many sequences were originally
11 binned into bin 41, including both success as well as
12 failure to throttle. And note again that the
13 concurrent faults on the secondary really don't matter
14 so much largely because the primary, at this point,
15 has become, for the most part, decoupled from the
16 secondary.

17 And so what the status of secondary
18 depressurization and what the status of secondary feed
19 control is, at the same time, is not a dominant factor
20 in what the plant response is really doing. It's
21 driven by the SRV. So that allowed us to put a lot of
22 sequences into this bin 41.

23 Okay. Now, so therefore how the plant is
24 going to respond, once that valve recloses, because
25 again we've said the secondary doesn't matter quite so

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1 much, etc., is going to be largely driven by how fast
2 the operator does, in fact, throttle back injection to
3 avoid the repressurization scenario.

4 And so we need to focus on does the
5 operator throttle and, if so, when does he throttle.
6 So there is a fault tree that supports that HPI
7 throttling event in the event tree that breaks it down
8 essentially into these two situations where the
9 failure to throttle is divided up into does the
10 operator fail to throttle at approximately one minute
11 after he's met the throttling criteria?

12 The assumption being here or the way that
13 that probability is actually assessed is that we look
14 at the failure -- that he would fail to throttle at
15 one minute. But would, in fact, successfully throttle
16 by the next time period that we asked, which, in this
17 case, is ten minutes.

18 And then the one on the right, and that's
19 an ORGATE up there, the one on the right says well
20 what about though if he's failed to do it at one
21 minute, does he also fail even nine minutes later? In
22 other words, ten minutes into the event or ten minutes
23 after he has met the throttling criteria.

24 And now the assumption being that we will
25 assume that if the operator has failed to throttle by

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1 ten minutes after meeting the throttling criteria, we
2 will conservatively assume that the operator never
3 recovers and, therefore, we indeed have the bin 41
4 case where the operator has taken no action at all.

5 And we have to assess the probability, of
6 course, for that. The success of or the compliment of
7 this tree is the success state. It is that the
8 operator has successfully throttled one minute or less
9 into the event.

10 So therein lies really the three cases.
11 The success of this tree is the operator does throttle
12 by or before one minute. Then the event on the left
13 represents he fails to throttle at one minute but does
14 by ten. And then finally, he fails by ten and it's
15 assumed he never does. So we have the three cases
16 that eventually we're going to get to.

17 Okay, at this point, I would like to
18 digress a moment and just recognize for the main steam
19 line break scenarios, we had to do the same thing. We
20 had a bunch of sequences that were main steam line
21 break-types of scenarios.

22 And we binned them into our main steam
23 line break, TH bin. And then we had to address what's
24 the chance that the operator does isolate the faulted
25 steam generator? And how quickly will he do that?

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1 So we kind of get to the same point but in
2 a different kind of scenario.

3 For the moment, if you don't mind, I'd
4 like to put this aside and address, with the addendum
5 slides that we gave you this morning, I would like to
6 address the main steam line break. And why are we
7 giving so much credit to the operator to isolate the
8 faulted steam generator in a fairly quick order?

9 A couple of things I want to point out
10 before we actually get into what we did to quantify
11 the numbers or come up with the numbers or the
12 estimates for the operator failing to isolate the
13 faulty steam generator.

14 I just want to show you with these three
15 first slides some of the procedures that the operator
16 would be going into in a main steam line break event.

17 And mainly for the reason to show you how
18 quickly at Oconee that operators gets focused on
19 isolating the faulted steam generator by their
20 procedures and by their training.

21 If there is a reactor trip condition or
22 there should have been a reactor trip condition, the
23 procedure that the operators would go into is their
24 so-called EP-1. That's the first, if you will, trip
25 EOP procedure that they'd go into.

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1 There are three really but there's also a
2 fourth check. So I'll call it four immediate steps
3 that they'd take upon entering that procedure. And
4 you can see those steps there.

5 They ensure or, if necessary, manually
6 trip the reactor. They ensure or, if necessary,
7 manually trip the turbine. They ensure that, indeed,
8 the turbine bypass valves are properly controlling the
9 secondary pressure as well as obviously that has an
10 effect on the RCS temperature and Tavg, etc.

11 They make sure that that, indeed, is
12 functioning properly. Or, if necessary, take manual
13 control of that. And they do a check just to make
14 sure that they have RCP seal cooling. And if not,
15 address that issue.

16 To do those steps, even if you have to
17 manually do those things, we're talking 30 seconds
18 into the event, these four steps are done. Okay?

19 Now you'll notice that in the way the
20 Oconee procedures are written, and I think this is
21 pretty indicative of most of the BNW if not all the
22 BNW plants, at this point in EP-1, they can do one of
23 two things.

24 They are, at this point, while one of the
25 operators, one of the board operators is primarily

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1 focusing on these four initial steps, the other
2 operator is checking the status of various
3 instruments, etc., to see does he have entry
4 conditions into one of these other EOPs that I've
5 listed over on the right.

6 Now there are more but they are
7 essentially other EOPs that at this junction in EP-1,
8 if they feel they have an entry condition into one of
9 those EOPs, they immediately jump out of EP-1 and they
10 enter these other EOPs.

11 There is a hierarchy, there is a priority
12 as to which procedure they would enter. And I've
13 actually shown that priority in terms of the way I've
14 listed them from first to third here. If they detect
15 they have an ATWS condition, they would enter a
16 different EOP to address ATWS situations and that's
17 called EOP-506.

18 If they have an adequate core cooling,
19 they would enter 507 and so forth. You'll see that
20 fourth on the list is excess heat transfer condition,
21 okay? And there are others. But there is a preferred
22 order as to which EOP they would enter.

23 Or, if they don't see those entry
24 conditions and even if they exist and for some reason
25 didn't detect the entry conditions, you'll notice that

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1 even if they stay in EP-1, I just wanted to highlight
2 that the fact the very next step in the procedure is
3 to look at their feed system to the steam generators
4 and make sure that levels are appropriate, that the
5 RCS temperature's not diving for the bottom.

6 So even if they were to miss and not go
7 into the excess heat transfer procedure, they're still
8 likely to detect that they've got an overfeed or
9 something wrong with the steam generators that they've
10 got to deal with because, in fact, that's the very
11 next thing they look at in EP-1.

12 And remember, as I mentioned, to get
13 through the RCP seal cooling step, we're talking 30
14 seconds to get there. Now we're going to be asking in
15 the main steam line break, we're going to be asking
16 does he isolate the steam generator ten minutes into
17 the event?

18 So we're talking about 30 seconds to get
19 through the four steps. And how does he deal with
20 this isolating the steam generator ten minutes into
21 the event?

22 He's essentially got nine and a half
23 minutes to deal with the steam generator per the time
24 period that we're going to ask about. Okay, so in any
25 event, he can go out, at this point he can go out of

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1 the procedure.

2 If he senses that he does have an excess
3 of steam demand, which, of course, we would have in a
4 main steam line break, more than likely, the operator
5 is going to go out of EP-1 at this point and enter
6 503. Okay?

7 Next slide.

8 MEMBER BONACA: The other only thing you
9 could think of is there some intermediate LOCA because
10 of the pressure transfer.

11 MR. KOLACZKOWSKI: He could.

12 MEMBER BONACA: I'm just saying what he
13 could do, too.

14 MR. KOLACZKOWSKI: Yes, he could. Now, of
15 course, one of the significant differences between the
16 detection of whether it is really a LOCA on the
17 primary or whether, indeed, it's the secondary
18 cooling, is to look at subcooling.

19 MEMBER BONACA: That's right.

20 MR. KOLACZKOWSKI: Because if we've got
21 the LOCA, subcooling's going to zero. If we don't,
22 subcooling, in fact, is rising because we're
23 overcooling the primary. And so subcooling's marching
24 up.

25 And that's a key parameter that will tell

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1 him or help him figure out whether indeed he's got a
2 LOCA situation or indeed he's got a secondary problem.

3 MEMBER BONACA: So there is a gate there
4 between 501 and 503?

5 MR. KOLACZKOWSKI: Yes. But I wanted and
6 I hopefully anticipated your question because I wanted
7 to show even if he entered 501 by mistake --

8 MEMBER BONACA: Okay.

9 MR. KOLACZKOWSKI: -- Notice that the
10 third step in that procedure says, "Do you have an
11 excessive heat transfer?" And if so, and if you
12 haven't addressed 503 yet, go out of this procedure
13 and go into 503.

14 It's even going to force him after he's
15 done what he can do with a possible isolable LOCA,
16 he's going to end up over in 503 if the cooling
17 continues anyway. Very, very quickly.

18 MEMBER BONACA: Okay.

19 MR. KOLACZKOWSKI: Because all he does in
20 501 is just make sure that he's tripped the reactor
21 coolant pumps, that he's got as much injection as he
22 needs to have.

23 And there's a curve that he looks at to
24 make sure that he's got adequate injection. And then
25 he tries to isolate possible leak paths. He closes

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1 the PORV block valve and so on and so forth.

2 Again, those two steps probably take on
3 the order of, you know, a half a minute to perform in
4 let's say nominal conditions.

5 And then the 501 will send him to 503 if
6 he senses that he's still got an overcooling
7 situation. Just to make sure that he's going to go
8 and check and see if he's got to deal with a steam
9 generator issue.

10 So I wanted to point out that even if he
11 was to go into 501, the LOCA procedure, in error in
12 the main steam line break event, it's going to get him
13 over to addressing the main steam line break side of
14 the event anyway.

15 MEMBER BONACA: Good.

16 MR. KOLACZKOWSKI: Next slide. Now what
17 he really should do in only a main steam line break
18 event is go to 503. So however he gets to 503,
19 whether he goes through 501 and then to 503 or he goes
20 directly to 503, which would be the case that he
21 really should have done, if either steam generator
22 pressure is below 550 pounds and is continuing to drop
23 or if he has other signs that overcooling has not
24 stopped, which would be the case in a main steam line
25 break, then essentially the first step in this

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1 procedure, once he gets to it, is ensure or manually
2 perform, if necessary, the initiation of the main
3 steam line break circuitry.

4 What that essentially does is it isolates
5 the main feed and also the turbine-driven feed water
6 pump. And he checks to make sure that, indeed, that's
7 been done.

8 And if not done, he manually shuts down
9 those things. So that's kind of getting to the next
10 step, trip the main feed water.

11 He also trips the emergency feed water
12 really addressing the motor-driven pumps. He trips
13 those to the affected steam generator.

14 And then just completes the isolation
15 process in terms of steam valves he can close or that
16 kind of thing.

17 The point I'm trying to make here is that
18 once -- I guess there are two points I'm trying to
19 make. One, he should get to 503 very quickly
20 regardless of what the pathway is to get there.

21 And secondly, once he enters 503, the
22 first thing he's doing is isolating the affected steam
23 generator.

24 When we looked at some main steam line
25 break and other types of overcooling events, I

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1 mentioned we went to Oconee and actually looked and
2 watched them do simulations of events like this, they
3 typically had the affected steam generator completely
4 isolated about two minutes into the event typically,
5 okay?

6 That gives you some feeling for how long
7 it took them to get to this point. Okay, next slide.

8 MEMBER BONACA: He hasn't isolated that he
9 uses, he doesn't have, does he have feed water
10 isolation valves?

11 MR. KOLACZKOWSKI: Yes, he could, yes, he
12 actually -- I mean on the EFW, what he does is
13 actually shuts -- there's a couple of controllers in
14 which he shuts the injection valves and then he
15 actually trips the pumps just to make sure.

16 MEMBER BONACA: Okay.

17 MR. KOLACZKOWSKI: The time to take that
18 action is small --

19 MEMBER BONACA: Yes.

20 MR. KOLACZKOWSKI: -- You know, ten
21 seconds, he's got it done. Once he actually puts his
22 hand on the switches and does it.

23 MEMBER BONACA: Okay.

24 MR. KOLACZKOWSKI: Next slide. Okay, so
25 in the main steam line break, we're trying to assess

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1 what's the probability the crew fails to isolate the
2 faulted steam generator by some time.

3 What I've highlighted here is, again,
4 remember we were using an expert elicitation process
5 and Oconee was done a little bit different as I
6 mentioned yesterday than what we're doing on Palisades
7 and probably the other plants where, in this case, we
8 pulled together a set of experts.

9 One had a thermal hydraulic background.
10 And one had more of a human reliability background.
11 And one had a system background, etc.

12 And these were all NRC contractors. And
13 asked them to assess this probability that the
14 operator would fail to isolate the faulted steam
15 generator by X time, which I'll get into in a moment.

16 And then we went to Oconee later and asked
17 them to review our assessment and they provided
18 comments on that. And then we adjusted our numbers if
19 we thought it was appropriate.

20 Again, for Palisades and the other plants,
21 it's more integrated. We went to Palisades back in
22 November and actually sat down with them for three
23 days and put in all the human error numbers in the
24 Palisades model by having some of their experts, some
25 NRC contractor experts acting as the expert team.

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1 And, therefore, was actually more dynamic
2 as opposed to this comment review process that we did
3 on Oconee.

4 But, nevertheless, that was the way that
5 we did it. And I just want to point out, and these
6 are not all the considerations, but these are the
7 things that we discussed and talked about in setting
8 up qualitatively what we needed to consider into what
9 was the likelihood if the operator would get this
10 faulted steam generator isolated in fairly quick
11 order.

12 If you look, the number, the location and
13 the readability of the steam generator pressure and
14 the RCS temperature indications, make the
15 pressurization easily discernable.

16 In other words, we looked at the layout of
17 the Control Room. We looked at the redundancy of the
18 instruments. And we talked about what if one or two
19 instruments would fail, how confusing would that be,
20 etc., etc.

21 Can we delay the discernability in the
22 operator's mind that he's got a main steam line break
23 going on? The conclusion basically was the whole crew
24 would just about have to be asleep to not see that
25 this is a main steam -- this is a pretty major cool

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1 down event going on on the secondary side.

2 So Point No. 1, isolation is early in the
3 procedure guidance. Hopefully I've illustrated that
4 to you already. That the procedures and where he gets
5 to the point that tells him to isolate the steam
6 generators, he will get to those points in the various
7 procedures he might have gone to very early in this
8 scenario.

9 So hopefully he is already guided both by
10 his training and the procedure steps. There will be
11 something there within minutes into the scenario that
12 says excuse my French, "Hey dummy, it's time to
13 isolate the steam generator." Okay?

14 Next point. If the pressure drop, even if
15 it's slow, suppose it's a small steam line break, so
16 the pressure drop is slow, it isn't the major,
17 catastrophic event, and so maybe it does make the
18 discernability of the depressurization a little harder
19 to get, the operators at Oconee are taught to err on
20 the side of isolation.

