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NUCLEAR REGULATORY COMMISSION

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MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

SUBCOMMITTEE ON MATERIALS AND METALLURGY

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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

ALSO PRESENT:

EDWIN HACKETT

SHAH MALIK

MARK KIRK

DAVID BESSETTE

ALAN KOLACZKOWSKI

ALI MOSLEH

JACK ROSENTHAL

TERRY DICKSON

BRUCE BISHOP

FRED SIMONEN (on the phone)

ROY WOODS

I-N-D-E-X

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 Oconee 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CHAIRMAN FORD: Good.

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

CHAIRMAN FORD: Excellent.

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

CHAIRMAN FORD: Probably 5 minutes.

MR. HACKETT: Okay.

(Laughter.)

MR. HACKETT: Oh, and there are slides?

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

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

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

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

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

MR. KOLACZKOWSKI: I understand.

MEMBER BONACA: Yes, thank you.

CHAIRMAN FORD: Dave Bessette.

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

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

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

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

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

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

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

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

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

CHAIRMAN FORD: Okay.

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

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

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

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

MR. BESSETTE: This facility is an

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

CHAIRMAN FORD: Okay.

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

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

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

CHAIRMAN FORD: Okay.

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

MR. BESSETTE: Same way.

MEMBER BONACA: Yes.

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

MEMBER BONACA: Okay.

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

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

CHAIRMAN FORD: Yes.

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

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

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

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

MEMBER BONACA: Oh, okay.

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

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

MR. BESSETTE: It gave better agreement.

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

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

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

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

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

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

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

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

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

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

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

PFM model.

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

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

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

CHAIRMAN FORD: Yes.

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

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

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

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

of the validation of the code.

CHAIRMAN FORD: Yes.

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

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

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

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

CHAIRMAN FORD: Right.

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

And we did sensitivity studies to see how

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

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

CHAIRMAN FORD: Yes.

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

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

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

MR. BESSETTE: You know --

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

MR. BESSETTE: No.

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

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

MR. BESSETTE: See what, yes --

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

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

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

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

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

actions and the plant controls.

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

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

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

CHAIRMAN FORD: Yes.

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

CHAIRMAN FORD: Right.

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

obviously like this comparison with the APEX tests.

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

CHAIRMAN FORD: Oh, absolutely, yes.

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

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

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

MR. HACKETT: Okay, that sounds good.

CHAIRMAN FORD: Right.

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

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

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

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

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

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

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

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

MR. HACKETT: Okay.

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

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

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

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

MR. BESSETTE: Okay.

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

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

MR. KOLACZKOWSKI: Okay.

MR. HACKETT: Alan?

MR. KOLACZKOWSKI: Okay.

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

oversight previously.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

I will, at an appropriate point in here

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MEMBER BONACA: I understand, I understand.

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

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

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

MEMBER BONACA: Oh, these are safety release.

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

MEMBER BONACA: Okay. I understand.

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

MEMBER BONACA: Right.

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

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

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

MEMBER BONACA: Yes, okay.

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

MEMBER BONACA: All right.

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

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

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

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

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

MR. MALIK: 36.

MR. KOLACZKOWSKI: What was that? It was

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

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

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

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

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

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

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

bin 41.

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

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

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

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

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

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

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

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

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

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

And, for the most part, the primary has

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

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

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

So while it is a non-conservative binning,

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

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

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

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

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

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

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

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

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

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

And so for the time being, whether he

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

Any questions to this point?

(No response.)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

the procedure.

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

Next slide.

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

MR. KOLACZKOWSKI: He could.

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

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

MEMBER BONACA: That's right.

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

And that's a key parameter that will tell

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

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

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

MEMBER BONACA: Okay.

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

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

MEMBER BONACA: Okay.

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

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

the PORV block valve and so on and so forth.

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

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

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

MEMBER BONACA: Good.

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

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

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

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

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

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

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

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

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

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

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

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

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

MEMBER BONACA: Okay.

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

MEMBER BONACA: Yes.

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

MEMBER BONACA: Okay.

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

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

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

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

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

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

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

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

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

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

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

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

down event going on on the secondary side.

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

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

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

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

excessive demand going on over there.

