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U.S. NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON
REACTOR SAFEGUARDS

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MATERIALS AND METALLURGY AND
PLANT OPERATIONS SUBCOMMITTEES

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TUESDAY,
APRIL 22, 2003

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The Subcommittees met at 8:30 a.m. in Room OG16, One White Flint North, 11545 Rockville Pike, Rockville, Maryland, F. Peter Ford and John D. Sieber, Co-Chairmen, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

F. PETER FORD, Co-Chairman
JOHN D. SIEBER, Co-Chairman
THOMAS S. KRESS
DANA A. POWERS
STEPHEN L. ROSEN
WILLIAM J. SHACK
GRAHAM B. WALLIS

NRC STAFF PRESENT:

MAGGALEAN WESTON, Staff Engineer
ALAN HISER, RES
RICHARD BARRETT, NRR
WILLIAM CULLEN, JR., RES

ALSO PRESENT:

LARRY MATHEWS, Southern Nuclear
TOM ALLEY, Duke Energy
ALEX MARION, NEI
DAVID STEININGER

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

(8:33 a.m.)

CO-CHAIRMAN FORD: Good morning. The meeting will now come to order.

This is a two-day meeting of the ACRS Joint Subcommittees on Materials and Metallurgy and on Plant Operations.

I'm Peter Ford, Chairman of the Materials and Metallurgy Subcommittee. My Co-Chair is Jack Sieber, Chairman of the Plant Operations Subcommittee.

ACRS members in attendance are Thomas Kress, Dana Powers, Steve Rosen, Bill shack, and Graham Wallis.

The purpose of this meeting is to discuss the vessel head penetration cracking and RPV head degradation issues. We've had a number of full committee and subcommittee meetings on these issues over the last couple of years.

The subcommittee will gather information, analyze relevant issues and facts, and formally propose positions and actions as appropriate for deliberation by the full committee.

Maggalean W. Weston is the cognizant ACRS staff engineer for this meeting.

The rules for participation in today's

meeting have been announced as a part of the notice of this meeting published in the Federal Register on April the 4th, 2003.

The transcript of the meeting is being kept and will be made available as stated in the Federal Register notice.

It's requested that speakers use one of the microphones available, identify themselves, and speak with sufficient clarity and volume that they may be readily heard.

We have received no written comments from members of the public regarding today's meeting.

This whole topic of the VHP degradation issues has been the subject of two bulletins and one order in the last couple of years. It covers a wide range of degradation phenomena, cracking, boric acid corrosion, and inspection methods and strategy, and repair/replacement decisions, plus the associated understanding of the various physical phenomena.

We have raised questions at various meetings and/or communications relating to, for instance, adequacy of crack prediction, inspection prioritization, algorithms for Alloy 600 and 182; prediction and, therefore, management of boric acid corrosion in VHP assemblies; factors of improvement for replacement Alloy 690 and its relevance; qualification of the inspection methods and its application periodicity; the review of the safety analysis; and also the impact of VHP observations on cracking of other components, for instance, pressurizers for the bottom head penetrations for PWRs and BWRs.

Now, I hope that many of these issues will be discussed at this meeting.

Jack, do you have any comments at this stage?

MR. POWERS: Has the NRC budget been cut so badly that we can't afford lights?

(Laughter.)

CO-CHAIRMAN FORD: Can we deal with that?

Actually it is rather dark in here.

MS. WESTON: I think he cut them off because of the screen.

CO-CHAIRMAN FORD: Ah, okay.

MR. SHACK: What you need is darkness and speak very softly.

CO-CHAIRMAN FORD: Okay. Could you just experiment with the lights?

Okay. We'll now proceed with the meeting, and I'll ask Richard Barrett of the NRR to start off.

Sorry. We will turn around.

MR. BARRETT: This is all very new. We don't know where to stand or where to sit.

CO-CHAIRMAN FORD: That's right.

MR. BARRETT: Hopefully we know what to say.

(Laughter.)

MR. BARRETT: Thank you. Thank you very much for inviting us here today. I think this is obviously the perfect kind of a topic for the ACRS. It's a technically complex topic, one that's very important to safety, and one that requires attention over long periods of time, and so as I've said on many occasions, we always learn something when we come to ACRS, and this is an area where we continue to learn and grow.

I think it goes without saying that there was a time when we believed that the reactor coolant system was impervious to failure, and because of that we didn't see the need to even analyze its failure as part of the design basis.

Over the past several years, we've gone through a cycle where we've begun a cycle which seems to go in three phases. The first phase is surprise, followed by interim compensatory measures.

The second phase is the imposition of robust requirements or what we believe to be robust requirements.

And the third phase is to go back and examine those robust requirements to see if we've gone too far.

And we certainly haven't even begun to touch the third phase in this area right now.

I'd say that we could start the history of this with about two and a half years ago when we began to see some large surprises, and we began to take interim compensatory measures as a result. We saw a surprise at Oconee in the spring of 2001 when we found large circumferential cracks in the reactor vessel head penetrations, and as a result we issued 2001-01, clearly an interim compensatory measure, looking, doing visual inspections, looking for leaks, clearly not the kind of situation you want to be in in the long term.

In the spring of 2002, we found another large surprise which was the wastage in the Davis-Besse upper head. Again, we issued an interim compensatory measure, Bulletin 2002-01, asking licensees to assess wastage at their plants, again, not the kind of situation you want to be in the long term.

And then we found the surprise last fall where in North Anna Unit 2 shut down and found a great deal of problems with failures or what degradation of their head, which resulted in a special effort on their part to replace the head in an unscheduled manner.

We felt that last fall we began to turn a corner. We issued Bulletin 2002-02, which had as its purpose the requirement that licensee begin to look for the precursors of leakage, not the leakage itself. We began to look at the existence of axial cracking in tubes, the existence of moisture in the annulus region outside of these tubes.

And we followed that in February of this year with a set of orders which not only requested the licensees consider these types of inspections, but actually placed upon them a binding requirement that they do so. And we feel that that was justified, and we felt at the time that we were beginning to get a handle on this.

And I think it's fair to say that we are getting a handle on this. Nevertheless we continued to see surprises, and at this moment, as this meeting starts today, we're not sure of the magnitude of some of these surprises.

I think that clearly all of you by now are aware of the 5072 event report that came in a week ago Sunday from South Texas, and the potential implications of that in terms of the possibility that there would be a mechanism that would lead to crackage and leakage on the lower head of the vessel; that this is leakage that could potentially be outside of the regime of the models that we have been using to analyze previous cracking.

So it's fair to say that we continue to get surprises, and this is one that we're taking extremely seriously. I can say on the positive side of the ledger that we've had conversations with the licensee and they're taking it equally seriously and pursuing this with a great deal of vigor.

MR. WALLIS: Rich, you said it was beyond something that had been considered before. If you had a break of the size of the Davis-Besse on the lower head, that would be a different event than having it on the upper head.

MR. BARRETT: Absolutely.

MR. WALLIS: Loss of coolant accident.

MR. BARRETT: Right.

MR. WALLIS: And I'm not sure that that

sort of event has been analyzed.

MR. BARRETT: No, that's certainly the case. One of the issues, one of the aspects of Bulletin 2002-01 that we issued following the Davis-Besse wastage issue discovery was a request, was kind of a far-reaching request that licensees begin to tell us what they're doing with regard to work acid control, corrosion control programs for the remainder of the reactor coolant system.

And we issued that for two reasons. One was that we knew there were other places in the reactor coolant system that were potentially susceptible to the same kind of problems that we saw at Davis-Besse because, given the model that we had, the susceptibility model, we knew there were other areas that were also quite hot.

We also knew that there were other areas of the reactor coolant system that were potentially more serious in their implications, and as you pointed out, the LOCA in the lower head from a thermal hydraulics perspective can be more challenging, can be significantly more challenging than a LOCA in the upper heard or in the piping systems.

So that's one of the reasons why we considered this to be something we wanted to watch extremely carefully.

The reason I said it was potentially outside or could be outside of the models that we used is that our models for stress corrosion cracking tend to point toward time at temperature. This is a plant that has not had very much time, as much time to operate as some of the plants that have seen cracking in the past, and the lower head does not see the temperatures that we've seen in the upper head.

So this is another potential surprise for us and one that we plan to pursue very vigorously. And there will be hopefully some discussion of that.

As I mentioned earlier, there is a third phase to all of this and a phase that we haven't even begun to enter, and that is that at some point in time when we feel that we have gotten our arms around the entire reactor coolant system, when we feel that we've got requirements out there that cover all of the surprises we've seen and all of the potential other problems that you could see, then I think it would be appropriate for us to go back and ask have we gone too far in some ways.

It's possible, for instance, that we would take a closer look at the phenomenology here , which is a complex phenomenology involving the tube itself, the J groove weld, the base metal, the liner and other aspects, and ask ourselves if there's a smarter, more efficient way of doing the inspections and assessments and repairs than what we've been requesting and requiring so far.

And I think the other possible avenue in this respect, of course, is to take a hard look at what we will do for Alloy 690 as plants begin to replace heads, replace penetrations. We currently make no provision in our requirements for a distinction between the Alloy 600 and Alloy 690.

So that's a phase that's somewhere down the road. I'm sure you're going to hear about some of that from the industry today. We believe that our Office of Research has a key role in performing confirmatory research to understand what we can feel justified to do in this area.