21 If they see that the one steam generator
22 or both for that matter are depressurizing and are not
23 staying up at 900 pounds nominally, etc., they are
24 pretty quick to act that maybe we need to isolate.
25 Maybe we've got an overcool, we've got a steam-

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1 excessive demand going on over there.

2 And they tend, if anything, to err on the
3 side of isolation. That's the way their training is.

4 Training is strongly oriented towards
5 following the procedures. In other words, it isn't
6 likely that they're going to digress from these
7 procedures very much. They're told pretty strict
8 compliance.

9 And I mentioned yesterday, there's a high
10 sensitivity at Ocone to overcooling events. They
11 recognize once through steam generator design where
12 the primary starts acting to the secondary pretty
13 quickly and they're pretty sensitive to overcooling in
14 the once through steam generator design.

15 So again, sort of an attention to let's
16 act quickly if we do see any signs of overcooling at
17 all.

18 The use of BAGS, and I forget what that
19 acronym stands for, it's before and after and I forget
20 what the G is. But every so often in the process of
21 responding to an event, the crew will basically stop
22 and say, "Where have we been, where are we now, where
23 are we going, etc.?"

24 And so even if they had failed to isolate
25 right when they should have, at some point in the

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1 process, they have a chance to sort of all talk about
2 where are we.

3 And that provides an opportunity, too, if
4 they did fail to carry out a step when perhaps they
5 should have, there's a chance to recover from it and,
6 therefore, still take the appropriate action ten more
7 minutes later into the event for instance.

8 Again, the isolation, the actual act of
9 isolating is very quick and very simple. It's hands
10 on a few switches, they close them, it's done. It's
11 not a complicated, "we've got to carry out 15 steps to
12 get the steam generator isolated" that kind of thing.

13 I mentioned the fact that when watching
14 simulations of either this kind of event or similar,
15 they typically had the steam generator isolated in a
16 matter of one to two minutes.

17 The shortest time period of interest that
18 we are interested -- if you look at the thermal
19 hydraulic response to the main steam line break,
20 remember I mentioned that as long as the temperature
21 stayed up above 400 degrees, we weren't even going to
22 call it a PTS challenge.

23 And, therefore, it would not go to the PFM
24 folks. Well, we won't cross that magical, for now,
25 400-degree line, even with a main steam line break,

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1 until we get about 10 minutes into the scenario.

2 So we decided we won't even ask does the
3 operator do it in one or two minutes because even if
4 he doesn't do it until five minutes, we're not below
5 400.

6 And he usually doesn't do it until roughly
7 ten minutes, that's when we're finally crossing that
8 400 point.

9 So the first point that we will ask in the
10 model is does the operator get this done ten minutes
11 into the event, after the main steam line break has
12 happened?

13 Other considerations that we thought of:
14 Does time a day, day of shift, is it going to really
15 matter in this response? And we discussed those.

16 And there were others. These were some of
17 the more dominant things. I just want you to get a
18 feel for what the experts discussed and talked about
19 in ultimately trying to assess a probability of
20 failure of the operator to isolate the steam generator
21 by ten minutes into this event.

22 MEMBER BONACA: Just a question. Did you
23 equate detection with isolation? I mean did you look
24 also at the possibility that he detects it, tries to
25 isolate and simply the equipment doesn't work?

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1 MR. KOLACZKOWSKI: Yes we did. As a
2 matter of fact, we addressed what if the valve doesn't
3 close? And then we said, well, yes, but he's also
4 going to trip the pumps.

5 And so okay, well, what's the probability
6 also the pumps won't trip? And pretty soon, the
7 frequencies are getting so low that again it drops out
8 on frequency space.

9 But yes we did -- we also, as part of the
10 distribution on this human error probability, we were,
11 and I'll grant you it's probably not as explicit as we
12 would like, but we were trying to address as part of
13 that distribution, what if there are malfunctions of
14 equipment that means that we're at the high end of the
15 distribution?

16 What if everything goes exactly ideal?
17 Well, that's the low end of distribution. And we
18 tried to, even as part of this assessment, talk about
19 what if certain equipment malfunctions?

20 What if certain indicators malfunction?
21 How many would have to malfunction before it would be
22 confusing to the operator and he wouldn't know what
23 event he's in, etc.?

24 And we tried to discuss that and hopefully
25 capture it. I'll grant you in perhaps a more implicit

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1 way than really separating out the aleatory and
2 epistemic uncertainties. But we tried to discuss that
3 as part of our formation of the distribution.

4 Okay, when we did the first cut at Ocone,
5 for all the human failure events, we put constraints
6 on ourselves. We basically said we're only going to
7 pick from four values.

8 Mr. Experts, you have -- you can pick any
9 one of those four values as to what you think is the
10 mean estimate for this.

11 .5, kind of in qualitative space, is
12 saying I think the failure's pretty likely.

13 .1, the failure is infrequent, yes you
14 might see it on occasional times if you were to run
15 this 100 times through 100 crews, ten percent of the
16 time I might see the crews not get this done in ten
17 minutes, for instance.

18 .01, qualitatively basically is saying I
19 thing the failure's pretty unlikely. You'd be hard-
20 pressed to see a crew fail to do this. But yes, you
21 might pick up the occasional case under very non-ideal
22 conditions.

23 And then .001, that the failure's
24 extremely unlikely. So in other words, we never put
25 into the model a human error probability less than 10^{-3}

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1 ³ in terms of a mean value.

2 And we constrained ourselves to these four
3 values. The experts had to pick which one of these
4 they thought was best representative.

5 Now, to put the uncertainty on there,
6 typically, well we did the following: For the most
7 part, there were a few exceptions, for the most part,
8 we assumed that the distribution on the uncertainty
9 about that mean was logged normal.

10 And typically the error factor between the
11 95th percentile and the median was generally chosen as
12 either 5 or 10, although, again, there were exceptions
13 on that.

14 And to decide what it should be was
15 largely driven by THERP guidance that we used to
16 decide what we thought the distribution should be to
17 handle some of the kinds of cases that you were
18 talking about, Dr. Bonaca.

19 Questions on that?

20 (No response.)

21 MR. KOLACZKOWSKI: Okay, next slide.

22 MR. HACKETT: Alan, let me interrupt at
23 this point. It's just a schedule note for the
24 Chairman. At the rate we're going, we're not going to
25 meet the schedule.

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1 CHAIRMAN FORD: Okay.

2 MR. HACKETT: So I guess we have some
3 choices. Either we get back onto this because we are
4 looking at finishing by noon. And trying to allow
5 time for the other two disciplines, we're probably in
6 the need of summing up here. Or we leave it up to
7 you. If you feel you need to --

8 MEMBER BONACA: No, I think you made a
9 very convincing case here. And I think it was
10 appropriate, however, because you're eliminating a key
11 scenario of the past, raising probability --

12 MR. HACKETT: But maybe at this point, is
13 that a feeling of this Committee that you've had
14 enough on that and we can --

15 MR. KOLACZKOWSKI: Is that enough on this
16 to see what's going on?

17 MR. HACKETT: -- So Alan, if you could go
18 back into the mainstream and try to summarize.

19 MR. KOLACZKOWSKI: Sure, sure. To help
20 you get a better feeling for what was really done,
21 etc., what we considered, why we feel pretty confident
22 of giving the credit to the operator in the main steam
23 line break case.

24 MR. HACKETT: Okay.

25 MR. KOLACZKOWSKI: Okay, coming back to

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1 the example, and I'll try to get through that pretty
2 quickly. We're at the same point here where we're
3 trying to assess does the operator throttle a high
4 pressure injection. If so, how quickly?

5 And the same kinds of considerations you
6 saw for the main steam line break are now being
7 thought about to try to come up with probabilities for
8 these events but now for HPI throttling in this SRV
9 reclosure event.

10 So we're looking at how will he know it's
11 reclosed, etc., etc.? Next slide.

12 Again, this is sort of a cartoon just to
13 represent that remember there's a lot of event trees
14 for different initiators. There's a lot of sequences
15 that have gone into bin 41. But we're now going to
16 take the solutions of all those sequences and we're
17 going to break them out into essentially three sets.

18 When we apply that fault tree that I
19 showed you on the previous slide to the model, we're
20 going to get out solutions that are of the form, the
21 three forms that are indicated on the right.

22 The first one being some sort of
23 initiating event, the SRV sticks open, the SRV
24 recloses and the operator does successfully throttle
25 by one minute or less. Again, that's the compliment

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1 of that fault tree that you saw in the previous slide.

2 So you're going to get out, for those of
3 you that are familiar with the PRA terms, some cut
4 sets that are of that form. Those go into a new bin
5 called bin 83.

6 And we're actually going to run a thermal
7 hydraulic bin, a run where we're going to apply an SRV
8 stuck-open. We're going to reclose it at 100 minutes
9 but we're going to let the operator throttle high
10 pressure injection one minute after meeting the
11 throttling criteria.

12 So now we get a new curve for that taking
13 credit for that operator action. We also get
14 solutions of the second form. And that goes into bin
15 84.

16 And then solutions of the third form,
17 which is really the old bin 41, the operator never
18 does anything. So they stay in bin 41.

19 So now we redistribute the cut sets. And
20 once you do that, next slide, you also partition the
21 frequencies accordingly. And so you get out new
22 frequencies now of what used to be, if you will, the
23 summation of that would be the frequency of what the
24 old bin 41 used to be.

25 And now bin 41's frequency has been

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1 partitioned into three bins, bin 83, bin 84, and the
2 old bin 41.

3 Now these are just mean values and, of
4 course, so there's really distributions on those,
5 okay? Next slide.

6 Now you heard yesterday that University of
7 Maryland folks, etc., or ISL together did a lot of
8 sensitivities on certainties as to what's going to
9 dominate the response of this event? And which
10 uncertainties do we need to really worry about?

11 And for the case of the SRV stuck open and
12 recloses kinds of situations, we concluded, based on
13 all the sensitivities they did, etc., that the four
14 things that are listed on the bottom were issues that
15 really would dominate what the T/H response would
16 really be.

17 In other words, when does the valve
18 reclose? Obviously, if it recloses much sooner than
19 the 100 minutes that's in this particular case, you're
20 not going to get as much cooling. You're going to
21 have a very different temperature curve and so on and
22 so forth.

23 How open the SRV sticks open? There's a
24 stick open all the way, part way, etc., has a large
25 effect on the cool down rate. So that's another one

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1 we're going to look at.

2 Whether this event happened while we were
3 at full power or at hot zero power is going to have an
4 effect.

5 And then finally, the original bin 41 did
6 not credit, if you will, high cold leg reverse flow
7 resistance. And you'll see that when we finally
8 complete this process, we do, in fact, account for
9 that particular phenomena.

10 So these were four phenomena that we
11 decided really drove the uncertainty on what the plant
12 response would really be. The other things that are
13 listed up at the top for instance would not matter
14 that much, relatively speaking. And so the
15 uncertainty was focused on those four items at the
16 bottom.

17 How do we handle each one of those? I
18 will grant you that the first one was handled pretty
19 coarsely. And perhaps we could do a better job.

20 But for the moment, we basically said,
21 we're going to take all the possible times that the
22 SRV could reclose and we're going to put it into two
23 very coarse bins.

24 Either, in fact, the valve does reclose at
25 about the time that we've been discussing, a little

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1 less than two hours into the event. Or, in fact, that
2 the valve recloses at a time a little less than one
3 hour into the event.

4 Now we could, in fact, have picked ten
5 times and done more distributions, etc. Right now,
6 that's where we're at.

7 And because the data did not suggest that
8 one was any more likely than the other. Do valves
9 reclose very quickly when they do? Or do they
10 sometimes wait until the pressure gets low enough that
11 finally they reclose?

12 There's too little data to suggest that
13 there's a preference, a strong preference one way or
14 another. So we assigned a 50-50 probability to those
15 two times.

16 Next thing, the open area of the valve.
17 It was clear that unless the valve is open at an
18 equivalent diameter of about one and a half inches or
19 beyond, you really don't get very much cooling.

20 Remember I mentioned the PORV is only one
21 inch and when it's open, you hardly even, the primary
22 system hardly sees it. But one and a half inches so
23 that magic line when we're beginning to get a severe
24 enough ramp that we're getting concerned about it.

25 And the valve full open would be 1.8

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1 inches equivalent diameter. Now, we don't know when
2 the valve sticks open whether it sticks open half way,
3 part way, full way, etc.

4 And, therefore, what we did was assume a
5 uniform distribution with regard to that open area.
6 And, therefore, the probability that the valve is
7 stuck open at least one and a half inches or more,
8 which is the portion of area of concern, you can just
9 take that portion of the area, divide it by the total
10 possible areas that it could be stuck open and that
11 comes out .3 when you look at the portion of the area
12 that you're really concerned with.

13 But it is based on that assumption of a
14 uniform distribution on the open area space.
15 Essentially what we do then is we take those bin
16 frequencies you saw on the previous slide for 83, 84
17 and the new 41 if you will.

18 And multiply them by that .5 term and the
19 .3 term to account that we're only interested in that
20 portion of the frequency where the valve does reclose
21 at 100 minutes as opposed to 50.

22 And to account for the fact that the
23 probability that the valve is open sufficiently enough
24 that it really is a severe cool down event that we
25 need to worry about.

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1 And those were treated as point estimates.
2 In other words, no uncertainty on the .5 as well. And
3 no uncertainty on the .3. Okay? Now finally, for hot
4 zero versus full power, just recognize that this same
5 thing is going -- I've shown you the full power cases,
6 that's bin 41. And how it gets separated into 83, 84,
7 and 41.

8 Similarly, we are doing the same thing at
9 the hot zero power conditions. And that happens to be
10 bins 92, 93, and 42. And then what we actually did
11 was we added the two contributions together to get an
12 overall per year what the chance of a PTS challenge
13 due to this kind of scenario would be. Either due to
14 hot zero power conditions, which obviously don't occur
15 very long in the year, versus full power conditions.

16 And I'll show you that addition in just a
17 moment. And then finally, the last point is we felt
18 that the old bin 41 and the way it was done, as I
19 said, did not account for high cold leg reverse flow.

20 And we think that that, in fact, the
21 likelihood that we will have that reverse flow is so
22 near to one that we just called it one. So it really
23 had no effect on adjusting the probabilities
24 ultimately. Next slide.

25 When you go through that process, then

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1 what you end up with is the final bin frequencies for
2 what became now -- we took -- and I don't remember if
3 I'm going to get the corresponding ones right -- we
4 took 83 and by the time you multiply 83 times .5 times
5 .3, add in the hot zero power, account for the reverse
6 flow which was just multiplying by 1, then eventually
7 you get a new frequency out.

8 And that's the final set of 109, 112, and
9 113. So it isn't like we started with 109, 112, and
10 133 and put a bunch of sequences in it.