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

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

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

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

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

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

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

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

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

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

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

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

until we get about 10 minutes into the scenario.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

And then .001, that the failure's extremely unlikely. So in other words, we never put into the model a human error probability less than 10⁻

^{3} in terms of a mean value.

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

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

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

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

Questions on that?

(No response.)

MR. KOLACZKOWSKI: Okay, next slide.

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

CHAIRMAN FORD: Okay.

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

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

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

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

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

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

MR. HACKETT: Okay.

MR. KOLACZKOWSKI: Okay, coming back to

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

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

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

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

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

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

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

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

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

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

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

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

And now bin 41's frequency has been

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

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

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

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

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

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

we're going to look at.

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

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

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

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

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

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

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

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

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

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

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

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

And the valve full open would be 1.8

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

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

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

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

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

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

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

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

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

When you go through that process, then

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

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

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

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

Questions on that?

(No response.)

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

MR. HACKETT: Sounds good.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

So you get the average impact on a single

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

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

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

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

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

The base frequency coming from PRA

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

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

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

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

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

consider.

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

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

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

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

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

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

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

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

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

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

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

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

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

CHAIRMAN FORD: Thank you.

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

CHAIRMAN FORD: Good.

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

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

MR. MOSLEH: Yes.

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

finally ended to match those temperatures?

MR. MOSLEH: Right. Right.

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

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

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

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

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

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

CHAIRMAN FORD: Good.

MR. HACKETT: It should be okay.

CHAIRMAN FORD: Good. Okay.

MR. ROSENTHAL: Just before we break, my

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

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

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

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

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

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

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

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

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

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

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

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

CHAIRMAN FORD: Okay.

MR. ROSENTHAL: If you're expecting any

more than that, please let us know.

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

MR. ROSENTHAL: Sure.

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

MR. ROSENTHAL: Right.

CHAIRMAN FORD: -- In the input.

MR. ROSENTHAL: Right.

CHAIRMAN FORD: That was all my concern was.

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

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

Because those are not tests, experiments,

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

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

MR. ROSENTHAL: Right.

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

CHAIRMAN FORD: Okay. Thank you, Jack.

MR. HACKETT: Thanks Jack.

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

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

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

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

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

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

MR. HACKETT: Right.

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

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

MR. KIRK: Okay.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

So it's a two dimensional array where the IJ entry is the conditional probability of initiation of the J^{TH} vessel subjected to the I^{TH} transient, if you will.

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

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

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

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

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

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

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

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

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

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

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

CHAIRMAN FORD: Right.

MR. KIRK: Yes.

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

MR. KIRK: NDE.

MEMBER BONACA: NDE.

MR. KIRK: Or NDENDE?

MR. DICKSON: NDE.

MEMBER BONACA: It's NDE.

MR. KIRK: Okay.

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

MR. DICKSON: Yes.

MR. HACKETT: You're just showing this as

an illustration.

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

MR. HACKETT: Okay.

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

(Laughter.)

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

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

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

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

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

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

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

MR. KIRK: Yes, that's correct.

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

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

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

just one of them chosen at random.

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

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

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

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

MR. DICKSON: No.

MEMBER SHACK: If you only do a thousand cases.

MR. DICKSON: No, no.

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

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

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

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

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

MR. DICKSON: Yes.

MEMBER SHACK: Okay.

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

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

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

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

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

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

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

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

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

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

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

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

MR. DICKSON: Okay.

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

MR. DICKSON: Okay, I'm sorry.

MR. KIRK: Bruce?

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

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

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

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

CHAIRMAN FORD: Oh.

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

CHAIRMAN FORD: Okay.

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

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

CHAIRMAN FORD: Right.

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

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

just what you calculate.

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

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

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

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

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

MR. HACKETT: Terry?

MR. DICKSON: Yes.

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

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

MR. DICKSON: Okay.

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

MR. DICKSON: No.

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

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

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

They're going to assume that they interact.

CHAIRMAN FORD: Oh.

MR. HACKETT: And the way they do that is

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

CHAIRMAN FORD: Okay.

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

CHAIRMAN FORD: Okay.

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

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

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

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

CHAIRMAN FORD: Okay.