But we also feel that the industry has the burden of responsibility in this respect, and I know that the industry is very interested in this problem. You'll probably hear a great deal about it here today from the industry, and of course, as a reliable regulator, we will be very carefully evaluating what they bring to the table.

How will all of this play out in the long term? I don't have a crystal ball. I can imagine two extreme possibilities. The one extreme might be a situation in which the reactor coolant system some day will revert to the situation we thought we had some time ago in which it's impervious to cracking, imperious to leakage, and can be ignored. I don't believe that's a realistic possibility. Perhaps at the other end of the spectrum you could imagine a situation similar to what we do today with stream generators in which we have very active programs to inspect, assess, and repair.

I think that it's possible that as time goes by we will evolve to something in between. Where in between I'm not quite sure, but at the moment it's difficult to look that far down the road because we're still in the stream here.

And while I would say we're far better off today than we were in the early part of 2001-01, when we found the Oconee cracking, we're not out of the woods yet, to mix metaphors. And we believe there's a great deal to learn.

MR. WALLIS: Rich, I mean, when you say you're far better off now than you were, it's really a matter of how better off you think you are because if you look to 2000, you thought you were much better off then.

MR. BARRETT: Right.

MR. WALLIS: So I'm not quite sure whether you're talking about your state of mind or something that's more objective.

MR. BARRETT: Right. I understand your point, and, of course, it's easy to say. It's easy to question is the NRC staff still in the dark on this issue. I don't think that is the case.

I think that where we are today, and I believe this is always the case, you're always better off when you're engaged, when you're looking hard at the operational experience, when you're asking yourself tough questions, when you're taking actions in a timely fashion.

I believe that when you compare our situation today, having issued three bulletins and an order to every plant in the country vis-a-vis where we were before the Oconee cracking, when, in fact, we had operational experience, not as serious as Oconee, not as serious as Davis-Besse, but nevertheless we had operational experience; I believe that being engaged as we are today is a far better position to be in than we were before.

CO-CHAIRMAN FORD: As Dr. Wallis points

out, it is an evolving technical situation, and you made the point that in the middle of last year you were starting to get into a proactive phase. You had all of the problems --

MR. BARRETT: Right.

CO-CHAIRMAN FORD: -- sorted out and you were going to solve them before they occur.

MR. BARRETT: Right.

CO-CHAIRMAN FORD: You came up with an action plan. The NRR came up with an action plan involving research and other contractors. Has that action plan been modified in view of the changing situation and has there been changes in the prioritization in that action plan?

MR. BARRETT: Well, I think if you're referring to South Texas, I think it's a bit early to be in that situation. I think right now with regard to South Texas we're on a pretty steep learning curve, as is the licensee. We're trying to keep an open mind about what we're seeing and why we're seeing it.

So modifying the action plan, I don't know that that's in the cards at the moment, but I will say this. The Lessons Learned Task Force, the action plan that resulted from the Lessons Learned Task Force has in it --

CO-CHAIRMAN FORD: You're talking about the action plan that was issued in the middle of last year, which is primarily related to the cracking problems rather than the Davis-Besse lessons learned. There's two action plans.

MR. BARRETT: Right. I think that it's fair to say that as a result of the Lessons Learned Task Force, the action plan that we now have in place, the four-part action plan which came from the Lessons Learned Task Force, which includes a part that relates to the vessel, is more balanced between the cracking phenomena the boric acid corrosion control phenomena than perhaps we were before.

One of the provisions of that is that we examine the results of the industry survey that came out of Bulletin 2001-01 regarding boric acid control program attributes and make a recommendation to management as to what additional requirements might be necessary.

And the deadline for that is coming soon. We're in the process of evaluating that within the staff as to what we would propose to upper management, and at the moment as we look at what we saw at South Texas, which was the result of a full environmental visual of the lower head, clearly that's going to color what we propose.

But as we look at the industry programs, the South Texas program is on the more aggressive end of the spectrum at this point.

So I'm not sure I've answered your question. I've said a lot of things, but I'm not sure I've answered your question.

CO-CHAIRMAN FORD: I think we'll come to it at the end of the meeting again.

MR. BARRETT: Sure.

MR. POWERS: Rich, I get the impression -- well, I can put a different spin on everything you've said.

MR. BARRETT: Sure.

MR. POWERS: Which is almost a negative, but I don't want to go into that exercise. What I'm a little more interested in is we find ourselves confronting a variety of material interaction issues for the current generation of plans. We now have before us a lot of proposals on some very, very innovative plans which involve innovative materials, new material interactions, and whatnot.

Are we getting some sort of insight on the magnitude of effort that we need to undertake to understand material interactions in those new plants?

MR. BARRETT: Frankly, Dana, I'm not in the position to answer that question.

MR. POWERS: Yeah.

MR. BARRETT: I would really --

MR. POWERS: You know, I mean, it's a little bit afield.

MR. BARRETT: Yes.

MR. POWERS: But it hints at if we go into a new style of plant, one maybe where water isn't used as a coolant, we really need to do a heck of a lot more than we did when we went into the current generation of plants just because we never want to get into this sort of situation again.

MR. BARRETT: Right. I know that this is an area that has been looked at, but I would not be in a position at this point to really give you a sense of how deeply, how thoroughly. I know, for instance, that people --

MR. POWERS: I don't think that --

MR. BARRETT: -- are looking at the experience in Canada and other places regarding the CANDU reactors, but I'm not in a position to speak to it with any authority. Perhaps when we have presentations from the Office of Research today you can delve into that more. Maybe by that time they can go back and find the answer.

MR. POWERS: But I mean, I think the reasonable answer -- I mean, it would stun me if you said, "Oh, yes, and here's the outline we have on what has to be done."

MR. BARRETT: Yeah.

MR. POWERS: But it seems to me that as we go through these things we need to bear in mind what has to be the baseline technical detail that we have about these material properties going into a reactor design.

I mean, it's not just a regulatory agency. I mean, it seems to be the kind of information that someone who wants to build one has to have.

MR. BARRETT: Yeah, I think that you could take the view that, gee, for these advanced reactors we don't know what kind of issues we will run into.

I would rather take the other view which is that over the 30 or so years that we've been building and operating nuclear power plants certain types of issues have recurred over and over again, and materials issues will be with us, and they need to be a focus, and we just need to make sure that we put our resources there.

CO-CHAIRMAN FORD: Just finally, Rich, it is likely that we'll be writing a letter at the full committee meeting. Is it your formal position that you would like a letter?

MR. BARRETT: Well, I think --

CO-CHAIRMAN FORD: Are you requesting a letter?

MR. BARRETT: I don't know that we've had a discussion about that. Let me discuss that with others involved and get back to you and see, you know, whether we want a letter and what the scope of that would be.

CO-CHAIRMAN FORD: Fine. Thank you very much, indeed.

I'd like to call now on Larry Mathews, Southern Nuclear. If I'm right or wrong, make a comment, Larry. I understand that your co-authors are Tom Alley from Duke, Alex Marion and Jim Riley from NEI; is that correct?

MR. MATHEWS: Yeah, they're here. They don't have -- I'll tell you who's going to make presentations.

As you said, I'm Larry Mathews from Southern Nuclear Operating Company. I'm the Chairman of the Alloy 600 Issues Task Group of the Materials and Liability Program.

I'm going to make a presentation to start this off on reactor vessel head inspection results.

First off, I'm glad to be here and I'm glad it's not a blizzard outside like it was to keep us from coming in February, and this is basically the presentation we had planned for February. A lot of issues have been going on and we really haven't had much time to update this presentation. We have more information in our minds. So maybe we can answer a few questions.

I'm going to make a presentation on the reactor vessel head inspection results up through February, and you know, there's been some since then and maybe I can update that as I walk through, not in numbers, but --

MR. WALLIS: Is there a focus somewhat better on that picture?

MR. MATHEWS: I don't have any control over it.

MR. SHACK: They're working on it.

MR. POWERS: I think it's the technology.

MR. MATHEWS: They're working on the zoom anyway.

MR. POWERS: They have an action plan in place, and they will be sending out a generic letter on this item.

MR. WALLIS: Is 95 percent good enough?

MR. MATHEWS: It depends on your eyes.

Following my first presentation, David Steininger from EPRI is going to make a presentation on our process that we're going through to revise our recommended inspection program for the top head. Then he's also going to talk about some research that we have planned for the North Anna 2 head, which has been replaced. It's sitting in the burial cell in Utah, and he's going to discuss our plans for retrieving samples from the head.

That was a very interesting set of inspection results from the head, and we're going after that to try and learn more information.

And then finally Tom Alley from Duke Energy will make a presentation concerning the update on the inspection demonstration program that we've had ongoing relative to the inspection volume or volumetric inspection techniques.

CO-CHAIRMAN FORD: Just looking through the list of topics that are going to be covered here, Larry, we asked for a presentation on the EPRI sponsored research on boric acid corrosion, the capability to predict the extent of corrosion at a given head penetration. Is that going to be covered?

MR. MATHEWS: We don't have a presentation on that. It's a little bit early. I can pull out our action plan --

MR. STEININGER: I can give the status of it.

MR. MATHEWS: -- and we can talk about where we are on that.