11 We started with a worst case scenario and
12 then started making adjustments to that and eventually
13 working to 109, 112, and 113.

14 And that really is an illustration of how
15 the frequencies come about and how, in this case, bins
16 109 and 112 and 113 cut perform. And accounted for
17 certain uncertainties, etc.

18 Questions on that?

19 (No response.)

20 MR. KOLACZKOWSKI: And, of course, there's
21 a histogram for each one of those, etc., and that's
22 what went to the PFM folks. If there are no
23 questions, I think we're ready to go onto the TH
24 portion of this.

25 MR. HACKETT: Sounds good.

1 MR. MOSLEH: Actually, to a large extent,
2 what we did in thermal hydraulic is already covered
3 by, in terms of highlights, by what Alan said. So I'm
4 going to try to maybe add a little bit more detail to
5 that.

6 This is just the statistics as to how many
7 runs we made so by now, it's clear that what we used
8 in the analysis was a subset of all the sensitivity
9 and the variabilities that we considered.

10 And I'm going to go to Slide No. 39 in the
11 example package, even though I think it is 1.39. And
12 just to mention the fact that we have, we are talking
13 about that yellow cell.

14 And focusing uncertainty on a dominant
15 scenario in there starting with a case where the SRVs
16 in one of the scenarios, the SRVs stuck open and
17 remain open and the scenario of interest is a case
18 where SRVs stuck open and then they reclose. And that
19 is the case for which Alan described the scenario.

20 So that fits and falls in that box, that
21 yellow box, in the category of SRVs stuck open. Alan
22 also showed a number of variables we considered. This
23 must be a familiar list in the sense of how we
24 classified them in terms of parametric uncertainty and
25 model uncertainty in this.

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1 And you can see that we have three columns
2 under Value 1, Value 2, and Value 3, meaning all the
3 variables that were continuous variables we
4 discretized them into discreet values.

5 So, for instance, the probability of the
6 valve opening area in the range 1.5 to 1.8 inch is
7 discretized into two possible values of 1.5 and 1.8
8 only with a 50-50 percent probability.

9 Decay heat, we have two probabilities for
10 hot zero power, that's the .02 comes from the
11 percentage of time that you're running physically in
12 that condition on an average sense and a nominal in
13 operating condition is about .8 percent.

14 Seasons know no uncertainty about the
15 fraction of times we're in various seasons. HPI state
16 in this particular sensitivity of variability, we set
17 them at full success. We did not do variations in
18 terms of, you know, one out of two or two out of two
19 operating or degradations.

20 However, the flow rate we changed at a
21 nominal of 80 -- of 100 percent from 90 to 110 percent
22 with probability .8 assigned to the nominal case.

23 In the other part, as you can see, to
24 cover values, model uncertainty cases we mentioned
25 yesterday and ways of, surrogate ways of addressing or

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1 for covering the effect of such uncertainties with the
2 assigned probabilities.

3 These probabilities say under the vent
4 valve state .25, .5, and .25 are subjectively assigned
5 by the subject matter experts, interim hydraulics
6 translating their confidence and knowledge into these
7 numbers. So they're subjective in engineering
8 judgment.

9 The same thing about the break flow area,
10 flow rate model. The same type of probability
11 assessment based on engineering judgment.

12 When you take these variables and you see
13 like about, you know, eight, nine variables, two or
14 three values each, you get a number of combinations.
15 And I don't know how many.

16 But you can see from the graph on the
17 left-hand side, that those points correspond to the
18 unique combinations of these cases. There are many.

19 And what you see there is a graph that
20 plots the average temperature as the result of
21 combining many different factors of unique
22 combinations of these factors, with the corresponding
23 probabilities calculated based on combining the
24 probabilities in this table.

25 So you get the average impact on a single

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1 parameter basis. And you have the corresponding
2 probabilities. You combine it using the additive
3 model we discussed yesterday. And you get a
4 distribution of various average temperatures and their
5 corresponding probabilities.

6 As I mentioned yesterday, you then select
7 that from the cumulative distribution version of this
8 probability distribution, we selected three
9 representative graphs with the corresponding average
10 temperatures 375, 400, and 425.

11 And we found the -- either we found among
12 the runs that we already made or we ran new cases to
13 cover cases that would correspond to or come very
14 close to these average temperatures.

15 These are listed as T/H runs 146, 147, and
16 148. This is for the base case where the SRVs stick
17 open and remain open. And the scenario we're
18 interested are the variations, the variance of this
19 scenario because then the valves reseal.

20 The characteristics of these scenarios run
21 by RELAP are listed in the description column and in
22 the probability column, you see 35%, 30%, 35%, which
23 comes from how we basically divided this cumulative
24 distribution into three regions.

25 The base frequency coming from PRA

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1 sequences corresponding to these cases is 2.9^{-4} , so
2 you multiply it by .35 and you get the frequency for
3 that class of events characterized by this particular
4 thermal hydraulic run.

5 You do the same thing for the other ones
6 and that's how we basically generate the types of
7 frequencies in this case, in the mean values sense
8 that are then passed onto the PFM analysis.

9 Now, from this, obviously we run the --
10 these are the results of running the RELAP code for
11 different cases. Three pairs of pressure and
12 temperature trends and these did, indeed, come from
13 RELAP.

14 The case of valves reseating after
15 sticking open is a case where you start with a base
16 case of well the three base cases that I mentioned
17 earlier and then you run variations. The case where
18 the valves reseal after 50 minutes or 100 minutes, two
19 representative cases.

20 Then, in terms of pressure
21 characteristics, we looked at HPI being throttled
22 after one minute, ten minutes or not throttled at all.
23 So you're talking about, I think in this case, 18
24 combinations that we needed to consider as base runs.
25 And on top of that, you had other variations to

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1 consider.

2 So what we did here, we started with the
3 six cases or the three cases that I showed earlier
4 here and tried to capture other variations.

5 You have three cases worth of temperature
6 times two cases for the pressure, oh sorry, for the
7 valves reseating and then times three cases for the
8 pressure, HPI, the impact of HPI. So you have 18
9 cases.

10 We didn't want to end up with 18 cases
11 here. If we did the same thing for all other cases,
12 we'd end up with probably 500 or 600 T/H runs. We
13 didn't want to do that. So we had to go and reduce
14 this further.

15 What we did, we recognized, realized, you
16 know, looking at the graph of the results, that if you
17 look at just the reseating time, and all other
18 variables being the same, you can see after six
19 possible cases on the temperature average behavior,
20 there are two distinct groups, groups representing the
21 valve reseating at 50 and 100.

22 So from each group, we selected the median
23 and added all the corresponding probabilities to this
24 single point and the same thing for the second group.
25 So now we have reduced six curves to -- six cases to

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1 two cases on which we then did the variations of the
2 HPI state.

3 As a result, when you have three HPI
4 states, throttling time and two valve reseating times,
5 you get six cases. Those are listed as cases 112,
6 113, 109, 114, 115, and 149 with the corresponding
7 probabilities.

8 The probabilities are coming from the
9 reseating time distribution of 50-50 percent, the
10 probability, as Alan mentioned. And the throttling
11 time operator action numbers of 2 percent, 3 percent,
12 and 95 percent, or HPIs being throttled after -- in
13 one minute.

14 When you multiply these numbers, you get
15 the probability of the corresponding combinations at
16 .7475, .015, etc. Again, you take a base frequency of
17 the corresponding set of sequences going into these,
18 modify them by the corresponding probabilities or
19 fraction of probabilities that apply to that
20 particular bin or sequence, and you get the frequency,
21 the mean frequency of the class or category that is
22 then sent to the PFM analysis.

23 These are the six temperature trends and
24 their corresponding probabilities coming from RELAP.
25 And you can see the valves reseating at this time,

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1 3,000 seconds and 6,000 seconds, 50 and 100 minutes.
2 And the corresponding set of six pressure trends.

3 As Alan mentioned in his viewgraph, these
4 pairs, combined with the frequency distributions
5 modified by the corresponding probabilities are the
6 ones that are now sent to the T/H.

7 If you look at your table on viewgraph 57,
8 you see in the yellow highlighted box or the
9 highlighted box, you see these cases listed. But
10 these are how these were generated from the old bin
11 41.

12 CHAIRMAN FORD: Thank you.

13 MR. MOSLEH: I think that's basically it.

14 CHAIRMAN FORD: Good.

15 MR. HACKETT: Any questions for the
16 Professor on thermal hydraulics?

17 MEMBER SHACK: When you looked at your
18 epistemic uncertainties, those are really covered in
19 this distribution diagram even though the cases you
20 end up with don't really mention them, but they're
21 really covered because they've contributed to the
22 probabilities in a sense?

23 MR. MOSLEH: Yes.

24 MEMBER SHACK: Even though they're not
25 explicitly included in the calculation that you

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1 finally ended to match those temperatures?

2 MR. MOSLEH: Right. Right.

3 MEMBER SHACK: Right. Okay. So you
4 really have got both the aleatory and the epistemic
5 uncertainty in there hidden in the frequency.

6 MR. MOSLEH: They're hidden in the
7 frequency and combined they result on the cumulative
8 distribution from which we get the thermal hydraulic
9 represented, yes.

10 CHAIRMAN FORD: If I could make a
11 suggestion that we have a break at this time? Do you
12 get the feeling that we're about --

13 MR. HACKETT: I think we're back on
14 schedule.

15 CHAIRMAN FORD: -- On schedule? So we can
16 have a 15 minute?

17 MR. HACKETT: Just in terms of, you know,
18 Terry's got on the order of 15, 16 slides to go
19 through. And we have, when we return from the break,
20 about an hour and a half or so to do that plus get
21 into discussion on that and general discussion.

22 CHAIRMAN FORD: Good.

23 MR. HACKETT: It should be okay.

24 CHAIRMAN FORD: Good. Okay.

25 MR. ROSENTHAL: Just before we break, my

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1 name is Jack Rosenthal and I'm the Branch Chief of the
2 Safety Margins and Systems Analysis Branch in the
3 Office of Research. And I take it there was some
4 earlier discussion about how we validate RELAP itself.

5 And I want to be clear that we fully
6 understand what's expected of us. We did meet with
7 the Subcommittee at Argon State and discussed for a
8 day and a half with them issues.

9 In my own mind, issues such as is this a
10 3D or a 1D plume and how is it penetrating the
11 downcomer, swamp small matters of just how we might
12 model a heat transfer coefficient within RELAP. And
13 so I think that the experimental program gave us some
14 real good, a basis for saying that we have relatively
15 small penetrations in 1D, and we could handle this as
16 1D.

17 If we couldn't, then that would have been
18 a show-stopper because the whole PFM model is based on
19 -- as 1D versus 3D.

20 So now we get into the details of RELAP.
21 It was our, of course there is this history of the
22 developmental assessment that was done back at AP600
23 which is on public.

24 We were planning on detailed documentation
25 of the work at APEX, of the experimental work. And

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1 they did some RELAP calculations relative, of that
2 experiment and that would be documented.

3 We are planning to write a -- we have
4 another report from ISL which would discuss -- and
5 we're paying a fair amount of money for extensive
6 documentation of all the work that was done.

7 To discuss all that documentation and part
8 of that would include a chapter on calculating RELAP
9 against the experiments at APEX again. And we've also
10 done -- actually back about at Argon some Star-C,
11 that's some CFD work against experiment.

12 And we also did some what I call
13 pheophonic mixing cup calculations versus the
14 experiments. So all that we're planning on
15 documenting.

16 And then just because one is crushed with
17 the weight of the paper, we were planning a staff
18 overview document that would reference all these
19 documents, sort of a pyramid of a NUREG supported by
20 NUREG CRs supported by documentation.

21 So that's all planned and should be coming
22 out in the next few months and we would be glad to
23 share that with you.

24 CHAIRMAN FORD: Okay.

25 MR. ROSENTHAL: If you're expecting any

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1 more than that, please let us know.

2 CHAIRMAN FORD: There wasn't a question --
3 from my point of view, it wasn't a question of wanting
4 more. Not being a thermal dynamics expert, by any
5 means, just want to have a feeling, a gut feeling --

6 MR. ROSENTHAL: Sure.

7 CHAIRMAN FORD: -- That we don't have a
8 major uncertainty --

9 MR. ROSENTHAL: Right.

10 CHAIRMAN FORD: -- In the input.

11 MR. ROSENTHAL: Right.

12 CHAIRMAN FORD: That was all my concern
13 was.

14 MEMBER BONACA: Yes, on my part, it was
15 more reasonableness of results. I mean we've had in
16 the industry plenty of cool downs. And we have had,
17 in fact, even LOCAs of some types, stuck-open valves,
18 etc.

19 And we have had thousands of analysis of
20 steam line break and the LOCA against, you know, using
21 different computer codes. And so I'm saying that, you
22 know, I would feel confident also if you just look for
23 reasonableness against the previous predictions and
24 some results of those data.

25 Because those are not tests, experiments,

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1 but they are really practical results from power
2 plants and in industry.

3 And I'm sure you've done plenty of those
4 in the past. You know comparisons of that type.

5 MR. ROSENTHAL: Right.

6 MEMBER BONACA: So, again, I mean I think
7 more reasonableness than anything else, in my
8 judgment, at this stage.

9 CHAIRMAN FORD: Okay. Thank you, Jack.

10 MR. HACKETT: Thanks Jack.

11 CHAIRMAN FORD: Okay, let us recess for a
12 quarter of an hour until just after quarter past ten.

13 (Whereupon, the foregoing
14 matter went off the record at
15 10:06 a.m. and went back on the
16 record at 10:20 a.m.)

17 MR. HACKETT: Okay. I think, as we
18 discussed, it looks like we're pretty much on schedule
19 to complete the integrating piece here in the example
20 is walking through the probabilistic fracture
21 mechanics, in particular, and how this gets coded and
22 dealt with in the FAVOR code, which is really Terry
23 Dickson's specialty.

24 He's the author of the FAVOR code. And
25 you'll be hearing primarily from Terry and Mark Kirk

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1 in this presentation. And we'll shoot to be done on
2 schedule.

3 CHAIRMAN FORD: Yes. I want to make sure
4 we have a half an hour so that my colleagues and I can
5 give you some technical input.

6 MR. HACKETT: Right.

7 CHAIRMAN FORD: And also to discuss what's
8 going to happen in February.

9 MR. HACKETT: So Mark and Terry, if you
10 guys to shoot to finish before 11:30 is what we'd be
11 going for?

12 MR. KIRK: Okay.

13 MR. DICKSON: Okay. I might as well just
14 start now. This is a little different than the slide
15 that's in your handout. In fact, the slide -- I
16 believe the ACRS members were given a copy of the
17 FAVOR manuals, I believe.