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

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

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

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

CHAIRMAN FORD: Okay.

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

more like 10^{-5}.

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

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

MR. KIRK: You need the mic, Bruce.

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

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

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

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

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

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

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

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

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

unirradiated for this Flaw No. 1. Okay?

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

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

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

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

CHAIRMAN FORD: Yes.

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

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

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

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

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

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

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

You know you cool down and just probably

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

Okay, now there's several points I'm going to try to make with this slide. The conditional probability of initiation for each flaw is calculated by solving the Weibull cumulative distribution function for K_{1c} or fracture initiation toughness for the fractional part or fractile of the distribution that corresponds to the applied K_1.

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

Okay, this second graphic shows here is a time history of the applied K_1 for subject flaw. This red curve. This black curve coming down here, it's the Weibull location parameter A. And a physical interpretation of that parameter is that's the lowest value of K_{1c} that can exist. It's the bottom of the distribution.

So what we're interested in here is does

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

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

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

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

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

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

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

(Laughter.)

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

MR. KIRK: Yes.

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

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

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

CHAIRMAN FORD: Yes.

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

CHAIRMAN FORD: Right.

MR. DICKSON: Then, when you get ready to

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

CHAIRMAN FORD: Okay.

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

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

MR. DICKSON: Yes, right now.

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

MR. DICKSON: Yes.

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

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

CHAIRMAN FORD: Oh.

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

(Laughter.)

CHAIRMAN FORD: More detail?

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

MR. KIRK: And this is too detail.

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

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

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

(Laughter.)

CHAIRMAN FORD: Okay.

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

Initiation, CPI --

CHAIRMAN FORD: Yes.

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

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

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

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

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

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

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

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

MR. KIRK: Terry?

MR. DICKSON: Yes?

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

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

MR. KIRK: Okay.

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

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

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

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

MEMBER SHACK: All right.

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

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

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

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

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

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

done on this circ. flaw.

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

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

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

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

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

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

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

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

(No response.)

MR. DICKSON: So this is the instantaneous CPI. This is the ΔCPI.

MEMBER SHACK: Okay.

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

axially-oriented flaw.

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

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

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

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

Okay. Does that answer your question at all?

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

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

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

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

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

MEMBER SHACK: Yes.

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

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

Because, you know, if it has failed, the

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

CHAIRMAN FORD: Right.

MR. HACKETT: Right.

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

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

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

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

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

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

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

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

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

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

MR. DICKSON: Okay.

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

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

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

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

(No response.)

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

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

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

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

MR. DICKSON: Right. Okay, but --

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

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

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

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

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

MEMBER SHACK: Right.

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

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

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

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

MR. KIRK: Well, all right, okay.

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

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

MEMBER SHACK: Yes, okay.

MR. DICKSON: Is my way of expressing it.

MR. KIRK: We do 100 arrest trials --

MR. DICKSON: For each time step.

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

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

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

MR. KIRK: There is one more.

MR. DICKSON: Okay.

MR. KIRK: On unembedded flaws.

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

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

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

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

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

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

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

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

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

And perhaps that's got a little bit of conservatism associated with it. The assumption is that you have a flaw that's propagating, it's getting longer so it's getting to be a larger K_1 and it's propagating into a decreasing resistance field.

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

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

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

MR. KIRK: No, you got one more.

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

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

CHAIRMAN FORD: I'm sorry.

MR. DICKSON: Okay.

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

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

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

MR. DICKSON: Yes.

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

MR. DICKSON: Yes.

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

MR. DICKSON: That's correct, yes.

CHAIRMAN FORD: Okay.

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

surface.

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

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

CHAIRMAN FORD: Yes.

MR. DICKSON: To the outside?

CHAIRMAN FORD: Yes.

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

CHAIRMAN FORD: Yes.

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

CHAIRMAN FORD: All right.

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

CHAIRMAN FORD: Sure.

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

CHAIRMAN FORD: Sure.

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

CHAIRMAN FORD: Sure.

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

CHAIRMAN FORD: Yes.

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

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

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

(Laughter.)

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

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

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

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

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

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

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

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

CHAIRMAN FORD: Oh, I understand.