MR. STEININGER: I have one slide. I can give a status in my presentation.

CO-CHAIRMAN FORD: What we'd like to know is, you know, what's your rationale and how you will get to the end result, you know, to predict why you have cracking -- sorry -- wastage in that penetration and not in that penetration.

MR. STEININGER: That's a challenge.

MR. MATHEWS: Well, it sure is.

MR. WALLIS: It's much more interesting to learn what you've understood rather than just what you don't. We can see that you've reached some sort of technical conclusions from your --

MR. MATHEWS: With boric acid we're not there yet.

CO-CHAIRMAN FORD: Well, I recognize that.

MR. MATHEWS: Yes.

CO-CHAIRMAN FORD: Just what your rationale is.

MR. MATHEWS: Okay. What I'm going to cover in the inspection results is an overview of the results by plant, and then we've done some subpopulation looks at it, trying to glean out some of what's the differences from plant to plant.

And then it says inspection plans for the spring, and we're at least half through that by now. So maybe I can touch on what people have done on some of those plants.

We brought this beautiful slide.

MR. WALLIS: You had that last time.

MR. MATHEWS: Yeah, and what I presented last time was a two-hour summary or shorter of what we're trying to cover today. So this was in the presentation last time. It's very difficult to see in black and white or color.

MR. WALLIS: Well, there was this sort of hypothetical point on Sequoia 1, which is the second one or third one up or something.

MR. MATHEWS: Yes, yes.

MR. WALLIS: But that has gone away now, hasn't it?

MR. MATHEWS: In a lot of people's minds

it has gone away. Alloy 600, kind of the surprise of the season, made a feint toward Tennessee and then dodged to South Texas.

(Laughter.)

MR. MATHEWS: So maybe it was a feint.

CO-CHAIRMAN FORD: Well, you made an interesting statement, Larry. In some people's mind it has gone away. Is that a slip of the tongue or is that --

MR. MATHEWS: No, I fully believe it has gone away, but --

CO-CHAIRMAN FORD: Do you know why it has gone? What is the rationale for it going away?

MR. MATHEWS: Yes, yes. They've inspected. They did everything they could on that nozzle, and to the best of my knowledge, they found no indications of a crack. Boric acid --

CO-CHAIRMAN FORD: UT and --

MR. MATHEWS: They did UT. They did PT of the weld. They did zero degree UT looking to see if there was any kind of erosion in the interference fit, and they aged the boron to be several years old, like ten years old based on their cesium ratio.

And they had a major leak on the top of the head back then, ten years ago, ten or 12. In

TVA's mind, they've concluded it was not a leaking nozzle. That was residual boron from their canopy seal weld leak ten years ago.

MR. ROSEN: Is there any possibility that the same logic pattern will follow South Texas?

MR. MATHEWS: It's a little early to say. It's a little early to say. The indications from South Texas now, they've got boric acid around two nozzles, and not a real clear other way it could have gotten there.

MR. WALLIS: It doesn't leak upwards and it doesn't trip upwards.

MR. MATHEWS: No.

MR. WALLIS: On the upper head it could --

MR. MATHEWS: It could easily run down from above, but to my knowledge, there was no indication that they had it running from above.

MR. WALLIS: It would have to run around to get there, around from above.

MR. MATHEWS: Frequently, a lot of plants have boric acid running down the side of the vessel from --

MR. WALLIS: Frequently they have boric acid running?

MR. MATHEWS: Yeah, from canopy -- I mean from the cavity seal. At least it's in cold condition. The cavity seals will have leaks.

MR. WALLIS: This is why it doesn't concern them when they see it?

MR. MATHEWS: Well, no. It's just it's cold and it's minor and it doesn't do any damage. But at South Texas right now they have boric acid around two nozzles, and that's about all we know at this point.

They're launching into, I believe, an NDE program to see what they can figure out about it.

MR. WALLIS: Well, if it's only around the nozzles, that's information. If it's a track coming from somewhere else --

MR. MATHEWS: There is no track, to my knowledge. So that that's -- there's no information that says that these aren't leaking that has been developed at this point in time.

MR. WALLIS: Could you tell me more? We heard about popcorn in Davis-Besse. Is this popcorn when you say it has been seen or is it something else that's seen?

MR. MATHEWS: The boric acid that accumulated around these two nozzles was very small popcorn I would say.

MR. WALLIS: It was popcorn. So it has been coming and drawing out.

MR. MATHEWS: I think so, yeah. I guess I'd rather not get into being the source of information out of those guys in the public forum, if you know what I mean.

(Laughter.)

MR. MATHEWS: I may know something they haven't released publicly, and I --

MR. WALLIS: Well, I'd ask him because I think that what you see when boric acid comes out of a crack and it squirts out and dries and the steam runs through it is probably rather difference in appearance than something which came from somewhere else and then just happened to dry in place. It will look different, won't it?

The drying mechanism is different for creating it, and so it will look different.

MR. MATHEWS: The tracks down the side of the vessels look different than the leakage in the annulus nozzles on the top head and looks different than at least --

MR. WALLIS: To make popcorn you always have to have something sort of blowing through it to fluff it up, don't you, that you wouldn't have if it just dried in place?

So maybe the appearance of the deposit is --

MR. MATHEWS: Well, I'm not sure you need air flow or steam flow through it, and if it's just kind of oozing out of the --

MR. WALLIS: Well, I'm saying just looking for it is different from looking at some characteristics of it as well that might tell you where it came from.

MR. MATHEWS: Yeah, and they're trying to characterize this stuff as well as they can from chemistry, radioisotopes, texture, everything they can get on it.

MR. WALLIS: Well, maybe if they understood how it formed, to get back to my colleague, Dr. Ford's questions, if they understood what was going on, you'd be in a better position to interpret what you see.

MR. MATHEWS: Yeah.

MR. WALLIS: Okay.

MR. MATHEWS: Go to the next slide.

The overview, that table showed graphically -- if you could see it in color, it shows how many of the plants had inspected and to what extent by the early part of this spring and where the cracks had been detected, and in general those were toward the plants.

They were sorted by effective degradation years, and most of the degradation was toward the top of the chart, which is where the high affected degradation years are.

There was other information on there.

MR. WALLIS: So by visual inspection of this slide, this is a digital projection. I wonder why it's so --

MR. MATHEWS: I guess it's coming through the TV camera.

We try and update that slide periodically every outage season.

If you look at the next one, maybe we can -- oh, we can't even read these numbers either place. This is just a wrap-up of all the plants that up till this spring had detected any kind of cracking in their nozzles and how many.

MR. WALLIS: I don't know if we're going to read their slides and if we had them out, they would be even more late.

MR. MATHEWS: That might be a good idea.

MR. WALLIS: Do we have some more?

MR. MATHEWS: I don't think we're going to be able to read these numbers on the overhead anyway. It depends on your trifocles.

MR. WALLIS: Well, we can read the slides if we have enough light on it.

MR. MATHEWS: Yeah. This is just a summary. At that point in time we had about 82 nozzles that had experienced cracking in the base metal and 75 with cracks in the weld. Most of those were axial cracks, but there had been up to 19 nozzles in the fleet that had detected circumferential cracking.

I'm just reading across the lower right-hand corner of the chart there, and most of these are B&W plant, B&W designed plants. There's one CE plant, and then a few Westinghouse plants that are all pretty high in effective degradation years.

Cook 2 is fairly low, and Millstone was also fairly low at the time they detected their cracking.

CO-CHAIRMAN FORD: You said just now, Larry, that these were all plants with circumferential cracking?

MR. MATHEWS: No, no. These are all of the plants that have had any cracking at all in their nozzle.

CO-CHAIRMAN FORD: That's what I thought. Okay.

MR. MATHEWS: And if you look at the right-hand column -- well, it's not even on the overhead. It's on the chart -- it shows the --

CO-CHAIRMAN FORD: Yes.

MR. MATHEWS: -- which ones had circ. cracks and how many.

CO-CHAIRMAN FORD: But the majority of them, just reading from this chart here, the majority of them have.

MR. WALLIS: This is interesting because, in fact, all welds have cracks. It's a question of how big the crack is. So what you're really saying is it's detectable on some scale, the cracks.

MR. MATHEWS: Yes.

MR. WALLIS: All cracks really --

MR. MATHEWS: Either with eddy current or BT.

MR. WALLIS: -- there ought to be some other indication of what you mean by a detectable crack.

MR. MATHEWS: Detectable crack, it's something that comes out with the PT or the eddy current.

MR. WALLIS: So then find out what that means technically in terms of risk because I know there are always cracks in these things of some size, aren't there, or flaws?

A flaw is a crack or how big is a flaw before it is a crack and all of that?

So I don't know whether these cracks are inevitable or not.

MR. MATHEWS: Well, they are significant because in many cases or in several cases anyway, they have led to leakage on top of the head with no detectable flaws in the nozzle itself, and so those cracks are significant.

The predominant source of the weld cracking, you know, if you look at the numbers, has been in the Rotterdam heads, the North Anna 2 head anyway. That's the one where they did the most weld inspections and they had a lot of flaws. That head has since been replaced.

Jim, go to the next one.

I'm just slicing and dicing all of the same data.

MR. WALLIS: Yes. If we knew how roughly these grew and we knew how big they were, we might be able to know whether it constitutes a risk or not.