18 Actually, on page 35 of the theory manual
19 is the representation that I'm going to be talking
20 about. So if you could get that in front of you, it
21 might be helpful.

22 Because when we prepared this for this
23 presentation, we found out that the illustration
24 that's on page 35 wouldn't fit on one page. So we
25 have it on two pages here so I apologize for that.

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1 MEMBER SHACK: Oh, it'll fit, you just,
2 you know, scale it to fit.

3 MR. DICKSON: Well, you could fit it but
4 you couldn't read it.

5 But this is kind of a high level flow
6 chart and we're not going to get lost in this flow
7 chart. But just to sort of briefly walk through it,
8 what's going on the FAVOR PFM code, is that we're
9 performing -- it's based on a Monte Carlo process
10 where the outside loop is vessels.

11 We're simulating vessels. Vessels of a
12 certain degree of embrittlement and certain flaw
13 characteristics. So the first block there, in that
14 blue box, the first innermost loop is the number of
15 flaws.

16 Because it's already been mentioned that
17 based on the new flaw data generated by Pacific
18 Northwest, that we may have literally thousands of
19 flaws postulated to be in each vessel.

20 So, outside loop vessels, next loop is
21 flaw. The first thing you've got to do with each flaw
22 is to locate it somewhere in the vessel. And I'll be
23 talking about this in detail.

24 And then you go through some sampling
25 processes to determine the degree of embrittlement and

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1 the flaw geometry, which I'll be talking about in
2 detail.

3 So you've gone to all this trouble to
4 simulate this flaw geometry and the embrittlement.
5 Now you're going to subject that to the loading of
6 each transient that's in the analysis. For the
7 accounting case, there was 46 in the base case, 50
8 sensitivities. So actually for each flaw, it was then
9 getting subjected to the loading of 96 transients.

10 Then the next innermost loop is time. So
11 for each transient, we're discretely, we used discreet
12 time steps that we're stepping through the transient
13 to see what's going on.

14 And the innermost loop there shows a -- it
15 doesn't show it very well here but hopefully in your
16 manual there, I'll be talking about this mathematical
17 relationship. That's the conditional probability of
18 initiation, which I will be expounding on that a
19 little more. So can we -- how do we go to the next
20 page?

21 But the main thing I would like for you to
22 remember from this slide, in the context of this
23 presentation, is that these two arrays that are shown
24 down at the bottom here, this is sort of the bottom
25 line that comes out of the PFM analysis.

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1 There is an array, the one down here on
2 the left keeps up with the conditional probabilities
3 of initiation. When I say conditional, that means
4 we're assuming that the transient has occurred.

5 So it's a two dimensional array where the
6 IJ entry is the conditional probability of initiation
7 of the JTH vessel subjected to the ITH transient, if
8 you will.

9 And analogous to that is the conditional
10 probability of failure array. So this is, out of all
11 this looping structure and all the fracture mechanics
12 that you saw presented yesterday, all the thermal
13 hydraulics, it ultimately ends up, the results ends up
14 in these two arrays, which will then be post-processed
15 with the initiating frequencies that have been given
16 by the PRA people.

17 So part of this presentation is going to
18 be to take one entry in that two-dimensional array,
19 and to actually sort of trace to pick a number out of
20 there and sort of trace through the derivation of that
21 number. Okay? Yes. Okay.

22 But before we get down to that specific
23 problem, there's two or three slides here that are
24 still kind of dealing with the general process a
25 little bit.

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1 This slide here, this shows, is an attempt
2 to show the process that locates the flaw in a
3 particular subregion. And it's been mentioned
4 earlier, and I think probably most of you guys have
5 seen some of these slides previously, the idea that
6 we're trying to get all of the variation of the
7 neutron fluence into the analysis.

8 So the vessel, when it's rolled out from
9 300 -- from 0 to 360 degrees, it's discretized into
10 major regions, which are then discretized further into
11 subregions to accommodate the level of detail provided
12 to us by Brookhaven National Laboratory in fluence
13 maps.

14 So FAVOR locates each flaw in a particular
15 subregion by sampling from a cumulative distribution
16 function that expresses the fraction of total flaws as
17 a function of subregion number.

18 The illustration on the right is just
19 that. It's an illustration. It's not particular to
20 Ocone, where it just shows a cumulative distribution
21 function that expresses the fraction of flaws as a
22 function of subregion numbers.

23 Now, of course, each one of these
24 subregions has its own distinguishing embrittlement
25 characteristics, its own chemistry, its own neutron

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1 fluence, its own initial unirradiated value of RT_{NDT} .

2 CHAIRMAN FORD: But the data to support
3 that graph on the right-hand side is based on the NDE
4 data that wasn't shown yesterday but I held up a
5 sample of it. And it's the max, it's the high, of the
6 four measurements that were taken at different places,
7 it's the highest -- it's the worst case scenario.

8 MR. KIRK: We used the largest flaws at
9 the highest density. But as you pointed out, it's
10 using distribution.

11 CHAIRMAN FORD: Right.

12 MR. KIRK: Yes.

13 MEMBER BONACA: Okay, I think it's NDE.

14 MR. KIRK: NDE.

15 MEMBER BONACA: NDE.

16 MR. KIRK: Or NDENDE?

17 MR. DICKSON: NDE.

18 MEMBER BONACA: It's NDE.

19 MR. KIRK: Okay.

20 MR. HACKETT: Also, I'd just add, in the
21 preparation for this, I think it's true, Terry, but
22 the subregion numbers that are listed here, there were
23 many more for Oconee.

24 MR. DICKSON: Yes.

25 MR. HACKETT: You're just showing this as

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1 an illustration.

2 MR. DICKSON: This is just an
3 illustration. In fact, for the Oconee analysis, the
4 vessel is discretized into almost 2,000 subregions.

5 MR. HACKETT: Okay.

6 MR. DICKSON: Okay. But obviously that
7 would have been a pretty crowded plot.

8 (Laughter.)

9 MR. DICKSON: So -- and FAVOR, before it
10 actually performs the first analysis, it does a lot of
11 overhead bookkeeping, determining the number of flaws
12 that are in each subregion, and so forth.

13 Okay, so the first step is you locate a
14 flaw in a particular subregion that has certain
15 prescribed embrittlement characteristics, chemistry,
16 neutron fluence. Then the next step is you're going
17 to simulate a flawed geometry. And there's three
18 quantities that have to be sampled.

19 And the way FAVOR does this, again, it
20 samples from cumulative distribution functions that
21 have been derived from the data that Pacific Northwest
22 Laboratory has given us that is input data into the
23 FAVOR program.

24 So the illustration on the left shows two
25 types of flaws. It shows an inner surface breaking

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1 flaw which are very rare but they do occur in these
2 analyses. And the embedded flaw. Now the embedded
3 flaw there, of course, one of the key features of that
4 is where in the wall. I mean it moves around.

5 And so the three things that get
6 determined by sampling is the flaw depth, the flaw
7 length, and the location of the inner cracked tip.

8 CHAIRMAN FORD: And when you say flaws, it
9 could be magnesium sulfide particles or whatever, but
10 they're treated as cracks?

11 MR. KIRK: Yes, that's correct.

12 MR. DICKSON: Right. So thinking back to
13 the flow chart, you know, we're Vessel No. 1, Flaw No.
14 1. We're doing all of this sampling. And at this
15 point, we've got it in a subregion and we've
16 determined some flaw geometry.

17 Okay. And there was some discussion
18 yesterday about the fact that the flaw size and the
19 density uncertainty is included in the analysis by
20 using 1,000 different characterizations, files that
21 characterize this.

22 And this is just an attempt to show an
23 actual histogram or probability distribution function
24 for the flaw size as characterized for the weld and
25 for the plate from one of those 1,000 files. This is

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1 just one of them chosen at random.

2 But -- so you'll notice -- and they are
3 expressed in -- the flaw depth is expressed in percent
4 of the wall thickness. Typically, you know, somewhere
5 between eight and nine inches. And clearly these
6 distributions are of an exponential nature.

7 And you notice that in the weld
8 characterization there, it gets truncated somewhere
9 around 21, 22 percent. In other words, you're largest
10 flaw, although you'll also notice that that occurs
11 very rarely.

12 And in the plate distribution, it gets
13 truncated at 5 percent of the wall thickness. So
14 you're just not going to have deep flaws in the plate.

15 MEMBER SHACK: Do you do some sort of
16 stratified sampling so you make sure you pick the
17 worst flaws?

18 MR. DICKSON: No.

19 MEMBER SHACK: If you only do a thousand
20 cases.

21 MR. DICKSON: No, no.

22 MEMBER SHACK: The tails are going to kind
23 of get missed, aren't they?

24 MR. DICKSON: Well, no. And here's why.
25 Because we're going to simulate -- let's say that

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1 we're going to simulate 10,000 vessels. And each one
2 of these vessels has, perhaps, 7,000 to 8,000 flaws.
3 So you're going to go in and sample this 10,000 times
4 8,000, which I don't know, what's that? 80 million?
5 Or it's 10^{-6} , 10^{-7} -type order of magnitude.

6 So you're going to get in on these tails.
7 You're going to get these. You're going to see these
8 big flaws occasionally.

9 MEMBER SHACK: Okay, but I mean that's the
10 kind of size we're talking about in Monte Carlo run
11 there.

12 MR. DICKSON: Yes.

13 MEMBER SHACK: Okay.

14 MR. DICKSON: Okay, now, the idea is that
15 we are going to trace this example problem through.
16 A lot has been said about Transient No. 109. So down
17 in this little red box down at the bottom of the page
18 here, I said there's entires, I think I meant to say
19 entries there -- entries in the PFMI and PFMF arrays.

20 In other words, those two arrays that are
21 on page 35 there in your book, you know, down at the
22 bottom, remember the final outcome of your PFM
23 analysis is these two arrays.

24 So, and I said that I was going to try to
25 trace one entry. You'll notice there that it says --

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1 the first one PFMI, that's the one that contains the
2 conditional probability of initiation. And the PFMF,
3 obviously the failure.

4 So I said that the 71st vessel subjected
5 to the 109th -- Transient No. 109 here, the entry
6 there for the CPI or conditional probability of
7 initiation is 1.16 times 10^{-3} and for the failure 1.14
8 times 10^{-3} .

9 So, in this 71st vessel, as I said,
10 there's somewhere around 8,000 flaws in each vessel.
11 There's two flaws in this vessel that had a
12 conditional probability of initiation greater than 0.

13 The rest of them had -- it was 0. Okay?
14 But here's two flaws that were simulated as discussed
15 above that had some 0, some none 0 value associated
16 with them. And these aren't meant to be scale
17 illustrations or anything.

18 But the first one there on the left, it's
19 an axially oriented flaw because it resides in an
20 axially weld. And that shows the mean value of the
21 characteristics, the neutron fluence, the chemistry,
22 the unirradiated value of RT_{NDT} associated with that
23 subregion.

24 It's an embedded flaw that's about .6 of
25 an inch away from the clad base interface. And I

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1 forget what the depth of it is. I believe the depth
2 is about 1/2 inch, I believe.

3 And the flaw on the right, it resides on
4 the circumferential weld that's, you know, when we
5 reached into the grab bag and decided where to put
6 this flaw, it went into one of the circumferential
7 welds. And there's the embrittlement-related
8 characteristics mean value associated with that.

9 MR. KIRK: Terry, now those flaws are
10 scaled. If you look at the dimension on each of the
11 flaws, that's your reference.

12 MR. DICKSON: Okay.

13 MR. KIRK: That's how big the flaws are.
14 They're both a little over an inch long. The circ.
15 one is about a little over .1 of an inch in the A
16 dimension. And the other one's about .05.

17 MR. DICKSON: Okay, I'm sorry.

18 MR. KIRK: Bruce?

19 MR. BISHOP: What type of values are
20 those? Are these mean values?

21 MR. DICKSON: No, those are the mean
22 values. Those are the mean values. Obviously, the
23 second flaw there, it's considerably closer to the
24 inner surface. So it's going to see those stresses a
25 little more than the other one.

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1 CHAIRMAN FORD: Is it conceivable that you
2 could have flaws that large?

3 MR. DICKSON: This is sampling from the
4 data provided by PNL.

5 CHAIRMAN FORD: Oh.

6 MR. DICKSON: I mean this is from the
7 databases that have been derived from the non-
8 destructive and destructive examination performed by
9 Pacific Northwest National Laboratory.

10 CHAIRMAN FORD: Okay.

11 MR. DICKSON: Now these, I won't say that
12 these aren't necessarily on the tail of the
13 distribution. But these are fairly good-sized flaws,
14 half inch. They're going to come up periodically.

15 But remember, there was roughly 7,900
16 other flaws put in this vessel that didn't register at
17 all.

18 CHAIRMAN FORD: Right.

19 MR. DICKSON: Okay. This is -- since
20 we're actually tracing through this particular case,
21 the treatment of multiple flaws, okay? In other
22 words, how do we come to do the flaw arithmetic.

23 And for -- if you have one flaw in an RPV
24 that has a conditional probability of initiation --
25 well, the conditional probability of initiation is

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1 just what you calculate.

2 But, thinking in terms of the case where
3 you have more than one, the probability of non-
4 initiation is just one minus $CPI(1)$, which is shown
5 there.

6 So then when you go to the case of two
7 flaws, which is what we have here for this 71st vessel
8 subjected to Transient 109, you have conditional
9 probability of initiation, $CPI(1)$, $CPI(2)$.

10 And so the probability, the joint
11 probability of non-initiation is going to be the
12 product of one minus the CPI .

13 Now, of course, implicit here is that
14 these flaws are totally independent of one another.
15 The fracture response of each flaw is totally
16 independent of all the other flaws.

17 So, the final statement there, the CPI of
18 any RPV is one minus the products of one minus CPI^n
19 flaw for the case of N flaws. So applied to this 71st
20 vessel, subjected to the Transient No. 109, we have
21 individual values -- and I guess I need to get up here
22 and point out --

23 MR. HACKETT: Terry?

24 MR. DICKSON: Yes.

25 MR. HACKETT: If you're going to get away

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1 from the mic, let me get you a traveling one.

2 MR. DICKSON: Okay.

3 CHAIRMAN FORD: Terry, while this is
4 happening, isn't that a huge assumption that there is
5 no interaction between the flaws?

6 MR. DICKSON: No.

7 CHAIRMAN FORD: I mean just like a piece
8 of toilet paper or isn't that the same analogy?

9 MR. HACKETT: There is, Peter, there's I
10 guess first off, to try to model the interaction, if
11 there were one, or if there was postulated in
12 interaction, it would probably be beyond the state-of-
13 the-art for the code at this point.