MR. KIRK: We just followed the axial

flaws that will do that more likely.

CHAIRMAN FORD: Right.

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

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

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

MR. KIRK: Yes.

CHAIRMAN FORD: They're going to be calibrated.

MR. KIRK: Right.

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

MR. KIRK: Yes.

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

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

wall on Terry's A slide.

CHAIRMAN FORD: Oh.

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

CHAIRMAN FORD: Oh, okay.

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

CHAIRMAN FORD: Okay.

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

CHAIRMAN FORD: It's a question of communication.

MR. HACKETT: Yes.

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

CHAIRMAN FORD: Yes.

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

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

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

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

MR. DICKSON: We're at your service.

(Laughter.)

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

CHAIRMAN FORD: Yes.

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

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

mechanics, and everything.

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

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

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

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

a row vector.

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

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

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

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

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

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

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

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

MR. DICKSON: Yes, I think for Oconee, I think roughly an order of magnitude.

MEMBER SHACK: Oh, it is that much?

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

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

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

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

MEMBER SHACK: I would, off the top of my

head, that seems surprisingly large.

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

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

MEMBER SHACK: Okay.

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

MR. DICKSON: Went five minutes over.

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

CHAIRMAN FORD: I love these acronyms, by gum.

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

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

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

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

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

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

And also meets the NRC plain language criteria.

(Laughter.)

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

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

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

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

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

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

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

MR. DICKSON: One of the earlier ones did. We are kind of getting smarter as we go. Maybe noy quite so long now.

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

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

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

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

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

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

CHAIRMAN FORD: Mario, I'm sorry.

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

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

I share the same questions that Bill had

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

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

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

CHAIRMAN FORD: Okay.

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

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

MR. WOODS: Yes.

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

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

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

MR. HACKETT: Closer to 2σ.

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

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

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

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

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

CHAIRMAN FORD: Well, that right.

MEMBER SHACK: That's the first answer.

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

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

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

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

MR. KIRK: Yes, I'm sorry.

CHAIRMAN FORD: No, I was about to open it

up now for discussion of where we move from, as far as the ACRS is concerned.

MEMBER BONACA: I just had one additional comment to this. The second, the third and fourth bullet really have to do with certain facts that now we understand better and so a better capability of the vessels. First the questions again still deal with the frequency of challenges.

And I think it would be interesting to understand how they separately configured some of this to this large degree because for some people, it's going to be more difficult to digest the exclusion of consideration of sequences. Irrespective of how low a probability they may be, okay, from consideration in allowing, for example, not to consider PTS a challenge any more.

I'm talking about purely the issue of defending that.

CHAIRMAN FORD: Yes.

MEMBER BONACA: And so that's not a consideration enough for this study, I think this is certainly appropriate that you combine also those considerations in this study. And they show how they all come together.

I'm just saying that at some point,

somebody will challenge it purely on the question of well, you know, it may be extremely low probability, but what if, what happens? And that's the traditional, old-fashioned way of defense in depth. But there are a number of believes behind that. And so that would be interesting to understand how separate contributions are to that large degrees.

CHAIRMAN FORD: As far as advice to you as to where we go from here, we do have scheduled a two-hour presentation for the full ACRS Committee in February as you mentioned Ed. I would suggest -- and then a following one in March?

MR. HACKETT: Probably March. I guess what --

CHAIRMAN FORD: To do with the SECY --

MR. HACKETT: The risk acceptance criteria. The SECY paper.

CHAIRMAN FORD: __ Paper. And so therefore, we'll deal with the question of risk aspects and what an appropriate frequency of failure or how you change the screening criteria. Those specific discussions will be put off until the March meeting.

So the February meeting, I think, should essentially concentrate on what we've discussed in the

last day and a half. And how you compress a day and a half's very detailed information into two hours, I'm not too sure.

But what I would suggest is that there will be some questions on the PRA and the thermal hydraulics which we'll have Graham Wallis and have George Apostolakis here. We will get areas from that area.

I don't know that you need to stress quite so much the stuff that you all did in terms of the developments that have gone on, the stuff that you gave yesterday because essentially Bill and I have heard that.