MR. MATHEWS: Well, weld flaws grow fairly rapidly, quite rapidly, more rapidly than the flaws in the base metal, at least from the test data that we've had. So a detectable flaw on the ID of the weld is not something that we want to find. It's something that leads to, you know, how long can you run with that.

And so we're into repairing detectable flaws.

MR. WALLIS: That's the question really, is how long can you run.

MR. MATHEWS: And the answer is we don't, I believe. We repair detectable flaws in the weld.

MR. SHACK: Larry, on the 42 cracks in the weld metal at North Anna 2, are those really cracks, you know?

MR. MATHEWS: Most of them are eddy current indications over a certain size, is the way that -- and they were reported as cracks.

MR. SHACK: Did they go back and UT those or they just --

MR. MATHEWS: Well, a UT weld is a very difficult thing to do. They had UTed the nozzles, I believe, or some of them.

MR. SHACK: So this is just a J. So they have to just rely on the eddy current.

MR. MATHEWS: That's right. It's the J group weld that had these indications on it, and when they started seeing this many, Dominion started looking for an alternative to try to repair all of those welds.

MR. SHACK: Now, I mean, have other people done comparable eddy current exams?

MR. MATHEWS: A few plants have done comparable eddy current exams. The Cook units, I believe have done comparable eddy current exams. A lot of people have done some weld exams, although not 100 percent on very many plants at this point in time.

I can't -- it's getting to be too many outages for me to remember it all. I used to be able to, but I can't do that anymore.

I do have a cheat sheet, but it's small Type 2, but most of them are doing volumetric on the tube and not that many plants have opted to do eddy current on the nozzles -- I mean on the welds.

If we look at the next slide, you'll see the CRDM/CEDM nozzles that have been inspected by the techniques, and this kind of goes to your question. For those plants that are in the greater than 12 VDY category, essentially 90 percent of the units or 92 percent of the head penetrations have been inspected by bare metal visual. About half of the nozzles have been inspected by eddy current or UT, and this was before the spring outage and before the implementation of the order.

And then only about 16 percent of the J group welds had been inspected by eddy current or PT.

MR. WALLIS: Well, I'm sorry to interrupt you, but the bare metal visual obviously depends on how well you're focused and how much you magnify the image and all of that sort of thing. I would think the same thing applies to ET.

If you had a much more sensitive ET, it would presumably detect more cracks. So I again don't quite know what to make of this because I don't know how sensitive these measurement techniques are. I don't quite know what they're telling me.

MR. MATHEWS: Tom's going to discuss the demonstration program that we've had for the vendors who are doing the eddy current, and he can get into some of that.

MR. WALLIS: But do you specify something about how good the eddy current technique has to be? Because there must be different grades of this, and if you really wanted to be fussy and to take very, very small cracks, you could presumably do it by using a very sophisticated computer analysis of some data or something. I don't know what it is, but --

CO-CHAIRMAN FORD: Are we going to be discussing the specifics of the sensitivity and the probability of the detection?

MR. MATHEWS: Yeah, Tom's going to discuss the mock-ups we've built, what flaws were in them, and what the inspection results were for the tools that were implemented in the field.

CO-CHAIRMAN FORD: So you will be able to answer Graham's question at that time?

MR. MATHEWS: Yeah, we'll tell him what we've got and go from there.

CO-CHAIRMAN FORD: On this one, just interpretation, if you look at the Lesson 8 EDY, so the nozzle tube middle column, maybe it's my interpretation of this graph or this table.

MR. MATHEWS: Okay.

CO-CHAIRMAN FORD: You've inspected none of the units, and yet you're saying you've inspected 92 nozzles?

MR. MATHEWS: That's interesting.

MR. SHACK: No, none of the units get 100 percent inspection

MR. MATHEWS: Ah, none of the units were totally, 100 percent inspected.

CO-CHAIRMAN FORD: Okay.

MR. MATHEWS: Thank you.

We did do some nozzles at some units. Okay?

Are we on the next one?

And this is the results of having performed that number of inspections spread across the various EDY groupings. Again, you can see from this that most of the detected flaws are in the higher than 12 EDY category. In fact, it looks like all of them.

MR. SHACK: But isn't Millstone an exception here?

MR. MATHEWS: Millstone was right at 12 when they did their inspection. It may have actually been slightly below, but you know, it's right in that ballpark.

MR. SHACK: I thought 11.2 was the number that sticks in my head.

MR. MATHEWS: Maybe it was. I'm not sure.

And we've had many more inspections this spring. So these numbers would be much more updated when we get through with the spring outage, a lot higher fractions.

The next chart, I believe, is just a bar chart way of looking at it. Some people like these.

Bare metal visual, you can see broken down by category. We've already covered most of the nozzles by at least a bare metal visual, especially in the high EDY category. We've done UT on about half of them, and that's going to jump way up this spring and then some smaller fraction of the welds.

Next.

The next one is just separating out the B&W units because they were the ones that operated typically at the highest temperatures and also the ones that have experienced the greatest amount of degradation except for the welds at North Anna.

I'm trying to pick out the pertinent information here.

CO-CHAIRMAN FORD: But apart from the operating temperature, there is nothing else in the B&W design or fabrication that would give you cause to think that the B&W design, forget the operating temperature, should make it more susceptible?

MR. MATHEWS: From a design standpoint, I don't know that there's a lot of difference. Perhaps the weld sizes and the manufacturing process might be slightly different resulting in slightly different stresses.

Another parameter which we don't have in our models is the material properties.

CO-CHAIRMAN FORD: But the shrink stresses, the size of the weld, and thereby the prediction of the amount of residual stress, how do they fit into the answer to my question? No difference in the shrink stresses?

MR. MATHEWS: Well, there's a range of shrink fits out in the industry. B&W plants were typically up to one and a half mils of interference fit.

CO-CHAIRMAN FORD: As compared with?

MR. MATHEWS: Plants ranging from two to four, I believe, and a half on the Titus one, and most of the CE vessels were manufactured with up to a three mil interference fit. So, you know, it's not huge differences there.

The tube diameters are essentially the same.

CO-CHAIRMAN FORD: So there's nothing in the B&W design, apart from the operating temperature, say, because of the stresses, because of the material per se; there's nothing to say that they are more susceptible than anything else, apart from the temperature?

MR. MATHEWS: Unless there's something that's tied to their material, that B&W tubular products material, but that goes across more than just the B&W plant because other plants have used B&W tubular products material, and so that would be something that might --

CO-CHAIRMAN FORD: We keep hearing Rotterdam Dockyards talking about. What is specific about Rotterdam Dockyards being the fabricator of the head?

MR. MATHEWS: That was --

CO-CHAIRMAN FORD: Has any pathological work been done on their fabrication method, point towards them, or is that just a red herring?

MR. MATHEWS: We don't know. We don't know if it's a red herring or not. We know that the places that have had the most extensive weld flaws, the units that have had the most extensive weld flaws, North Anna 2 and perhaps one of the Surry units -- I can't remember -- had several weld flaws and weld flaws only, nothing in the tube.

CO-CHAIRMAN FORD: And were done at Rotterdam.

MR. MATHEWS: Those were built at Rotterdam. All four of the original Dominion Energy vessels were built at Rotterdam, and there's about, I think, five other vessels in the country that were made by Rotterdam, all of which are cold head plants.

CO-CHAIRMAN FORD: Now, that seems to me a pretty important observation, that the weld defects in Rotterdam fabricated heads, the frequency of them, if that's a fact. Has that been followed up as to the impact of that on this failure frequency?

I'm trying to look for --

MR. MATHEWS: Sure.

CO-CHAIRMAN FORD: -- other things. Has that been done? Has that analysis been done?

MR. MATHEWS: As far as where the other Rotterdam welds are --

CO-CHAIRMAN FORD: Yes.

MR. MATHEWS: -- and who has those? Yeah, everybody knows who's got those, and those guys are --

CO-CHAIRMAN FORD: But the second part of my question is the impact. If Rotterdam Dockyards does not apparently have a very good weld quality control, what is the impact of that on the cracking?

MR. MATHEWS: I don't know. I don't know, and the inspections are the only way we're going to find out.

CO-CHAIRMAN FORD: Recognize that what I'm looking for is what other things are we missing in this prediction prioritization algorithm.

MR. MATHEWS: Yes. The four Rotterdam manufactured vessels that have high head temperatures, all four of those are being replaced, bam. They're all out at Dominion, and they're all being replaced right away.

The others are cold head plants, one of which was Sequoia, and they are, you know, evaluating what they need to do. Hopefully nothing, but you know, because they are cold head plants, but certainly Sequoia raised the flag, but then it turned out that it wasn't leaking in their minds.

MR. WALLIS: You might compare this with your previous slides. Your previous slides, the message seems to be it's the welds that cracked. There's 22 percent of the welds inspected that were cracked on the old plants, and the other numbers are much smaller.

But when we get to this slide, it's the welds which were inspected the least compared with the tubes, for instance. So I would think you emphasize inspecting the welds more and increase those numbers from eight percent to 40 percent or something.

MR. MATHEWS: Well, the B&W plants are all replacing their heads.

MR. WALLIS: But you see what I mean. It seems to be the welds that are the most likely to crack, and they're the ones you don't inspect so much.