14 However, the way we do address it, I think
15 Terry maybe mentioned briefly, using basically what
16 ASME would refer to as proximity rules. So if you do
17 see a series of flaws that you have detected through
18 the NDE that could interact or you think they may
19 interact, ASME has rules for that that usually governs
20 things on the order of the flawed diameter if one's
21 located within that kind of space or the next one.

22 They're going to assume that they
23 interact.

24 CHAIRMAN FORD: Oh.

25 MR. HACKETT: And the way they do that is

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1 treated in a conservative way. They'll just assume
2 it's one large flaw.

3 CHAIRMAN FORD: Okay.

4 MR. HACKETT: Which is, again, all you can
5 really treat with fracture mechanics. And unless you
6 get to a much more complex model than we have here.

7 CHAIRMAN FORD: Okay.

8 MR. KIRK: It's also important -- I think
9 useful to point out that even though we're generating
10 multiple thousands of flaws, the likelihood that any
11 two of them are going to be simulated in proximity to
12 each other is still pretty low because it's a big
13 vessel.

14 MR. SIMONEN: This is Fred Simonen at
15 TNNL. I guess another point to be made is that in our
16 examination of these vessels, if we did find two flaws
17 that were reasonably close to one another, we did look
18 at them from the standpoint of the proximity rules.
19 And would have reported it as one larger flaw if they
20 indeed were sufficiently close.

21 So I think the proximity concern was
22 really addressed somewhat through the selection of the
23 slide data in the examination of the vessel welds.

24 MR. HACKETT: That's a good point, thanks
25 Fred.

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1 CHAIRMAN FORD: Okay.

2 MR. DICKSON: Okay, I guess I would add
3 that there's been some papers, I know, by the Japanese
4 in some of the PBP proceedings the last few years
5 about -- they've done some analytical studies, not
6 experimental studies.

7 And there's a professor at the University
8 of Ottawa, I believe, that he kind of from an airplane
9 wing point of view, he's very interested in how does
10 one flaw influence another flaw.

11 And basically I followed his work. And
12 many times the presence of a flaw suppresses the
13 response of another one. In other words, it's not
14 always an amplification. It's not always detrimental.

15 In some cases, depending on the
16 orientations, sometimes the fracture response of one
17 flaw can suppress the fracture response of another
18 flaw. So suffice it to say it's beyond the scope of
19 where we are right now.

20 CHAIRMAN FORD: Okay.

21 MR. DICKSON: Okay, but in this flaw
22 arithmetic, you'll notice that of that axial flaw,
23 Flaw No. 1, it had a conditional probability of
24 initiation of 10^{-3} -type magnitude. And the second
25 flaw, the one that was in the circumferential, it was

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1 more like 10^{-5} .

2 Now on the CPF, you'll notice that the
3 value of the conditional probability of failure is the
4 same as the probability of initiation. The
5 implication of that is all of the flaws that initiated
6 failed. And I'll be talking more about that.

7 Whereas here, you'll notice that almost an
8 order -- only maybe 10 percent of the flaws that
9 initiated in the circumferential weld failed. So --

10 MR. KIRK: You need the mic, Bruce.

11 MR. BISHOP: It's one minus. You need the
12 one minus, okay, at the beginning of those, okay, for
13 the numbers to come out.

14 MR. DICKSON: Oh, yes, you're right. It
15 should be a one minus here. I actually made this
16 slide about an hour before I went to the airport. I
17 was in a hurry.

18 Okay, thinking back to the flow chart on
19 page 35 there in your manual, after you've located a
20 flaw in a subregion, after you've simulated the flawed
21 geometry, the next thing it says is calculate the RT_{NDT}
22 at the cracked tip. Okay?

23 So for Flaw No. 1, this is actually
24 carrying through the arithmetic of Flaw No. 1. RT_{NDT}
25 at the cracked tip, it's the sum of the initial

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1 unirradiated value of RT_{NDT} . And the radiation-induced
2 shift ΔT_{30} . In this particular case, for Flaw No. 1,
3 we end up with a value of RT_{NDT} of 186 which is a sum
4 of these two parts, 9 and 177.

5 Okay, this is showing where did the value
6 of 9 come from? Okay, it's the summation of two
7 values, the first of which -- the best estimate mean
8 value of the unirradiated value of RT_{NDT} was -8. And
9 it had a 1σ of 23.6. So we sampled from a Gaussian
10 distribution and for this particular case, it came out
11 to be 24.

12 And then, as Mark talked yesterday about
13 adding this epistemic uncertainty which basically the
14 purpose of this is to remove the conservatism
15 associated with using RT_{NDT} as an indexing parameter
16 for fracture toughness.

17 He talked about the derivation of this
18 cumulative distribution function from the 18
19 materials. And I'm not going to get lost in that
20 detail other than to say for this particular case, we
21 picked a random number, came in here, picked out this
22 value of about 15.

23 And this gets subtracted, remember?
24 Because we're trying to remove conservatism. So
25 here's the nine, so here's the value of the RT_{NDT}

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1 unirradiated for this Flaw No. 1. Okay?

2 This is the estimation of the ΔT_{30} mean.
3 And in other words, the mean value of the radiation-
4 induced shift in RT_{NDT} is a function of the sample
5 values of chemistry and neutron fluence.

6 Which, for this particular subregion, it
7 had a mean value of copper .19, nickel I think that's
8 .57, phosphorus .017, neutron fluence 1.26.

9 Well, notice, and this probably is
10 characteristic of most of your flaws that probably
11 initiate, most of these end up -- the samplings are
12 kind of the right-hand side of mean. You know, you
13 kind of reached in the grab bag for copper and got
14 something a little higher than the mean.

15 The same is true for nickel. It's
16 certainly true for phosphorus. And certainly true for
17 neutron fluence. So these are the sample values that
18 you plug into the equation that Mark -- that ugly-
19 looking hyperbolic tangent equation --

20 CHAIRMAN FORD: Yes.

21 MR. DICKSON: That he showed yesterday.
22 You plug these numbers into it and you get the 174
23 degrees here.

24 So moving right along. Okay. Then the
25 next step is you'll also remember the discussion

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1 about, okay, now that you've got the RT_{NDT} , that's not
2 the good indexing parameter for fracture toughness.

3 So accounting for trying to get the
4 difference between the CVN and fracture toughness
5 transition, we do another sampling here where the
6 174.3 that we calculated from the embrittlement trend
7 calculation, we now sample that. And actually this
8 uncertainty should be 25 here.

9 And if you look in your FAVOR manual,
10 you'll find that it's 25.6. But we reach into the
11 grab bag one more time. And again we come out on the
12 right-hand side of the mean. So now our shift in RT_{NDT}
13 is 177.4.

14 Okay. This is a real busy slide but this
15 really -- this is an attempt to sort of nail down
16 what's going on in the PFM analysis. On the left is
17 shown this Transient 109 that there's been so much
18 discussion about how it got into the analysis.

19 But notice it's a fairly quick cool down.
20 But certainly the distinguishing characteristic of
21 this transient, which turns out to be the most
22 dominant transient of the analysis we've done so far
23 for Oconee, the most distinguishing characteristic is
24 this repressurization.

25 You know you cool down and just probably

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1 close to the time that your thermal load is kind of
2 starting to peak, you hit it with this
3 repressurization. So this is a pretty severe
4 situation here from a fracture mechanics point of
5 view.

6 Okay, now there's several points I'm going
7 to try to make with this slide. The conditional
8 probability of initiation for each flaw is calculated
9 by solving the Weibull cumulative distribution
10 function for K_{Ic} or fracture initiation toughness for
11 the fractional part or fractile of the distribution
12 that corresponds to the applied K_I .

13 Okay, now I'm going to -- hopefully this
14 graphic will maybe illustrate that a little bit. And
15 here's the equation again which, by the way, when you
16 plug in, we get this .001144, which a few slides ago
17 was shown to be the CPI for this first flaw.

18 Okay, this second graphic shows here is a
19 time history of the applied K_I for subject flaw. This
20 red curve. This black curve coming down here, it's
21 the Weibull location parameter A. And a physical
22 interpretation of that parameter is that's the lowest
23 value of K_{Ic} that can exist. It's the bottom of the
24 distribution.

25 So what we're interested in here is does

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1 the applied K_1 penetrate above this Weibull location
2 parameter? And in this case, it clearly does. In
3 other words, we think in terms of does the K_1 ever
4 penetrate into the K_{1c} space? And if does, how far?
5 Okay?

6 So here is an illustration to show that
7 yes, and it just so happens that it does it right at
8 the time of repressurization so it is that spike
9 associated with the repressurization that pushes this
10 K_1 up into the K_{1c} space and then the question is how
11 far does it go up?

12 It goes up to the .1144 percent K_{1c} curve.
13 Or in other words, that's the reason CPI is .001144,
14 okay? And to try to further nail this down, this
15 again shows this red curve here, in this case red is
16 the A, the Weibull location parameter. The blue is
17 showing that percentile. In other words, this curve
18 is the same as this curve.

19 I'm just -- what I'm trying to show here
20 is the Weibull distribution at this slice of $T - RT_{NDT}$
21 or at this time. I'm just trying to show that what
22 we're doing here is we're asking how far does the K_1
23 get into this Weibull distribution of K_{1c} ?

24 That's what -- this is an attempt to show.
25 And if you understand this slide, you'll understand

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1 about 80 percent of what's going on with PFM analysis.

2 MR. KIRK: And now for the other 20
3 percent.

4 (Laughter.)

5 CHAIRMAN FORD: One of the concerns I had
6 from your talk yesterday, Mark, was a question about
7 the fluence attenuation --

8 MR. KIRK: Yes.

9 CHAIRMAN FORD: -- We go through. And,
10 therefore, the attenuation of K_{1c} . And this is why
11 I'm listening to this very closely to see where that
12 comes into the argument.

13 MR. KIRK: I believe we skipped it. It
14 would go back -- back there, what Terry's pointing out
15 is where we've sampled the fluence, has that already
16 been attenuated to the cracked tip at that point,
17 Terry?

18 MR. DICKSON: No, no. The values of
19 fluence that are handled up front --

20 CHAIRMAN FORD: Yes.

21 MR. DICKSON: -- The value that's input
22 and the value that's sampled are understood to be the
23 value at the inner surface of the vessel.

24 CHAIRMAN FORD: Right.

25 MR. DICKSON: Then, when you get ready to

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1 calculate the RT_{NDT} , you use your exponential
2 attenuation to attenuate it to the location of the
3 cracked tip.

4 CHAIRMAN FORD: Okay.

5 MR. DICKSON: So the numbers of fluence
6 here. But these flaws are pretty close to the inner
7 surface. Remember, we're talking about the inner
8 cracked tip of flaws that are located --

9 CHAIRMAN FORD: You're right that so far,
10 we just consider that the initiation of the crack.

11 MR. DICKSON: Yes, right now.

12 CHAIRMAN FORD: Into the growing and the
13 arrest of the crack --

14 MR. DICKSON: Yes.

15 CHAIRMAN FORD: -- That's where you're --

16 MR. KIRK: Well, well. No, it has been
17 attenuated for the initiation as well. We just, we
18 skipped that step.

19 CHAIRMAN FORD: Oh.

20 MR. KIRK: But then, yes, certainly. As
21 we grow through the wall, the temperature changes and
22 the fluence attenuates as you go through. That's
23 correct. See I told you we needed more details.

24 (Laughter.)

25 CHAIRMAN FORD: More detail?

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1 MR. DICKSON: Well, that's the problem
2 with a presentation like this. How much detail is too
3 much detail? And if I get through this slide, I'll be
4 doing good.

5 MR. KIRK: And this is too detail.

6 MR. DICKSON: And this is borderline too
7 much detail right here. But remember, there's two
8 arrays that I'm trying to fill up here. The one that
9 contains the conditional probabilities of initiation
10 and one that contains the conditional probabilities of
11 failure.

12 In fact, it's the conditional probability
13 of failure that's probably going to be used to
14 regulate with. So we have to talk about how do you
15 get from CPI to CPF.

16 Okay, and I'm going to attempt to talk
17 about it.

18 (Laughter.)

19 CHAIRMAN FORD: Okay.

20 MR. DICKSON: For this particular
21 transient. Here's three -- actually here's five
22 discreet time steps. This first one corresponding to
23 the time of repressurization. And what this is, this
24 is -- you can't read it on here. But if you could,
25 this says Instantaneous Conditional Probability of

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1 Initiation, CPI --

2 CHAIRMAN FORD: Yes.

3 MR. DICKSON: -- As a function of T. So
4 notice that at this time of 120 minutes that
5 corresponds to the repressurization, when that K_1
6 spikes up into that K_{1c} space the maximum amount,
7 there it is.

8 Okay? And that says right here, that is
9 the conditional probability of initiation of .001144,
10 which is the value for this flaw. Okay? So these
11 other values that occur after that maximum value,
12 they're calculated but they are really not relevant.
13 Because remember at this point in the analysis, we're
14 deterministic.

15 We've gone to all this trouble to place a
16 flaw of some very specified embrittlement, subject it
17 to a very specified transient that has a specified K_1 .
18 So at this point, if it breaks at 120, it's kind of a
19 moot point what happens at 125, you know? So we're
20 interested in the maximum value.

21 So in this case, and this case is a little
22 bit unique and I'm going to show a second case which
23 has different characteristics in a moment. This case
24 is a little bit unique insofar as all of this -- this
25 shows the ΔCPI , which happens to be identical to the

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1 CPI here because there was nothing before this
2 repressurization. And at the repressurization, you
3 get the full thing.

4 So the question is in trying to determine
5 the conditional probability of failure is what's the
6 fraction of this -- if you want to think of this as a
7 certain number of flaws that initiate, what fraction
8 of those would propagate on through the wall and fail
9 the vessel versus what fraction would propagate some
10 fraction away through the wall and end up in a stable
11 arrest?

12 Okay, so that's the question. And in this
13 particular case, all of them. It's an axial flaw
14 subjected to a very severe repressurization so to
15 calculate the CPF of actually put -- kind of the
16 arithmetic of what's going on here, it's -- to
17 calculate the -- at any discreet time step, the Δ CPF
18 is equal to the Δ CPI times this ratio. Where the
19 ratio is the failures divided by the initiated flaws.

20 Okay? Or mathematically, it's the
21 summation of the Δ CPF over the times of interest.
22 Which here there's only one time, at 120. So CPI is
23 equal to CPF in this particular case.

24 MR. KIRK: Terry?

25 MR. DICKSON: Yes?

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1 MR. KIRK: I'm not sure if you are going
2 to get to this, but maybe we need to tell them how we
3 got the ratio. I mean how you figured out that 100
4 percent of them went through?