So what I would suggest is maybe the first hour concentrating on just an overview from you Ed followed by the advancements that have gone on thermal hydraulics, PRA, and the PFM areas. And then the last hour, essentially redo what you've done today on the example and finishing off with Oconee. Because that thing on Oconee is, to me, very, very impressive.

Now that's a big --

MR. KIRK: And do it in two hours.

CHAIRMAN FORD: What?

MR. KIRK: And do it in two hours?

CHAIRMAN FORD: And do it in two hours.

MR. HACKETT: It's called the zip presentation.

(Laughter.)

CHAIRMAN FORD: Well, this is the problem, you've got so much to present.

MR. WOODS: Can we have zip questions?

CHAIRMAN FORD: Yes.

MR. WOODS: I would steal George's questions, too.

MEMBER BONACA: One other possibility would be maybe just I'm trying to deal with this tightness of time. The example is extremely interesting. And I wonder if one could conceive a presentation that's totally centered on the example with windows on some of the issues that are, like for example, uncertainty. Okay? There were a couple of slides on uncertainties.

And the bottom line of those, one could pull out during the example and say, these are the, you know, and then see how -- I don't know. I'm just brainstorming here to see if there is an alternative.

CHAIRMAN FORD: Well, the output from the meeting is going to be a letter, which letter I assume is going to be well done, keep going, we see where you're going and it is appropriate.

And they undoubtedly will come up with some technical suggestions. But that's what you're looking for. And so you've got to give them enough information that they can write that letter.

MR. HACKETT: Right. Like you said, it's going to be a challenge. I'm thinking, give them -- I like your idea for the broad outline, given the fact that George and Dana and Graham and others will not have heard this particular part of the story.

CHAIRMAN FORD: Correct.

MR. HACKETT: So they may need a little bit of entree into it.

CHAIRMAN FORD: Correct.

MR. HACKETT: And that's going to be kind of an art on our part to do that and stay within the time constraint. But we'll just, you know, take the best shot at it.

Maybe if you would like, we could, you know, in the interest of making sure you're going to get what you need, we could draft this thing up and do what we did before, you know, with this presentation.

CHAIRMAN FORD: Yes.

MR. HACKETT: Come down and show you, in advance, this is the way we're intending to do this and does that look okay?

CHAIRMAN FORD: Yes.

MR. HACKETT: And we should be ready, thanks to this presentation, we shouldn't have as much prep to do for that other than, you know, it's obviously harder to be brief. But if we can come down, you know, the week beforehand possibly which is?

It isn't next week, is it? It's soon.

(Laughter.)

MR. HACKETT: I don't want to commit to something crazy here. But, you know, soon. We'd come down and do that. And maybe that's with some subset of the Committee or at least yourself.

CHAIRMAN FORD: Yes.

MR. HACKETT: And maybe George, if he's available, and Graham since they haven't heard it.

CHAIRMAN FORD: Yes, I think between the three of us actually, since we know what you've got to present, we can probably give you the best advice as you bring on that general outline with the last hour being on the example.

MR. HACKETT: Okay.

CHAIRMAN FORD: And just saying --

MEMBER SHACK: I'd have done more with Mario. I'd show viewgraph 6 and 7 would be my overview.

CHAIRMAN FORD: Okay.

MR. HACKETT: Yes.

MEMBER SHACK: And then go right to the example would be sort of my --

CHAIRMAN FORD: Just go to the example.

MEMBER SHACK: Yes, 6 and 7 sort of give you a quick view of what's changed.

CHAIRMAN FORD: Okay, fine.

MEMBER SHACK: And where we've ended up.

MR. HACKETT: And then a more condensed version of the example?

MEMBER SHACK: Yes, even with an hour and forty-five minutes for the example, I think you're going to be --

MR. HACKETT: Challenged?

MEMBER SHACK: Okay, hard pressed but --

MEMBER BONACA: Also, the example gives you the opportunity for pulling out occasionally some of the critical --

MEMBER SHACK: Expanding, right?

MEMBER BONACA: Well, no. I mean, you'll get questions and you'll have the answers right in some exhibits. And I'm sure probable certainties will be one that says, you know, what are you putting on the epistemic and aleatory?