MR. MATHEWS: The weld data relative to the tube data is clearly skewed by the North Anna 2 results where almost every nozzle in the head had a weld flaw or --

MR. WALLIS: So it's artificial.

MR. MATHEWS: Yeah. When you look at how many of those were cracked, you know, relative to how many were inspected, it kind of skews the results. It really does.

CO-CHAIRMAN FORD: I haven't heard this weld flaw argument stated before. It may have been stated. I just don't remember. These are surface breaking weld defects?

MR. MATHEWS: Yes.

CO-CHAIRMAN FORD: So they could act as initiators for environment assisted cracking?

MR. MATHEWS: Yes, if they are not -- they could be and probably are PWSCC flaws either connecting weld defects during the manufacturing process.

CO-CHAIRMAN FORD: And is there any plan at all to, as you go forward, to try to improve the prioritization algorithms? Is there any plan at all to introduce that known fact into the prioritization in the future?

MR. MATHEWS: Yeah, we've got to learn everything we can. North Anna 2 was the head that had the most significant weld flaws. It also had circ. flaws in the nozzle we believe emanating from weld flaws without leaking to the top of the head because they never penetrated the annulus.

And that is very interesting to us, and we're going after those nozzles to understand what is going on there. We're going to take those nozzles and section them in the lab and figure out what's going on with those welds. It's the welds at North Anna and how that propagated into the nozzle.

CO-CHAIRMAN FORD: Looking forward -- I mean this is fascinating figuring it out here -- as you look forward and you're going to replace many of your heads with 690, are they going to be fabricated by Rotterdam?

MR. MATHEWS: I don't believe anybody bought a head from Rotterdam.

CO-CHAIRMAN FORD: Okay. That answers mine.

MR. MATHEWS: Good. Okay. Can I skip to the slide that says "Summary of Inspection Results Statistics"?

No, keep going. I'm going to skip these guys. This is just slicing and dicing with B&W separated out, et cetera.

The 3,871 CRDM nozzles, 1,090 CEDM nozzles, which are essentially the same, and 94 in core instrument nozzles on the CE units, which are very similar at 69 units in the country.

Bare metal visual and/or nonvisual NDE inspections have now been performed on almost 81 percent of the reactor vessel head nozzles, including the cold heads, and we found 47 roughly to be leaking. About eight percent of the nozzles in the fleet have shown leaking to date.

If you look at the non-B&W plants, however, it has been limited to North Anna 2 and Surry 1, and those were primarily weld cracking.

Nonvisual examinations have been performed on about half of the plants that were over 12, and it's going up significantly as a result of the spring outage inspections, and about a third of the moderate eight to 12 category and about two thirds of the nozzles in the B&W plants and 25 percent of the nozzles in the non-B&W plants have been examined volumetrically.

Go to the next slide.

About 19 percent of the inspected B&W plant nozzles show base metal cracking, and base metal cracking in the non-B&W plants has so far been limited to Millstone 2 and Cook 2, and although North Anna 1 and 2 nozzles had weld cracking, some of it did propagate into the base metal, we believe, on at least North Anna 2.

And this spring we detected at Beaver Valley some nozzle cracking on the OD of the nozzle below the weld, axial cracks on four nozzle., and those have been repaired, and the unit is on its way back to power.

About eight percent of the J groove welds have been examined by ET or PT, which is not a large fraction, but that's what the statistics were in February.

We've seen weld flaws, you know, some plants that have had no flaws, Robinson, for instance, and some plants that have had extensive flaws like North Anna 2, and they were both very high on the EDY rankings. So it says there could be something to the way the weld was manufactured, although, you know, so far we can't say, you know, that Rotterdam head, we don't have an issue. We're not going there.

MR. WALLIS: No, but if you go back to, again, this Slide 9, the non-B&W, less than 80 EDY, you've only inspected one weld. Maybe that means one -- sort of zero percent in that right-hand bottom corner. So you haven't inspected the welds on these plants which are nonsusceptible.

MR. MATHEWS: In the cold head plants, you're right.

MR. WALLIS: You can't reach any conclusion about them.

MR. MATHEWS: On the cold head plants, you're right. We have inspected some from the higher time and temperature.

Where was I?

The point, and I guess we've said it, Rotterdam and B&W are the only manufacturers in which we've detected weld flaws that were potentially leaking or significant weld flaws on any of the units. Basically I don't believe that there has been any cracking detected in a CE manufactured head or the other manufacturer in the welds.

We've also broken it down by material and fabrication groups and trying to glean out the data. That's one of the things we've been trying to do based on the inspection results, but it's hard at this point to isolate anyone out other than the information that I've already given.

If you look at the plants that have had circ. cracks above or over the J groove weld, there's only been five units that have had those circ. cracks, and the only one -- that have detected them -- and the only one that is not a B&W unit, B&W designed unit, is the North Anna 2 head, and those cracks for the most part, we believe, initiated in the weld and propagated up and into the tube.

Talking about inspection plans for the spring outages, per the order all of the plants that were in the greater than 12 BDUY category, I believe, are doing -- this was before the order -- but all of the plants that were in the greater than 12 are doing volumetric examinations, and everybody, I believe, is complying with the order as best they can.

So there's a lot more volumetric exams this spring.

Back to San Onofre, which may have been included, they did UT. Let's see who else. Turkey

Point has done UT. Beaver Valley has done UT. Sequoia did a few nozzles. They're a very low susceptibility plant. Farley 1 did UT. Indian Point did some UT, and when I said UT it may include eddy current also of the nozzle surface, and there are other plants that have not finished their outages yet that have plans to do so.

CO-CHAIRMAN FORD: I understand, Larry, that three of those plants, Turkey Point 3, Calvert Cliffs (phonetic), and Palo Verde, have all asked for some sort of relief on this inspection. Are you able to say anything at all about that, explain why?

MR. MATHEWS: Well, I suspect that every unit will have some relaxation request per the order. It's just kind of hard to write a generic order that covers every situation, and so most plants are going to find some minor limitations in coverage because it was very specific in the order: two inches above to the bottom of the nozzle.

Inspecting all the way to the bottom of the nozzle can be problematic, depending upon the probe design. Access could limit to two inches above or below or certain areas around. So everybody will probably -- I won't say everybody, but many plants will have some relaxation request.

I'm not sure exactly what Turkey Point's were. I believe theirs was related to minor lack of coverage at the bottom of the nozzles.

CO-CHAIRMAN FORD: Will someone from the staff be --

MR. HISER: Yes, this is Alan Hiser (phonetic).

Tomorrow we'll talk about a little more detail on the relaxation requests, but actually I think of the plants up there, Turkey Point, Farley, Calvert --

MS. WESTON: Palo Verde he mentioned.

MR. HISER: Yeah, Palo Verde, Beaver Valley, Indian Point, virtually all plants. A lot of it is things at the bottom of the nozzles, either threads for guide funnels or tapers on the ID of the nozzles to prevent coupling of the transducer. Things like that are a lot of the issues.

There are some more significant ones, but we'll talk about those tomorrow in more detail.

CO-CHAIRMAN FORD: Thank you.

MR. SHACK: The order, you had to do UT because you have to be able to see both the ID and the OD?

MR. MATHEWS: Well, the order allowed a

full surface eddy current where you did the weld, the OD of the tube and the ID of the tube. If you could do that and say there's no flaws, then that would be good enough or if you chose the UT path instead of doing a weld exam, they allowed a zero degree query for the leakage assessment and through the interference fit.

MR. SHACK: But you can't do an OD exam with the eddy current, can you?

MR. MATHEWS: Below the weld you can.

MR. SHACK: Oh, below the weld.

MR. MATHEWS: On the stub piece that sticks down. So it would be like a full wedded surface eddy current, and if you examine the surface and there is no surface breaking flaws, then that was satisfactory per the order.

MR. WALLIS: That stub that sticks down is not really characteristic of what's up above it, is it? The stresses and everything are different.

MR. MATHEWS: Exactly. The stresses taper off very rapidly once you go below the weld, but you want to -- if you want to use just the surface exam to say there's no leakage path, then you need to examine the whole surface so that you can assure yourself there's nothing that started right below the weld and propagated up through to the annulus.

So if you chose the surface, the eddy current, you need to do the full wedded surface. If you chose UT, then you could query the tube and also look for leakage through the annulus. Okay?

I'm not sure there's much point in walking through the rest of the inspection plans for this spring since the order kind of preempted what a lot of people had at that point in time, although we were already -- the MRP was already in the process of recommending that all units at some point in the near future go do a baseline volumetric or under the head NDE exam.

We had just had too many surprises, and we said we need to know what the condition of the fleet is. So we were in the process of making that same or a very similar recommendation to that.

CO-CHAIRMAN FORD: Do I understand that the outstanding questions about the inspection sensitivity will be covered later on?

MR. MATHEWS: Tom will cover the demonstration program.

CO-CHAIRMAN FORD: And we'll be talking later on about on the basis of these observations, plus the possibility at South Texas, how you're going to change your prioritization. That's going to be discussed later?

MR. MATHEWS: Yes. David is going to walk through a process that we're going through right now to revise our inspection recommendations.

CO-CHAIRMAN FORD: And will that also cover other than VHPs?

MR. MATHEWS: Well, this is geared toward the vessel head penetration.