5 MR. DICKSON: I'm going to get to that.

6 MR. KIRK: Okay.

7 MR. DICKSON: I want to talk about this
8 second flaw first because it demonstrates a little
9 something different. But from the last slide,
10 remember ratio. That's the key thing you want to
11 remember.

12 MEMBER SHACK: Why don't I use a
13 cumulative probability of initiation rather than just
14 the max value? Why don't I look at those second ones
15 and add contributions for those?

16 MR. DICKSON: Because remember -- because
17 this is a deterministic case. And if the vessel
18 breaks at 120 minutes, there is no 125. The transient
19 -- the vessel has fractured. And this is a
20 deterministic case.

21 So we don't care what happens at 120 -- or
22 at least in the consideration of the initiation, we
23 don't care what happens. Now we do in the propagation
24 through the wall. We care very much.

25 MEMBER SHACK: All right.

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1 MR. DICKSON: Maybe this -- I'll tell you,
2 let me go through the second example. And maybe
3 you'll get some clarification on this perhaps.

4 MR. HACKETT: I was going to say the same
5 thing. Terry's second example I think illustrates
6 that a little bit better.

7 MR. DICKSON: The second example, in fact,
8 remember what we're doing here. We're tracing through
9 Vessel No. 71 subjected to Transient 109. There were
10 two flaws that had CPI greater than 0. Here's the
11 second one.

12 What's -- and a distinguishing
13 characteristic of No. 2 versus No. 1 is it resides in
14 a circumferentially-oriented weld. So it's a
15 circumferential flaw. So again, following the same
16 type format we just went through.

17 Here's the transient. Here's the applied
18 K_1 for that circumferential flaw. And it too gets --
19 it penetrates into the space or we wouldn't have a CPI
20 greater than 0.

21 But notice there's a couple of different
22 things here about this K_1 curve. It maxes out before
23 the repressurization. It's more of a thermally
24 driven. Here's the repressurization spike at 120. It
25 spikes but it's kind of already after the damage is

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1 done on this circ. flaw.

2 Now why is that? What's the physics of a
3 circ. flaw versus an axial flaw with regard to this
4 repressurization? Well, first of all, this flaw was
5 closer to the inner surface so it's seeing the thermal
6 effect quicker. So it's getting steeper quicker.

7 And number two, just the physics of a
8 circumferential flaw kind of back to Mechanics and
9 Materials 101, a pressure-induced stressed in an axial
10 direction is one-half the magnitude in the hoop
11 direction. So just some basic physics are going on
12 here, too.

13 This spike doesn't affect the circ. flaw
14 to the same degree that it effected -- impacted the
15 axial flaw. So anyway, following the same format,
16 this only gets up to -- it penetrates the space up to
17 the .002 percentile, or fractile if you wish. So the
18 conditional probability of initiation is considerably
19 smaller. It's around 2 times 10^{-5} .

20 And again, you know what I'm trying to
21 show here. I'm not going to do this. But, okay. Now
22 hoping that this will maybe answer your question a
23 little bit. Now this is a little different because
24 see we don't get everything all in that spike.

25 Here's the spike over here. Here's the

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1 repressurization here for this circ. flaw. So notice,
2 this is kind of a gradual build up at -- I can't even
3 read the minutes there, 70 -- maybe 70 minutes? At 70
4 minutes, we get a little CPI. At 75, we get a little
5 more. At 80, a little more still. And then we start
6 dropping off, okay?

7 Well, this value here, this tall one, is
8 the 2 times 10^{-5} , which if you want, you can think of
9 this as being the summation of this and then the
10 difference between these two and then the difference
11 between this. And that's what this is an attempt to
12 show.

13 This is the Δ CPI, okay? This is how much
14 the CPI increases in each discreet time step, okay?
15 Are you with me so far? This is sort of fundamental.

16 (No response.)

17 MR. DICKSON: So this is the instantaneous
18 CPI. This is the Δ CPI.

19 MEMBER SHACK: Okay.

20 MR. DICKSON: How much does the CPI change
21 from one time step to the next time step? Okay? Now,
22 back to this ratio concept. Now, this -- kind of
23 again, without getting lost in the fracture mechanics
24 but it's a known fact that circumferential flaws don't
25 propagate through the vessel nearly as often as an

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1 axially-oriented flaw.

2 And we could do another whole presentation
3 on that. So let's don't get lost there.

4 So we have the expectation that
5 circumferential flaws won't propagate through as
6 often. Well, here's this ratio again. So the
7 question here is that same as it was a moment ago.
8 What fraction of these -- of this little bit
9 propagates through the wall to failure?

10 And you ask that question at each one of
11 these time steps. Well, in this case, the answer is
12 16 percent, 14 percent, and 10 percent. So
13 essentially these get scaled down to this.

14 Now we do the summation. We're doing it
15 from 75 to 85 and we get the 2 times 10^{-6} , which is an
16 order of magnitude -- almost an order of magnitude
17 because these are basically an order of magnitude.
18 The ratio. So basically 10 percent of the time, this
19 initiated circ. flaw is going to propagate through the
20 wall for this very prescriptive, deterministic case
21 that we're dealing with.

22 Okay. Does that answer your question at
23 all?

24 MEMBER SHACK: No, I guess I'm still
25 having a problem, you know. Suppose -- I agree that

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1 if the vessel fails, I certainly don't have to
2 consider what happens at T plus ΔT because the ball
3 game is over.

4 But I would argue that if my conditional
5 probability at the first step is whatever it is, then
6 I have a condition -- the true conditional probability
7 at the second time increment is 1 minus chance that it
8 failed at the first one times the instantaneous
9 conditional probability of failure.

10 That is, I scale it because of the fact
11 that yes, maybe if it failed, I'm certainly not going
12 to worry about it. But if it didn't fail, then I
13 presumably still have a chance to fail, right?

14 MR. DICKSON: Well, isn't that what we're
15 doing when we go from here to here? This increment
16 right here is the same as this minus this.

17 MEMBER SHACK: Yes.

18 MR. DICKSON: This is doing that algebra
19 that you just described. This minus this is this.

20 MEMBER SHACK: Well, no, I would multiply
21 by one minus the conditional probability. That is, I
22 look at the probability that it didn't fail, which is
23 one minus CPI times the instantaneous one, rather than
24 the Δ .

25 Because, you know, if it has failed, the

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1 ball game is over. If it didn't fail, then I have a
2 new instantaneous probability of failure. But I have
3 to scale that by the chance that it failed in the
4 first step.

5 CHAIRMAN FORD: Right.

6 MR. HACKETT: Right.

7 MR. DICKSON: Let me go on through the --

8 MEMBER SHACK: Now maybe when I do the
9 multiplications, the problem is small.

10 MR. DICKSON: -- rest of it. And we can
11 come back to this. Basically we convinced --
12 Professor Mubhares of the University of Maryland might
13 want to chime in here. He and I sort of worked
14 together, I don't know, a year or two ago, kind of on
15 this concept.

16 And I remember we did play with that,
17 exactly what you're describing. But it got so kind of
18 crazy of trying to track it, particularly when you
19 come to the propagation through the wall, that we
20 convinced ourselves that this was the same thing.
21 This is doing the same thing.

22 MEMBER SHACK: And it may be as I
23 linearize the problem, it is.

24 MR. DICKSON: Now I don't know if what I'm
25 fixing to say will help you or not. But I'm going to

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1 try. How do we calculate this ratio? Okay, how do we
2 calculate this ratio?

3 What we actually do, remember, we're
4 inside of a Monte Carlo loop at this level. We've way
5 down here four levels deep in a Monte Carlo loop. And
6 at this point, we're going to break out and go do
7 another Monte Carlo to answer the question of how --
8 what fraction, what ratio of these flaws that initiate
9 propagate through the wall to fail?

10 We're going to say take 100 cases and see
11 what fraction of those hundred. And we're going to do
12 that for each of these time steps. Propagate through
13 the wall to failure.

14 MEMBER SHACK: I'll take it back. You've
15 just linearized my problem.

16 MR. DICKSON: Okay.

17 MEMBER SHACK: And that's legitimate in
18 this case.

19 MR. DICKSON: Which involves -- so in
20 other words, at this time right here, yes, what
21 happens at 120 or 200 minutes is important. And
22 everything through the wall. So as far as space,
23 through-wall space and time, that's considered in the
24 through-wall analysis that we're going to do probably
25 100 times for each one of these.

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1 Now what's the variable when we do that
2 Monte Carlo through the wall? What's variable is K^{1a} ,
3 the aleatory uncertainty in K^{1a} . So each time we do
4 that through the wall, we're going to reach into the
5 grab bag of K^{1a} .

6 Okay? To include the aleatory uncertainty
7 associated with K^{1a} . So at the end of the day, does
8 that satisfy?

9 (No response.)

10 MR. DICKSON: Okay. So at the end of the
11 day --

12 MEMBER SHACK: Well, it satisfies me here
13 but I'm not sure why I didn't do the same thing on
14 Flaw No. 1.

15 MR. DICKSON: Flaw No. 1 was unique, it
16 just had one spike.

17 MEMBER SHACK: No, no. It had a couple of
18 little spikes after that. The first spike was the
19 biggie.

20 MR. DICKSON: Right. Okay, but --

21 MEMBER SHACK: But why didn't I take the
22 first spike and then add the Δs ?

23 MR. DICKSON: Because, I guess I'm
24 starting to sound redundant, but with regard to
25 initiation only, without any consideration of what

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1 happens after initiation, if everything going back --
2 if I had that slide up, you'd have that big spike at
3 120 minutes. And then a little spike at 125, the
4 point is, if it was going to break, it broke at 120.

5 MEMBER SHACK: Yes, I guess I can argue
6 that on the physics of the thing. I'm just -- I'm
7 back to just the simple math now.

8 MR. KIRK: I think we were, at least my
9 way of explaining it, my way of understanding it was
10 more based on the physical argument --

11 MEMBER SHACK: Right.

12 MR. KIRK: -- That if you've got a
13 climbing probability of initiation, if it doesn't go
14 at your max probability, it's not going to go once the
15 probability drops. Right?

16 MEMBER SHACK: Then the rest of it is just
17 a matter of --

18 MR. KIRK: Yes, admittedly, that's -- yes.

19 MEMBER SHACK: And I'm willing to buy
20 that.

21 MR. KIRK: Well, all right, okay.

22 MR. DICKSON: I'm not going to actually
23 trace through all -- take -- because for that case, I
24 would have to trace through 100 cases to show you.
25 Suffice it to say that those ratios are determined by

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1 reaching in the grab bag of K_{1a} .

2 MEMBER SHACK: Yes, okay.

3 MR. DICKSON: Is my way of expressing it.

4 MR. KIRK: We do 100 arrest trials --

5 MR. DICKSON: For each time step.

6 MR. KIRK: -- for each, 100 deterministic
7 arrest calculations and just for each one record
8 whether the crack penetrated the wall or didn't. And
9 that gives us a fraction to multiply CPI with.

10 MR. DICKSON: But perhaps if you stop and
11 think about it, it will give you an appreciation of
12 why this program takes a long time to execute
13 sometimes. We're four levels deep in a Monte Carlo
14 and now we're going to go do some more Monte Carlo.
15 So it's pretty CPU intensive.

16 Okay, this is, I believe, the last slide.

17 MR. KIRK: There is one more.

18 MR. DICKSON: Okay.

19 MR. KIRK: On unembedded flaws.

20 MR. DICKSON: Oh, okay. I just want to
21 point out that there is a couple of assumptions
22 associated with this through wall analysis that are
23 substantiated by experimental evidence.

24 After the crack has occurred, okay, kind
25 of a little bit of the physics, a flaw that initiates

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1 in cleavage fracture is assumed to become an infinite
2 link inner surface breaking flaw.

3 And this is an attempt, this illustration
4 is an attempt to show okay we start off with a surface
5 breaking flaw that is predicted to initiate in
6 cleavage fracture. Okay, this little orange here is
7 the clad. This is the base. And this is showing the
8 stress gradient. This is showing the temperature
9 gradient.

10 This is showing that this flaw is assumed
11 to be running long before it runs deep. So an
12 assumption in the, when you do the through wall
13 analysis to determine that ratio, when you do that 100
14 analysis for each time step, and it's a surface flaw,
15 you assume that that flaw runs long to become an
16 infinite length flaw before you actually start
17 propagating it through the wall.

18 And the way you do that, the flaw was
19 propagated through the wall incrementally to compare
20 K_1 versus K_{1a} . Sometimes it will arrest. Then you
21 fall back in the time loop to see if it reinitiates.
22 It's very tedious to try to illustrate it.

23 Here's the same idea but much more often
24 the case is you have an embedded flaw, okay? Like
25 both of our flaws that we've tried to illustrate here

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1 started off as being embedded flaws. Well, what we
2 assume there is that -- remember we're checking the
3 inner crack tip for initiation.

4 And if initiation is predicted, CPI
5 greater than 0 from a Weibull function, we assume that
6 it propagates back through, pops through the cladding.
7 And again it becomes a long flaw.

8 And perhaps that's got a little bit of
9 conservatism associated with it. The assumption is
10 that you have a flaw that's propagating, it's getting
11 longer so it's getting to be a larger K_I and it's
12 propagating into a decreasing resistance field.

13 In other words, the material resistance is
14 decreasing as you go back toward the inner surface.
15 There have been a few calculations done.

16 Paul Williams, and there's a paper that we
17 did at the Water Reactor Safety Meeting a couple of
18 years ago, not in the context of PTS, in the context
19 of a start up and shut down. But that somewhat
20 substantiated that assumption.

21 But I'm certainly willing to admit there
22 might be some conservatism there. So I think that's
23 it.

24 MR. KIRK: No, you got one more.

25 MR. DICKSON: Oh yes, okay. Okay. So

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1 what I've done so far is hopefully have traced through
2 one entry in each of the matrices that comes out of
3 the PFM analysis. Vessel 71 subjected to Transient
4 109 just to --

5 CHAIRMAN FORD: I'm sorry.

6 MR. DICKSON: Okay.

7 CHAIRMAN FORD: Before you get into this
8 aspect, would you mind just going back one slide?

9 MR. DICKSON: Sure. How do I go back?

10 CHAIRMAN FORD: I'm just trying to
11 understand what this schematic is telling me. What
12 you're saying on this particular example here, B, the
13 shaded brown area, that area is the crack after
14 initiation?

15 MR. DICKSON: Yes.

16 CHAIRMAN FORD: So in all of these
17 examples you've shown here, the crack, in fact, popped
18 back onto the ID surface?

19 MR. DICKSON: Yes.

20 CHAIRMAN FORD: It didn't go to the OD
21 surface?

22 MR. DICKSON: That's correct, yes.

23 CHAIRMAN FORD: Okay.

24 MR. DICKSON: We check the flaw -- we
25 check embedded flaws for initiation at the inner

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1 surface.