And you have something you can provide from the overall presentation. But that way you go selectively rather than having the burden of selecting ahead of time. You do have the material. You just pull it out. And speak to it.

I don't know. I just -- there are many ways. I agree with you that there have to be --

CHAIRMAN FORD: But surely -- oh, okay then, leave out, you know, the details of the stuff you do on materials and stuff like that in the first two days. Just start with your very -- just two graphs.

MR. HACKETT: Maybe we should even start with this slide.

(Laughter.)

MR. HACKETT: At the risk of really winding people up.

CHAIRMAN FORD: But recognize that George was the original instigator of this particular meeting.

MR. HACKETT: Right.

CHAIRMAN FORD: And he wanted an example given of Oconee. So I think we'd better end up with the Oconee.

MR. HACKETT: I actually have that.

CHAIRMAN FORD: Go through the example methodology that you've just done for the last couple of hours. And then finish off with maybe two graphs on specific information.

MR. HACKETT: That's the problem.

MEMBER BONACA: This, you know, is such an exciting project because I mean the point was made, you know, only because we have the tools we have today, calculational tools, we can do this kind of stuff.

It is actually an example of how all things come together here, it's unfortunate that we have only two hours to jam it through for the whole Committee. It is to serve the whole Committee.

CHAIRMAN FORD: I suspect, quite honestly I suspect that as this thing moves forward, if you do Palisades and Beaver Valley is it, Beaver --

MR. HACKETT: Beaver Valley.

CHAIRMAN FORD: Beaver Valley, and then Calvert Cliffs, you know, we're going to have other meetings.

MR. HACKETT: Oh yes.

MEMBER BONACA: I think we have to have a meeting like this at some point for the whole Committee because the whole Committee is going to be

interested to learn more. And it's impossible to go through this in two hours.

MR. HACKETT: Yes.

MEMBER BONACA: I think it was difficult to go through that in a day and a half.

MR. HACKETT: Maybe as an aside, too, I took away an action item as a note here that if the Committee would desire this, I know it's been a while since our branch has sort of brought before you guys the whole program we have on advanced fracture mechanics and what's going on that area.

We had a significant diversion yesterday talking about activities related to the master curve and there's been a lot of action in that area. It's been an awful long time since we talked to the Committee about that.

So that may be another presentation we'll volunteer in the next six months somewhere. And go ahead and do that. I think the last time we did it was either myself or Mike Mayfield several years ago. And so it's probably more than overdue.

CHAIRMAN FORD: I cannot perceive, conceive rather, that something of this importance they're just going to have this meeting and then one in the fall. I just don't see it. Okay, any other

questions?

MR. BESSETTE: Just from the material that I've sent out to you, what material do you feel the other members would get the most utility out of receiving in the next week?

CHAIRMAN FORD: I don't think they need this package.

MR. BESSETTE: Okay.

MEMBER BONACA: What about the presentation?

MEMBER SHACK: No, I think the presentation, package is what they really need.

CHAIRMAN FORD: Yes.

MEMBER BONACA: They should look at that.

MR. BESSETTE: Okay.

CHAIRMAN FORD: And so they'll be given less than this during the presentation, obviously. But they know there's a heck of a lot of background.

MEMBER BONACA: And maybe, you know, what's suggested would be when you send it out, when you write giving a preview of the presentation, if you can get from the presenters what they're going to do, you know, present of this package, to focus on, that would also help them in what review to look at and how to tie things together.

You may, for example, end up saying the presentation will be centered around the example with, you know, that kind of information would help them.

CHAIRMAN FORD: Okay, any other comments?

MR. HACKETT: Just thanks for bearing with us through a day and a half of this.

CHAIRMAN FORD: Actually this is one of the more exciting meetings -- presentations I've heard in the last year. Thanks very much indeed.

MR. HACKETT: Thank you.

CHAIRMAN FORD: This meeting is now adjourned.

(Whereupon, this meeting went off the record at 11:44 a.m.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: ACRS Materials and Metallurgy Subcommittee

Docket Number: (Not Applicable)

Location: Rockville, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Pippa Antonio

Pippa Antonio
Official Reporter
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