CO-CHAIRMAN FORD: Will the next, the further discussion that's going to come on later on; will that also extend this prioritization to cover over components in the primary system, such as popcorn?

MR. MATHEWS: The MRP is working on that, but we don't have a presentation on that. We're developing that process, and it's going to be a more rigorous process than we've been through in the past.

CO-CHAIRMAN FORD: Okay.

MR. MATHEWS: Now, you had asked about the --

CO-CHAIRMAN FORD: At some time or other we would like to know what the industry's position is on, for instance, inspection prioritization algorithms that extend the VHP situation to bottom head, not only from the pressure vessel, but also the pressurizers. It's all the same mechanism. Therefore, the prioritization algorithm --

MR. MATHEWS: Yeah.

CO-CHAIRMAN FORD: -- should at least account for these changes due to material or stress differences.

MR. MATHEWS: Or time at temperature if that's still relevant.

CO-CHAIRMAN FORD: Correct.

MR. MATHEWS: So, you know, --

CO-CHAIRMAN FORD: So you may not be able to cover it today or tomorrow, but soon.

MR. MATHEWS: We'd be glad to come back and talk to you when we get a little further down. You had asked a little bit about the boric acid program that we have. I believe David has the status of it.

We had laid out a program that was going to go after some of the first principles on the head penetration issue, and some of the first principles just on alloy steel corrosion rates, et cetera.

There has been a lot of work done in the past, but some of it was not, if you will, prototypical of the configuration that is at the top of the head.

And so we have laid out a program to go after --

CO-CHAIRMAN FORD: When are you planning to present that?

MR. MATHEWS: Well, right now it's in the process of bidding to do the work.

CO-CHAIRMAN FORD: No, I knew that. It's just when you mete out your RFP, you presumably had some idea of a logic plan --

MR. MATHEWS: Yes.

CO-CHAIRMAN FORD: -- of what you wanted to cover and what the endpoint was going to be --

MR. MATHEWS: Yes.

CO-CHAIRMAN FORD: -- and when that endpoint was going to be. That's what we like to hear.

What was your logic?

MR. MATHEWS: Well, we --

CO-CHAIRMAN FORD: -- the RFP, what was your logic thought?

MR. MATHEWS: Our logic was to look at the various both -- what do you call it? -- separate effects tests, to go after the various conditions that could exist as a cavity develops or leak starts and a cavity develops on top of a head, and then to combine them into full mock-up tests if and when those are necessary.

CO-CHAIRMAN FORD: What about the physical phenomena associated with it, fundamental phenomena associated with it?

MR. MATHEWS: Of the corrosion?

CO-CHAIRMAN FORD: Corrosion kinetics, thermal hydraulics.

MR. MATHEWS: Yes, we were going to look at stagnant and low flow tests. We were going to look at high flow tests with jets and impingement.

CO-CHAIRMAN FORD: Well, that would be covered later on even on one page? Yes?

The reason why I'm asking when it was going to be done is because I know that Bill Cullen has got a fairly extensive discussion of the NRR and his research plans, and it would be useful to have those two presentations side by side so that we can see what's being covered.

MR. MATHEWS: We don't have a presentation. We've got one slide on the status; is that correct?

MR. STEININGER: I can talk off the top of my head, but --

MR. MATHEWS: And I have about a six page write-up on the plan that we had put together to go after this. This was before we went out for bids, but --

CO-CHAIRMAN FORD: It is rather important that we have a prediction capability for this so that we can prioritize where we look for boric acid corrosion on the head and, indeed, anywhere else in the country into the primary system.

MR. MATHEWS: Unless you look everywhere.

CO-CHAIRMAN FORD: Yeah.

MR. MATHEWS: And frequently enough.

CO-CHAIRMAN FORD: And prioritize. If you knew what the mechanism was, et cetera, et cetera.

Okay, Larry. Thank you very much.

MR. MATHEWS: Okay.

CO-CHAIRMAN FORD: If we may, we'll cover that one page of your extemporaneous discussion at the time we take Bill.

MR. MATHEWS: Okay.

CO-CHAIRMAN FORD: Are there any other questions for Larry on this particular segment?

(No response.)

CO-CHAIRMAN FORD: Thank you very much, indeed.

MR. MATHEWS: Okay. At this time I would like to have David come, and he's going to walk through the slides.

Craig Harrington was going to make this presentation originally. He's the Chairman of the RPV head working group in the ITG.

CO-CHAIRMAN FORD: Okay. This is for the record David Steininger?

MR. MATHEWS: David Steininger with Electric Power Research Institute.

MR. STEININGER: Well, hello, gentlemen. Like Larry said, the person that created this presentation, Craig Harrington, who is Chairman of our RPV head working group, went to South Texas to help out. Craig is from Texas Utilities, and South Texas asked for a number of industry people to go help out at South Texas, which they do.

Craig went, and the person that works for me that would have been the next choice to make the presentation, Christine King, also went. So I'm the one that drew the short straw.

So what I'd like to talk to you about is the process that Larry mentioned earlier, and that is a much more formal, detailed procedure that we're going to institute when we relook at our inspection plan for the RPV head.

As you know, last year the -- well, first let me introduce myself. My name is David Steininger, and I am the lead manager for both the MRP program at EPRI and the SGNP program, the steam generator management program, at EPRI.

So a lot of this stuff that's going on in the MRP program is not too unknown to me because I've suffered through quite a bit of 25 years of disasters in the steam generator world.

MR. ROSEN: As have some of us.

MR. STEININGER: Yes. In fact, he was on one of our committees for many years, Steve was.

Okay. As you know, last year the MRP did, in fact, produce an inspection document for its members for inspection of the RPF top head. For practical reasons, as we all know, that inspection plan was essentially replaced by the requirements or the suggestions provided in the NRC Bulletin 2002-02 and then subsequent to that the order.

But in any event, there's nothing to suggest that the inspection frequencies and the inspection tapes that were presented in our inspection plan were invalid, and in fact, we still believe that everything that, in fact, we had proposed in the inspection plan is still valid.

But what we want to talk to you today about is the process that now we are formally going to institute to take a relook at that inspection plan and see if it still holds true and modify it as necessary.

So the topics that I'm going to discussion are what we now call the overall safety assessment process, which will support the inspection plan. I'll mention to you the requirement that we've now placed on our members to actually go in and do a baseline inspection. I'll mention the failure modes and effects analysis, which is a very formal procedure trying to identify all the possible modes of failure associated with --

MR. WALLIS: Those inspection intervals chosen to insure safety implies that you know something about how rapidly things occur between these intervals.

MR. STEININGER: Yes, we thought we did.

MR. WALLIS: Do you know that?

MR. STEININGER: Well, the documented the MRP 75, which was a technical basis document for our inspection program that we provided our members last year.

MR. WALLIS: So you're pretty sure about

this insuring safety because you know the things couldn't happen faster?

MR. STEININGER: We still are very confident that what we provided in the document still holds true.

Okay. Then the supporting, again, everything that we have just mentioned here obviously boils down to that you have to know your crack growth rates; you have to know your stress intensity factors; and obviously with the boric acid situation, you're going to have to know how the boric acid corrodes the carbon steel.

So let's go on to the next slide.

CO-CHAIRMAN FORD: David, just to make sure, this is essentially the MRP 75?

MR. STEININGER: This is a whole new process to relook at MRP 75 and modify it if necessary. We didn't actually go through this kind of formal process when we developed MRP 75. I guess you could call it the fog of war back then. There was a lot of midnight oil being burned, and we produced an inspection document and its technical basis.

CO-CHAIRMAN FORD: So this is what I see referred to as the revision of MRP --

MR. STEININGER: That's correct.

CO-CHAIRMAN FORD: -- 75, and has this been reviewed by the staff, what you're about to --

MR. STEININGER: The revision hasn't been produced yet. This is going to lead to possibly a revision of MRP 75. This is the process.

CO-CHAIRMAN FORD: But the process here is new.

MR. STEININGER: Yes. This is the process that we've essentially now instituted that we will follow in coming up with a revision to MRP 75.

MR. POWERS: Peter, do we have MRP 75?

CO-CHAIRMAN FORD: We do not. ACRS does not formally have MRP 75. I have it.

MR. STEININGER: A long time ago, and we've made presentations on MRP 75.

CO-CHAIRMAN FORD: Oh, everyone has received it?

MS. WESTON: Yes.

CO-CHAIRMAN FORD: Oh, I take that back. So what you're hearing today, Dana, is --

MR. POWERS: New and different. I understand. I'm trying to recall MRP 75.

MS. WESTON: Yeah, way back in the early part of 2002 we sent you a copy.

CO-CHAIRMAN FORD: The approach was

discussed at the full committee meeting in June of 2002, June or July.

If I may for Dr. Powers, there's two key documents, MRP 55, I believe it is, which relates to the crack growth rate, which you have seen, I think. And subsequent to that was MRP 75, which made use of crack growth rate.

MR. STEININGER: That's correct.

CO-CHAIRMAN FORD: What you are about to hear now is not in the document, MRP 55. We have not received a copy of this.

MR. STEININGER: Correct.

Okay. So let me just go over very briefly the overall process that we've now defined that we will formally go through in order to verify that what we have in MRP 75 is correct or it needs modification.