2 CHAIRMAN FORD: Now, what's the scenario
3 for getting -- for it popping through the other way?

4 MR. DICKSON: Oh, for popping through the
5 wall?

6 CHAIRMAN FORD: Yes.

7 MR. DICKSON: To the outside?

8 CHAIRMAN FORD: Yes.

9 MR. DICKSON: Well, that's what -- that
10 gets back to that whole ratio thing. What we do is we
11 -- you understand this is a long --

12 CHAIRMAN FORD: Yes.

13 MR. DICKSON: -- Flaw now. And what we're
14 going to do, we're going to incrementally propagate
15 that flaw through the wall. We're going to let it get
16 a little bigger.

17 CHAIRMAN FORD: All right.

18 MR. DICKSON: And it's moving into -- it's
19 moving through the vessel that's got a temperature
20 gradient, a neutron fluence gradient, all of these
21 gradients going on.

22 CHAIRMAN FORD: Sure.

23 MR. DICKSON: So all of these gradients
24 are accounted for as we move the tip of that flaw
25 through the vessel.

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1 CHAIRMAN FORD: Sure.

2 MR. DICKSON: Continuously asking the
3 question as we incrementally propagate it, stopping
4 and asking the question, do you arrest here or do you
5 continue to propagate.

6 CHAIRMAN FORD: Sure.

7 MR. DICKSON: And the answer is always,
8 well, I either arrest or I propagate. So if you
9 continue to propagate, you know what's going to
10 happen.

11 CHAIRMAN FORD: Yes.

12 MR. DICKSON: You blow the other side out.
13 But if you don't, if you arrest, okay, that means you
14 arrested for now. Then you fall right back into the
15 time loop and you're asked the question do I
16 reinitiate at a later time in the transient?

17 So some of these are a series of arrests -
18 - of initiation, arrest, reinitiation, arrest, before
19 the final -- before one of two things happens. It
20 either gets through the wall or the transient's over
21 and it didn't get through the wall.

22 CHAIRMAN FORD: I understand what you've
23 done on these three examples. I'd have loved to see
24 an example, which surely you don't want to see, of --

25 (Laughter.)

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1 CHAIRMAN FORD: -- Of the fluence
2 attenuation. And so the initial fluence and
3 attenuation is such that, in fact, you did pop all the
4 way through. In other words, you do have this
5 scenario?

6 MR. DICKSON: Oh, I can -- yes. I can
7 show you scenarios for where they popped through and
8 for where they don't pop through.

9 CHAIRMAN FORD: Because I keep coming back
10 to the graph that you showed originally, Ed, of what
11 is the probability of through-wall cracks. I keep
12 coming back to that one. And that's what I don't
13 want. But --

14 MEMBER SHACK: Well, this first flaw did
15 go through, I mean --

16 MR. DICKSON: The first flaw did to go
17 through.

18 MR. HACKETT: The first flaw did, it just
19 wasn't --

20 MR. DICKSON: The first flaw went through
21 every time.

22 MEMBER SHACK: Yes, it went through every
23 time. I mean it died every time.

24 CHAIRMAN FORD: Oh, I understand.

25 MR. KIRK: We just followed the axial

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1 flaws that will do that more likely.

2 CHAIRMAN FORD: Right.

3 MR. DICKSON: And the physics associated
4 with that a little bit, I don't want to get lost, is
5 for an axial flaw, the K_1 variation, the applied K_1
6 variation through the wall pretty much continues to
7 increase all the way through the wall.

8 For a circumferential flaw, it reaches a
9 maximum and turns over.

10 CHAIRMAN FORD: I guess my -- I can
11 understand what you just said. I keep coming back to
12 in February, when you're talking to the full ACRS
13 Committee.

14 MR. KIRK: Yes.

15 CHAIRMAN FORD: They're going to be
16 calibrated.

17 MR. KIRK: Right.

18 CHAIRMAN FORD: I want to see what makes
19 me go through a full wall crack and this is the piece
20 d'resistance.

21 MR. KIRK: Yes.

22 CHAIRMAN FORD: These graphs, they don't
23 show me a through the wall crack.

24 MR. HACKETT: This may be as simple as we
25 didn't show the brown shading all the way through the

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1 wall on Terry's A slide.

2 CHAIRMAN FORD: Oh.

3 MR. HACKETT: And it probably should have.
4 Or we could do that.

5 CHAIRMAN FORD: Oh, okay.

6 MR. HACKETT: Because it does go, indeed,
7 as Bill said, it goes all the way through the wall
8 every time.

9 CHAIRMAN FORD: Okay.

10 MR. KIRK: We could, I mean what we tried
11 --

12 CHAIRMAN FORD: It's a question of
13 communication.

14 MR. HACKETT: Yes.

15 MR. KIRK: Yes. What we've tried to talk
16 through is the -- I think Terry did a real good job of
17 details on the initiation part. As you can tell from
18 your questioning, not in an effort to hide anything,
19 but we've skipped many of the details --

20 CHAIRMAN FORD: Yes.

21 MR. KIRK: -- In the arrest part. If you
22 feel like that's something that you'd like to see
23 worked through later, or you'd like to have the main
24 Committee work through later, we can certainly do
25 that.

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1 CHAIRMAN FORD: No, I don't need to see.
2 I can understand what you're getting at. Again, I'm
3 moving one month ahead here and trying to think well,
4 what are we trying to convince people about in one
5 month's time?

6 MR. DICKSON: Well, we can, whatever level
7 of detail you want to see, we can provide it.

8 CHAIRMAN FORD: That's what I'm scared
9 about.

10 MR. DICKSON: We're at your service.

11 (Laughter.)

12 MR. DICKSON: Okay. Now remember, going
13 back to your chart there on page 35, we traced one
14 entry in these arrays.

15 CHAIRMAN FORD: Yes.

16 MR. DICKSON: And in the full-blown
17 analysis, we've done maybe 10,000 vessels for 50
18 transients. So we've got big arrays.

19 Now, all the PRA work of the transient
20 frequencies that you've been -- has been illustrated
21 and explained earlier, gets integrated into the
22 analysis. So this slide is an attempt to sort of show
23 kind of a full integration of those arrays that come
24 out of the PFM analysis, which contain all of the
25 knowledge of the thermal hydraulics, the fracture

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1 mechanics, and everything.

2 Now, to be integrated with these
3 frequencies of the event. So, I'll just read it. Now
4 this is a different module of FAVOR. You complete the
5 PFM analysis. You stop. And then you totally execute
6 another code, part of the FAVOR suite of codes, I
7 guess.

8 We call it the FAVOR post-processor, it
9 integrates the uncertainties of the transient
10 initiating frequencies with the results of the PFM
11 analysis which are contained in these arrays, the
12 PFMI, the PFMF that we've been discussing here, to
13 generate distributions for the frequency of RPV
14 fracture and RPV failure.

15 Usually RPV fracture is known as frequency
16 of crack initiation. You see that in the literature
17 more than you see fracture RPV failure. This is just
18 an illustration to show that we've got N transients
19 up here.

20 How do we integrate the transients with
21 the results, okay. We -- for each vessel, let's say
22 we've got 10,000 vessels, we go through and we sample
23 a value from the distribution of the initiating
24 frequencies for each of these transients, which is
25 this Step 1, which I like to think of that as kind of

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1 a row vector.

2 And then our arrays, and I like to think
3 of them as column vectors. So then we multiply these
4 times each row in the respective array to come out
5 with a value. So in other words, what you're doing is
6 you're multiplying the frequency of the event times
7 the conditional probability.

8 In units, the frequency of event is events
9 per year, conditional probability of initiation is
10 cracks per event. So what you come out with in each
11 one of these is cracks per year. Or failures per year
12 depending on which array.

13 So we do this 10,000 times if we have
14 10,000 vessels, okay, so we end up with 10,000 values,
15 or 100,000, however many we've done. Enough that we
16 can then build a histogram. In other words, we don't
17 have a single value, we have a distribution.

18 So, and this is an illustration to try to
19 illustrate that. I made this slide a long time ago.
20 And at that time, my preconceived notion -- I knew
21 there would probably be a kind of a stair step over
22 here at 0 because hopefully most of your entries are
23 going to be 0.

24 And then I thought, well, maybe it will be
25 Gaussian after that. It's not. But for Oconee, it's

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1 just a very asymmetrical distribution. There's no way
2 to describe it other than to say it's far from being
3 a Gaussian. It's just very unsymmetrical.

4 So for each one of -- so each one of those
5 arrays, each one of those values, IJ values gets
6 processed, integrated with the initiating frequencies
7 to come out with your bottom line answer. That's it.

8 MEMBER SHACK: How much difference do you
9 get between the initiation and the failure? Suppose
10 you gave away failure?

11 MR. DICKSON: Yes, I think for Ocone, I
12 think roughly an order of magnitude.

13 MEMBER SHACK: Oh, it is that much?

14 MR. DICKSON: You know, roughly, yes. I
15 mean, it might be a factor of 7, a factor of 12, I
16 don't know.

17 MEMBER SHACK: But it's not a factor of
18 .25, 25 percent?

19 MR. DICKSON: No, and it's not four levels
20 of magnitude either.

21 MR. HACKETT: I think it's an interesting
22 question, Bill, because I think that ended up more
23 than we expected. At least I'll say more than I
24 expected.

25 MEMBER SHACK: I would, off the top of my

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1 head, that seems surprisingly large.

2 MR. HACKETT: Because to simplify this
3 entire process, and I think Mark mentioned this
4 yesterday, we had contemplated the idea of making it
5 an initiation-based approach. And there's precedent
6 for that in other countries.

7 But it does look like you pick up a
8 substantial portion here in risk space when you
9 consider the arrest event.

10 MEMBER SHACK: Okay.

11 MR. HACKETT: It's an interesting point.
12 Thanks, Terry.

13 MR. DICKSON: Went five minutes over.

14 MR. HACKETT: Yes, I've got to say, it's
15 remarkably well on time. For those of you who paged
16 ahead and Mark can just go there, we made up an
17 emergency summary slide, figuring we might run into an
18 emergency, and luckily we did not.

19 CHAIRMAN FORD: I love these acronyms, by
20 gum.

21 MR. HACKETT: And now I'll say a few
22 things about this. One thing I think is to give
23 credit where it's due. Bob Hardies came up with slide
24 and Bob may not be in the room at the moment. But
25 it's too bad on the timing.

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1 Bob, this is a slide effectively that Bob
2 Hardies used to predict the way this thing would go
3 about three years ago, if I recall right, at a Water
4 Reactor Safety Meeting.

5 And basically it went along the lines that
6 are said here. He, you know, conjectured at the time.
7 Now we have some evidence, at least that we've been
8 caveating it here in a preliminary sense to say that
9 first off, I think Alan would say these transients are
10 happening a lot less frequently than they -- than we
11 thought they would.

12 In fact, they don't happen at all based on
13 since the 1980s. The operators are obviously, I think
14 Alan made a pretty convincing presentation of the fact
15 that the operators are performing a lot better and
16 previously had not been given credit for a lot of the
17 operator actions.

18 The vessel material is tougher than we
19 thought it was. Mark went into a lot of detail on
20 that.

21 And the vessel also is postulated to
22 contain generally smaller cracks although more of them
23 than we thought previously. So again, credit to Bob
24 since he's now back in the room. This is his slide
25 from years ago.

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1 And also meets the NRC plain language
2 criteria.

3 (Laughter.)

4 MR. HACKETT: If we were going to go to
5 one slide to sum up this whole day and a half, this is
6 a pretty good shot at it.

7 A couple of other comments I'd add and
8 then maybe some general discussion. We did get into -
9 - Mark raised the point yesterday in discussion with
10 Mike Mayfield. We talked about, obviously, in a need
11 for companion effort on Appendix G which governs the
12 heat up/cool down situation for the plants and the
13 pressure/temperature limits.

14 As a result of what has been happening in
15 this project, that may become more limiting or maybe
16 it is already more limiting.

17 There's a couple of interesting things
18 there though because when you look at that in
19 frequency space, obviously you've got the probability
20 of one that you're doing these things.

21 So from that perspective, it probably is
22 an inherently riskier thing because they are actually
23 doing those, you know, negotiating that space. And
24 anyone who's been through PWR training knows that
25 those people deserve a lot of credit for bringing

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1 these machines up and down the way that they do
2 because it's not an easy thing. But that is an area
3 we're going to need to pursue and a result of some of
4 the way this is turning out.

5 And I think there's going to be room to
6 make up some ground there, too, as was discussed
7 yesterday. And maybe just an aside, to me I was
8 thinking as Terry was presenting this thing, I think
9 I'm correct in saying these are taking about a week,
10 Terry? The average, if there is such a thing.

11 MR. DICKSON: One of the earlier ones did.
12 We are kind of getting smarter as we go. Maybe not
13 quite so long now.

14 MR. HACKETT: Yes, and again, Dave
15 mentioned this yesterday on the thermal hydraulics, I
16 think, Professor Mosley, you mentioned this, too. The
17 impact of computer power on this project is enormous.

18 I mean these are things that probably were
19 not doable even five or ten years ago. You know, we'd
20 be talking months, you know, to do some of these runs.
21 And now we're just, you know, we're down to days,
22 maybe weeks.

23 So it's been a huge impact on the project
24 all along. And maybe with that, just turn it to open
25 discussion since we're on, more or less on schedule.

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1 CHAIRMAN FORD: What I would like to do in
2 the next -- until we scheduled to finish at least, is
3 to first of all ask my colleagues for any comments
4 that they have about the very challenging stuff that
5 we've been hearing over the last two weeks.

6 And then for us to discuss what we will be
7 doing in February and then in the March meeting.
8 Bill, do you have any burning technical concerns or
9 comments?

10 MEMBER SHACK: No, I think it's all very,
11 very impressive. I'm still digesting here. But I
12 have no heartburn over anything.

13 CHAIRMAN FORD: Mario, I'm sorry.

14 MEMBER BONACA: No, I feel the same
15 because it's quite impressive. I had some questions
16 again regarding the first two points here. And I
17 think they were answered, you know, very convincingly
18 regarding that the fact that the operators perform
19 better than we give them credit for.

20 I mean, maybe when we gave them no credit,
21 they weren't performing so well. But today they are.
22 I mean clearly, particularly safety-oriented
23 procedures, I mean they really have gone a long way in
24 giving this kind of confidence.

25 I share the same questions that Bill had

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1 regarding that distribution at the end and I don't
2 think I understood it completely. But that's not a
3 major issue.

4 CHAIRMAN FORD: Okay, I've got a --

5 MR. WOODS: I'm sorry to interrupt. Alan
6 Kolaczowski is vital to this thing. He is -- he
7 needs to leave in order to save a whole day to get
8 back, he'd be working on this incredible schedule. If
9 anybody has any questions for him, I'd love to know
10 now. Because I really need to let him go.