We're now in the process of following a failure mode and effects analysis, and that's where, well, as we all know, we've been surprised many times in the past. We were surprised by the axial cracking in the nozzle. We thought that's all we were going to see, as mentioned before, and then we got hit with OD cracking outside of the nozzle.

We ended up getting wastage at the top of the head and now we're getting cracking at the bottom head of the vessel. So --

MR. ROSEN: Maybe.

MR. STEININGER: Maybe. In any event, we're sick of being surprised. So what we'd like to do is formulate a process here in our revision to MRP 75 which tries to get us ahead of the curve, and obviously one of the things that we need to do is to try to anticipate the various modes of failure and degradation that we may see in the future.

And if this overall process is successful in applying it to MRP 75, this is the process that will probably follow for all of the components in the RCS system because that's essentially where we're headed, to try to do this in a prioritization type way and trying to understand where failures are going to hit us in the future, and that's where the industry is going.

The first application of this overall process though is for the nozzles.

So you can see that what we first tried to do is we -- and this is an application to the nozzle -- we try to identify all failures, all forms of degradation that can lead to the failure for the nozzle, and as you can see, I've listed that here in the second column.

And once you do that, you obviously have to define a probability of detection for the degradation. You have to set your inspection cycles appropriately, and you finally go through and do a formalized safety assessment analysis.

MR. WALLIS: Do you have a probability of detection for these UT and ET methods?

MR. STEININGER: Well, we have a whole process that we have instituted to go and find out what that probability of --

MR. WALLIS: Actually you don't know what it is yet. Maybe he'll tell us.

MR. STEININGER: He may tell you. Probability of detection?

MR. ALLEY: POD, we did the mock-ups.

MR. STEININGER: So it's just demonstration then that's going on.

Okay. Tom will tell you about the program, but you're absolutely right. At some point you have to define probability of detection. That's what you were bringing up earlier. We can't get away from it.

Okay. Then you end up going into developing a safety assessment report. You have defined your inspection cycles. You've defined the types of inspections that you're going to recommend, and everything that is done out in the field will have to be bracketed by that safety assessment report.

Okay. The next slide.

CO-CHAIRMAN FORD: Hold it. Stop.

MR. MATHEWS: Yes.

CO-CHAIRMAN FORD: You say this schema you're showing here, schematic, is going to be the framework for which you're going to apply to all -- I think you said all components. I'm assuming you mean just to all --

MR. STEININGER: No.

CO-CHAIRMAN FORD: -- primary water side ones.

MR. STEININGER: Correct. This is the forma process that we're using to modify MRP 75, and I would hazard to guess if this process is successful, we'll probably use this kind of process for all other components that we have to address.

CO-CHAIRMAN FORD: And so this is the template upon which --

MR. STEININGER: Correct.

CO-CHAIRMAN FORD: -- you based all future developments of, four instance, inspection technology, et cetera.

MR. STEININGER: I would say that's probably true.

CO-CHAIRMAN FORD: You do not have on this graph low temperature embrittlement at 619 or 152.

MR. STEININGER: Well, if you look at it, there's a little box right up at the top. It says technical basis for Alloy 690, 152 and 52. That's where.

CO-CHAIRMAN FORD: But as it relates to the failure mechanisms showing the second --

MR. STEININGER: Right.

CO-CHAIRMAN FORD: -- and embrittlement is not in the second.

MR. STEININGER: That's probably true, but it is a concern.

CO-CHAIRMAN FORD: Is there work being done? I know I'm probably jumping the --

MR. STEININGER: You are. It's not even in the presentation.

CO-CHAIRMAN FORD: When you say I am jumping the gun, you mean you're going to cover it later on in this presentation.

MR. STEININGER: I'm not covering it in this presentation, but we are looking at that phenomenon, low temperature embrittlement of 690.

CO-CHAIRMAN FORD: And the welds.

MR. STEININGER: Yes.

MR. MATHEWS: The FMEA, you know, the second column here, are, if you will, results of degradation. The FMEA, he's got it as one box, but it's actually this huge flow chart that walks through every possible degradation and how that could progress to some accident scenario.

And so if we're evaluating a 690 component, that would be potentially one of the degredation mechanisms that has to be walked through the failure modes and effects analysis.

CO-CHAIRMAN FORD: Now, when you said it's going to be addressed, specifically when will it be addressed?

The reason why I'm pushing you here is that up until Davis-Besse we said, "Hey, you're not going to get boric acid corrosion in that particular part of that subassembly." Now I'm positing another failure mechanism that's not out of the question.

MR. STEININGER: You're talking about hydrogen embrittlement at low temperature.

CO-CHAIRMAN FORD: Well, hydrogen effects on high chrome-nickel based objects.

MR. STEININGER: Yeah, and we do have some testing going on in that area.

CO-CHAIRMAN FORD: Okay, and that will be completed in time so that they're not going to have a huge reaction.

MR. STEININGER: As Larry said, when we applied the failure modes and effects analysis, that's one of the phenomena we identified as a concern, and we are working on it. Okay?

CO-CHAIRMAN FORD: Okay.

MR. STEININGER: Next slide.

MR. WALLIS: Well, I just have a comment. You have all of these technical evaluations in these boxes. I hope that they include what our Chairman is talking about, which is an understanding of what's going on from the point of view of the physics, chemistry, and so on, in more than a superficial way.

MR. STEININGER: Yes.

MR. WALLIS: So your expert committees involve people who work on these areas?

MR. STEININGER: Well, that's what we did for MRP 55, which was the expert panel, to put together their recommendation on crack growth rate for Inconel 600.

MR. WALLIS: That's correct.

MR. STEININGER: That's the process we

follow.

Okay. So the MRP is essentially transitioning to a combination of baseline inspections and periodic inspections. The timing of the baseline inspection and the reinspection interval, obviously, will be based on all of this analysis, and it will be based up by a more extensive bare metal inspection of the reactor pressure vessel head.

The revised inspection plan, as I indicated before, will be based on the entire safety assessment report, which will document this entire process that I briefly described earlier.

Just in summary, the safety assessment report begins with the failure modes and effects analysis. It anticipates all possible failures associated with the component, subject component, or has been observed in the field.

Then finally we'll use the analysis, the kind of analysis that you've already seen, which is presented to MRP 75.

CO-CHAIRMAN FORD: Now, when you look at this and responding to Professor Wallis' comments and mine, you've got a huge program. There's a huge amount of development involved.

MR. STEININGER: Absolutely.

CO-CHAIRMAN FORD: So what is the timing of the completion of either the complete article or various submodes of it?

MR. STEININGER: We expect to have the safety assessment report done for the nozzles by the middle or late summer. So essentially we would have this finished for the nozzles by middle or late summer.

CO-CHAIRMAN FORD: So you'll have finished --

MR. STEININGER: Correct, this process.

CO-CHAIRMAN FORD: -- all of the boric acid --

MR. STEININGER: No.

CO-CHAIRMAN FORD: -- which goes into this?

MR. STEININGER: No, no. For nozzle cracking.

CO-CHAIRMAN FORD: Oh, nozzle cracking. I didn't hear.

MR. STEININGER: Correct.

CO-CHAIRMAN FORD: I missed the word "cracking."

Okay, and when will all of the other degradation modes be addressed? You'd gone down one path of this crack. The question of the treatment of the wastage, of the low temperature embrittlement, any other loads, your expert panel may --

MR. STEININGER: I'll have to get back to you on that. I don't know the schedule.

MR. MATHEWS: The boric acid schedule, well, you have the schedule, right? But it's a couple of year program to really understand this cavity formation.

MR. STEININGER: For example, we're just now going out with the RFP, as you know, on boric acid.

Okay. Next slide.

Well, again, the failure modes and effects analysis establishes the kind of technical evaluations that we'll need. I would like to point out as I indicated earlier, our existing calculations show that the nonvisual inspections that we've documented or recommended to MRP 75 probably still holds true. There's nothing to suggest that they're wrong.

The calculations done to date to support MRP 75 indicate extremely low probability of nozzle ejection and significant wastage, and ultimately an extremely small consequential increase in core damage frequency, which is consistent with NRC Reg. Guide

1.174.

Okay. As indicated earlier by Larry, subsequent to the release of MRP 75 to our members, which established our recommended inspection plan, we sent out a letter to our members which recommended a baseline inspection be performed, and this baseline inspection consists of a combination of inspections which I've listed here. The members could use UT or bare metal visual and UT of the base metal from the tube ID and bare metal visual to give an indication as to whether the weld had cracked or not. They could perform a UT or eddy current; UT of the base metal for the tube ID and ET or PT of the weld surface.

Finally, they could perform eddy current for both nozzle and the weld. For the nozzle it would be ID and OD, and then they could use ET/PT for the weld surface.

MR. WALLIS: Why is it just the weld surface? I mean, aren't there cracks inside the weld?

MR. STEININGER: The weld is very difficult to detect by --

MR. WALLIS: Well, you don't do it because it's difficult or you don't need to know it?

MR. STEININGER: Well, I think it's a combination. What we're asking here is simply to use eddy current surface.

MR. WALLIS: Well, you do what you can. It may not be that's enough and maybe you need a method for looking inside of the weld.

MR. STEININGER: Well, that very well could be.

MR. WALLIS: Well, if you do need it, then you ought to say so.