11 CHAIRMAN FORD: Okay.

12 MR. WOODS: If not, certainly have no
13 prior --

14 CHAIRMAN FORD: But I don't doubt of the
15 questions in March from George and people like this.

16 MR. WOODS: Yes.

17 MR. HACKETT: I was going to say, we're
18 certainly going to want Alan to make the trip back in
19 February.

20 CHAIRMAN FORD: I've got four kind of
21 general technical questions. And I don't know the
22 answers to them. The one is given the importance of
23 this particular phenomenon, I question the use of the
24 95th percentile for the through wall cracking
25 frequency that was shown in your overall slide.

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1 And this is more from public perception
2 point of view. You know, 95th percentile is a 1σ --
3 it's not exactly, I'll put my hand on my heart.

4 MR. HACKETT: Closer to 2σ .

5 CHAIRMAN FORD: Now I've heard people,
6 yes, you're right, 2σ . But, and I recognize that you
7 don't have all the data, but there are ways around
8 that. But I don't know -- I cannot give you advice on
9 how to presume that and solve that particular
10 technical concern.

11 Another technical concern is the question
12 of RELAP5 validation and we've already discussed that.
13 And I don't doubt that there'll be a thermal
14 hydraulics -- but we'll revisit the thermal hydraulics
15 outputs from the Oregon meeting last year.

16 And another one is the validation of the
17 fluence attenuation curves. Since we don't have any
18 data on the fluence attenuation and that must effect
19 the whole question of crack arrest. These are all
20 validation questions.

21 And the final one is, and I don't know, I
22 have no experience at all on how you validate such a
23 complex interacting model methodology. I just don't
24 know how you experimentally validate it. I suppose
25 you could undergo peer review.

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1 MEMBER SHACK: You certainly don't
2 experimentally validate it.

3 CHAIRMAN FORD: Well, that right.

4 MEMBER SHACK: That's the first answer.

5 CHAIRMAN FORD: But everything I've been
6 involved with, you've been able to experimentally
7 validate. I don't know how you'd experimentally
8 validate this one. There's a question of peer review,
9 which you have done. But I don't know how extensive
10 that has been in terms of outputs from it. Whether
11 there's been dissenting opinions, people have said,
12 what a load of rubbish. I just don't know that.

13 The EPRI verification validation exercise,
14 which is about to go on, I would question, again from
15 public perception point of view, whether it isn't a
16 conflict of interest in having them do the peer
17 review.

18 But, again, I'm just voicing off the top
19 of my head, some of the concerns I have.

20 But overall, gosh, this is a fantastic
21 program. A lot of good technical challenges, and
22 especially managerial challenges. And it looks as
23 though that many of them have been overcome.

24 MR. KIRK: Yes, I'm sorry.

25 CHAIRMAN FORD: No, I was about to open it

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1 up now for discussion of where we move from, as far as
2 the ACRS is concerned.

3 MEMBER BONACA: I just had one additional
4 comment to this. The second, the third and fourth
5 bullet really have to do with certain facts that now
6 we understand better and so a better capability of the
7 vessels. First the questions again still deal with
8 the frequency of challenges.

9 And I think it would be interesting to
10 understand how they separately configured some of this
11 to this large degree because for some people, it's
12 going to be more difficult to digest the exclusion of
13 consideration of sequences. Irrespective of how low
14 a probability they may be, okay, from consideration in
15 allowing, for example, not to consider PTS a challenge
16 any more.

17 I'm talking about purely the issue of
18 defending that.

19 CHAIRMAN FORD: Yes.

20 MEMBER BONACA: And so that's not a
21 consideration enough for this study, I think this is
22 certainly appropriate that you combine also those
23 considerations in this study. And they show how they
24 all come together.

25 I'm just saying that at some point,

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1 somebody will challenge it purely on the question of
2 well, you know, it may be extremely low probability,
3 but what if, what happens? And that's the
4 traditional, old-fashioned way of defense in depth.
5 But there are a number of believes behind that. And
6 so that would be interesting to understand how
7 separate contributions are to that large degrees.

8 CHAIRMAN FORD: As far as advice to you as
9 to where we go from here, we do have scheduled a two-
10 hour presentation for the full ACRS Committee in
11 February as you mentioned Ed. I would suggest -- and
12 then a following one in March?

13 MR. HACKETT: Probably March. I guess
14 what --

15 CHAIRMAN FORD: To do with the SECY --

16 MR. HACKETT: The risk acceptance
17 criteria. The SECY paper.

18 CHAIRMAN FORD: ___ Paper. And so
19 therefore, we'll deal with the question of risk
20 aspects and what an appropriate frequency of failure
21 or how you change the screening criteria. Those
22 specific discussions will be put off until the March
23 meeting.

24 So the February meeting, I think, should
25 essentially concentrate on what we've discussed in the

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1 last day and a half. And how you compress a day and
2 a half's very detailed information into two hours, I'm
3 not too sure.

4 But what I would suggest is that there
5 will be some questions on the PRA and the thermal
6 hydraulics which we'll have Graham Wallis and have
7 George Apostolakis here. We will get areas from that
8 area.

9 I don't know that you need to stress quite
10 so much the stuff that you all did in terms of the
11 developments that have gone on, the stuff that you
12 gave yesterday because essentially Bill and I have
13 heard that.

14 So what I would suggest is maybe the first
15 hour concentrating on just an overview from you Ed
16 followed by the advancements that have gone on thermal
17 hydraulics, PRA, and the PFM areas. And then the last
18 hour, essentially redo what you've done today on the
19 example and finishing off with Oconee. Because that
20 thing on Oconee is, to me, very, very impressive.

21 Now that's a big --

22 MR. KIRK: And do it in two hours.

23 CHAIRMAN FORD: What?

24 MR. KIRK: And do it in two hours?

25 CHAIRMAN FORD: And do it in two hours.

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1 MR. HACKETT: It's called the zip
2 presentation.

3 (Laughter.)

4 CHAIRMAN FORD: Well, this is the problem,
5 you've got so much to present.

6 MR. WOODS: Can we have zip questions?

7 CHAIRMAN FORD: Yes.

8 MR. WOODS: I would steal George's
9 questions, too.

10 MEMBER BONACA: One other possibility
11 would be maybe just I'm trying to deal with this
12 tightness of time. The example is extremely
13 interesting. And I wonder if one could conceive a
14 presentation that's totally centered on the example
15 with windows on some of the issues that are, like for
16 example, uncertainty. Okay? There were a couple of
17 slides on uncertainties.

18 And the bottom line of those, one could
19 pull out during the example and say, these are the,
20 you know, and then see how -- I don't know. I'm just
21 brainstorming here to see if there is an alternative.

22 CHAIRMAN FORD: Well, the output from the
23 meeting is going to be a letter, which letter I assume
24 is going to be well done, keep going, we see where
25 you're going and it is appropriate.

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1 And they undoubtedly will come up with
2 some technical suggestions. But that's what you're
3 looking for. And so you've got to give them enough
4 information that they can write that letter.

5 MR. HACKETT: Right. Like you said, it's
6 going to be a challenge. I'm thinking, give them --
7 I like your idea for the broad outline, given the fact
8 that George and Dana and Graham and others will not
9 have heard this particular part of the story.

10 CHAIRMAN FORD: Correct.

11 MR. HACKETT: So they may need a little
12 bit of entree into it.

13 CHAIRMAN FORD: Correct.

14 MR. HACKETT: And that's going to be kind
15 of an art on our part to do that and stay within the
16 time constraint. But we'll just, you know, take the
17 best shot at it.

18 Maybe if you would like, we could, you
19 know, in the interest of making sure you're going to
20 get what you need, we could draft this thing up and do
21 what we did before, you know, with this presentation.

22 CHAIRMAN FORD: Yes.

23 MR. HACKETT: Come down and show you, in
24 advance, this is the way we're intending to do this
25 and does that look okay?

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1 CHAIRMAN FORD: Yes.

2 MR. HACKETT: And we should be ready,
3 thanks to this presentation, we shouldn't have as much
4 prep to do for that other than, you know, it's
5 obviously harder to be brief. But if we can come
6 down, you know, the week beforehand possibly which is?

7 It isn't next week, is it? It's soon.

8 (Laughter.)

9 MR. HACKETT: I don't want to commit to
10 something crazy here. But, you know, soon. We'd come
11 down and do that. And maybe that's with some subset
12 of the Committee or at least yourself.

13 CHAIRMAN FORD: Yes.

14 MR. HACKETT: And maybe George, if he's
15 available, and Graham since they haven't heard it.

16 CHAIRMAN FORD: Yes, I think between the
17 three of us actually, since we know what you've got to
18 present, we can probably give you the best advice as
19 you bring on that general outline with the last hour
20 being on the example.

21 MR. HACKETT: Okay.

22 CHAIRMAN FORD: And just saying --

23 MEMBER SHACK: I'd have done more with
24 Mario. I'd show viewgraph 6 and 7 would be my
25 overview.

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1 CHAIRMAN FORD: Okay.

2 MR. HACKETT: Yes.

3 MEMBER SHACK: And then go right to the
4 example would be sort of my --

5 CHAIRMAN FORD: Just go to the example.

6 MEMBER SHACK: Yes, 6 and 7 sort of give
7 you a quick view of what's changed.

8 CHAIRMAN FORD: Okay, fine.

9 MEMBER SHACK: And where we've ended up.

10 MR. HACKETT: And then a more condensed
11 version of the example?

12 MEMBER SHACK: Yes, even with an hour and
13 forty-five minutes for the example, I think you're
14 going to be --

15 MR. HACKETT: Challenged?

16 MEMBER SHACK: Okay, hard pressed but --

17 MEMBER BONACA: Also, the example gives
18 you the opportunity for pulling out occasionally some
19 of the critical --

20 MEMBER SHACK: Expanding, right?

21 MEMBER BONACA: Well, no. I mean, you'll
22 get questions and you'll have the answers right in
23 some exhibits. And I'm sure probable certainties will
24 be one that says, you know, what are you putting on
25 the epistemic and aleatory?

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1 And you have something you can provide
2 from the overall presentation. But that way you go
3 selectively rather than having the burden of selecting
4 ahead of time. You do have the material. You just
5 pull it out. And speak to it.

6 I don't know. I just -- there are many
7 ways. I agree with you that there have to be --

8 CHAIRMAN FORD: But surely -- oh, okay
9 then, leave out, you know, the details of the stuff
10 you do on materials and stuff like that in the first
11 two days. Just start with your very -- just two
12 graphs.

13 MR. HACKETT: Maybe we should even start
14 with this slide.

15 (Laughter.)

16 MR. HACKETT: At the risk of really
17 winding people up.

18 CHAIRMAN FORD: But recognize that George
19 was the original instigator of this particular
20 meeting.

21 MR. HACKETT: Right.

22 CHAIRMAN FORD: And he wanted an example
23 given of Oconee. So I think we'd better end up with
24 the Oconee.

25 MR. HACKETT: I actually have that.

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1 CHAIRMAN FORD: Go through the example
2 methodology that you've just done for the last couple
3 of hours. And then finish off with maybe two graphs
4 on specific information.

5 MR. HACKETT: That's the problem.

6 MEMBER BONACA: This, you know, is such an
7 exciting project because I mean the point was made,
8 you know, only because we have the tools we have
9 today, calculational tools, we can do this kind of
10 stuff.

11 It is actually an example of how all
12 things come together here, it's unfortunate that we
13 have only two hours to jam it through for the whole
14 Committee. It is to serve the whole Committee.

15 CHAIRMAN FORD: I suspect, quite honestly
16 I suspect that as this thing moves forward, if you do
17 Palisades and Beaver Valley is it, Beaver --

18 MR. HACKETT: Beaver Valley.

19 CHAIRMAN FORD: Beaver Valley, and then
20 Calvert Cliffs, you know, we're going to have other
21 meetings.

22 MR. HACKETT: Oh yes.

23 MEMBER BONACA: I think we have to have a
24 meeting like this at some point for the whole
25 Committee because the whole Committee is going to be

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1 interested to learn more. And it's impossible to go
2 through this in two hours.

3 MR. HACKETT: Yes.

4 MEMBER BONACA: I think it was difficult
5 to go through that in a day and a half.

6 MR. HACKETT: Maybe as an aside, too, I
7 took away an action item as a note here that if the
8 Committee would desire this, I know it's been a while
9 since our branch has sort of brought before you guys
10 the whole program we have on advanced fracture
11 mechanics and what's going on that area.

12 We had a significant diversion yesterday
13 talking about activities related to the master curve
14 and there's been a lot of action in that area. It's
15 been an awful long time since we talked to the
16 Committee about that.

17 So that may be another presentation we'll
18 volunteer in the next six months somewhere. And go
19 ahead and do that. I think the last time we did it
20 was either myself or Mike Mayfield several years ago.
21 And so it's probably more than overdue.

22 CHAIRMAN FORD: I cannot perceive,
23 conceive rather, that something of this importance
24 they're just going to have this meeting and then one
25 in the fall. I just don't see it. Okay, any other

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1 questions?

2 MR. BESSETTE: Just from the material that
3 I've sent out to you, what material do you feel the
4 other members would get the most utility out of
5 receiving in the next week?

6 CHAIRMAN FORD: I don't think they need
7 this package.

8 MR. BESSETTE: Okay.

9 MEMBER BONACA: What about the
10 presentation?

11 MEMBER SHACK: No, I think the
12 presentation, package is what they really need.

13 CHAIRMAN FORD: Yes.

14 MEMBER BONACA: They should look at that.

15 MR. BESSETTE: Okay.

16 CHAIRMAN FORD: And so they'll be given
17 less than this during the presentation, obviously.
18 But they know there's a heck of a lot of background.

19 MEMBER BONACA: And maybe, you know,
20 what's suggested would be when you send it out, when
21 you write giving a preview of the presentation, if you
22 can get from the presenters what they're going to do,
23 you know, present of this package, to focus on, that
24 would also help them in what review to look at and how
25 to tie things together.

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1 You may, for example, end up saying the
2 presentation will be centered around the example with,
3 you know, that kind of information would help them.

4 CHAIRMAN FORD: Okay, any other comments?

5 MR. HACKETT: Just thanks for bearing with
6 us through a day and a half of this.

7 CHAIRMAN FORD: Actually this is one of
8 the more exciting meetings -- presentations I've heard
9 in the last year. Thanks very much indeed.

10 MR. HACKETT: Thank you.

11 CHAIRMAN FORD: This meeting is now
12 adjourned.

13 (Whereupon, this meeting went off the
14 record at 11:44 a.m.)

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