MR. STEININGER: Well, the PWSCC is going to attack the surface of the weld, correct? So that's why we're looking at the surface of the weld.

MR. MATHEWS: Plus volumetric exams of weld metal, nickel based weld metal is very, very difficult.

MR. WALLIS: Okay. So you're assuming if there's a crack under the weld because it's not subjected to this stress corrosion cracking you won't know unless it breaks the surface? That's sort of a technical judgment, I guess.

MR. MATHEWS: Well, I think fatigue analysis, et cetera, for those types of cracks would indicate they're okay.

MR. STEININGER: Okay. Next slide.

MR. SHACK: Dave, can I just come back?

MR. STEININGER: Yeah.

MR. SHACK: One thing in MRP 75. You really looked at an average plant, and are you going to do more to address the kind of range of variations that might be possible?

MR. STEININGER: I'm not so sure we looked at the average plant, but we took the worst case heat that was cracking in the field, for example. We used the --

MR. SHACK: No. When Pete did his Monte Carlo analysis, he really sampled over the whole distribution, which is, in effect, looking at an average. I mean, he did not try to define a 95th percentile probability of failure. He was basically getting the probability of failure of the average plant.

MR. STEININGER: But he took worst case material properties, for example, when he did that analysis, and he also used the --

MR. SHACK: No. I mean, he sampled from a distribution. He was trying to avoid -- I mean, that would be one solution, would be to take bounding cases, but he really didn't do that, you know. And it seems to me that that still has to be addressed in the MRP 75 kind of analysis.

Essentially it's not good enough to show that the probability of a failure in the average plant is very small.

MR. STEININGER: Well, I know in the past Steve Long has brought this up, the same comment, and you know.

MR. MATHEWS: There's been some modifications to the PFM analysis. I'm not sure of the details yet. I know we've changed the way we propagate the flaw and a couple of other things in response to some of the questions we've gotten from the staff, and Pete's not through his new work, but we need to take a look at that.

You're saying we need to possibly look at a worst case plan as opposed to an average.

MR. SHACK: Well, I mean, there's a distribution of plants.

MR. MATHEWS: Yes, there is.

MR. SHACK: I mean, you know, the average plant is not the one I'm worried about. The average plant is not a problem.

MR. STEININGER: You're worried about the plant where all of the uncertainties stack up in the wrong direction for you.

MR. SHACK: No, no, it's not even the uncertainty. It's just that there's a range of material properties. A plant with the average properties is probably not a problem. A plant with the worst properties --

MR. STEININGER: Worst case, that's right.

MR. SHACK: -- is a problem, and at least the way the analysis was done in MRP 75, I don't believe that you are really considering properly the range of properties that were encountered because of the way you did the analysis.

MR. MATHEWS: I think there were some sensitivity studies done, but I'll take a note, and we'll get back.

MR. STEININGER: Yeah, we'll get back to you. We'll let Pete develop an answer for you on that.

Okay. In this process, the time at temperature is still going to be the parameter of choice that we'll use to rank the susceptibility groups for a plant, and this baseline inspection is expected to be completed for the high susceptibility plants by the next refueling outage. So this presentation was made for, I guess, the February ACRS meeting. So probably all of the high susceptibility plants will have probably implemented the baseline inspection by now.

It is expected that the moderate susceptibility plants will perform the baseline inspection by approximately 2005, and the low susceptibility plants by 2007.

MR. ROSEN: So how does the South Texas experience, assuming that this time there are cracks, play with this whole strategy?

MR. STEININGER: Well, again, this is directed to the top head.

MR. ROSEN: Yeah, that's exactly my question.

MR. MATHEWS: It depends, you know, and we can go chase the rabbit trails of what if South Texas is this or what if it's that, and until we know, we're spinning our wheels.

CO-CHAIRMAN FORD: But combining that question with Bill's question, is this methodology you said was for all primary water systems.

MR. STEININGER: Probably will be a part.

CO-CHAIRMAN FORD: It must, therefore, include pressurized penetrations as well as open head penetrations.

MR. MATHEWS: Eventually.

MR. STEININGER: Eventually, yes.

CO-CHAIRMAN FORD: Oh, no, you said

cracking by the mid-summer.

MR. MATHEWS: Not the top.

MR. STEININGER: For the top head.

CO-CHAIRMAN FORD: For the top head. So assume South Texas, it turns out to be unfortunately the situation that we believe it might be, and therefore, you cannot --

MR. POWERS: Which is what?

MR. ROSEN: All we're doing here is hypothesizing one side or the other. So I want to know what your hypothesis in this sentence is.

CO-CHAIRMAN FORD: Well, I don't want to go on the record as saying South Texas is cracked. We just don't know.

MR. ROSEN: Right. No one knows right now.

CO-CHAIRMAN FORD: But we do know that pressurized is cracked.

MR. STEININGER: Yes.

CO-CHAIRMAN FORD: And it's the same mechanism. It's the same phenomenon. So if this all singing, all dancing analytical process is full, it should be able to take into account changes because of residual stress variability, materials variability, Bill's point, and cover pressurized, and moreover the repair of pressurized.

So does that enter into your timing? I know you said quite specific now it's cracking only for primary water side, vessel head penetrations.

MR. STEININGER: Right.

CO-CHAIRMAN FORD: But you've got to expand it eventually.

MR. STEININGER: Yes.

CO-CHAIRMAN FORD: And when does that expansion take place? How quickly does it take place, especially if it's pushed by potential --

MR. MATHEWS: Well, South Texas could clearly push us to speed up our process, if you will.

CO-CHAIRMAN FORD: Well, maybe this is another management discussion, but we all recognize resource restrictions.

MR. MATHEWS: Yeah. There's only so many of us.

CO-CHAIRMAN FORD: I'm assuming.

MR. ROSEN: And there's only so much inspection resource.

MR. MATHEWS: So much?

MR. ROSEN: Inspection resource.

MR. MATHEWS: Right, right.

MR. ROSEN: People who can do whatever

technique turns out to be necessary to determine what it is that may be cracking.

MR. MATHEWS: And tools that can deliver the transducers.

CO-CHAIRMAN FORD: I recognize we're putting you in the hot spot here, but obviously if there's resource limitations, there's going to be a prioritization.

MR. MATHEWS: Right.

CO-CHAIRMAN FORD: How are you going to decide on your prioritization, coming up with your prioritization algorithm? What's your decision making process for deciding how quickly you're going to evolve these modified all singing, all dancing prioritization of them?

MR. MATHEWS: For the top head, we're going to try and get it out by the end of the summer for revised inspection program, which is, to be honest, may not deviate a lot from what's been ordered, if you will.

CO-CHAIRMAN FORD: Right. You're already going ahead.

MR. MATHEWS: Yeah. We may have some recommendations to certain things, such as reinspection frequency or something, that we want to pursue with the staff in the process of revising that inspection plan.

For the rest of the components, we have another working group, not the head working group. We call it the butt weld working group, but their charter is to include all of the Alloy 600 in the plant and to go after it.

There's two things we're trying to do here. Number one, show that the plants are safe; and, number two, figure out when and how we need to be inspecting these components to assure the continued safety, and that's the point of what we're trying to do here with the FMEA and all of this other work, is to walk through a process so that we can figure out what is the right timing for what kind of inspections to assure the continued safety.

And you know, we've put our resources first on the butt welds, but then that got overshadowed very quickly by the top head, and we've put some more resources back on the butt welds and now South Texas could drive us to reassess not only what that does to other components, but perhaps also what it might do to our previous assumptions as far as the top head.

And we've just got to wait and see what

they find. We've got to wait and see what they find. And the configuration on the bottom mounted instruments is potentially going to make it very, very difficult to get to a real base root cause on this, you k now. You don't just go take a boat sample down there. It's not as easy as a top head or a weld in the plant or something like that.

CO-CHAIRMAN FORD: If you had cracking, what is physically different? You've had cracking in pressurizers, bottom head penetrations in pressurizers.

MR. MATHEWS: Temperature is very, very different. The pressurizer is the hottest component in the plant, and so the time at temperature on a pressurizer is basically T SAT for the life of the plant..

CO-CHAIRMAN FORD: Is that predicated by the current -- if that's the only change, temperature, is that predicted by any current algorithms?

MR. MATHEWS: Yeah. If we just do a time at temperature analysis, it would say that pressurizers ought to be having problems or that would be a component where you would expect to see PWSCC. Also for instrument penetrations, those are at T-hot for the life of the plant, if you will, and they experience problems there.

They've never seen them on cold leg nozzle penetrations I don't believe, and so you know, the time at temperature, it's a simplified model, but it has up till now been fairly useful to us in prioritizing where we need to look and what we need to be doing.

CO-CHAIRMAN FORD: So you're sticking to the -- I'm sorry to keep going on this line here, but it is fundamental to how we manage this whole situation.

So you are sticking to the argument for the time being that temperature is the sole driving parameter.

MR. MATHEWS: No, I'm not going to make that argument. I'm saying it is a major driver, and to say that you can't override the temperature effect which is there with some other effect to the extreme, the tails of some other distribution can't make things happen that will lower temperature; I'm not going to say that because it can. I mean, that's rather obvious, I think.

But you know, what the situation is at South Texas I don't know and, you know, it's going to be a while.

CO-CHAIRMAN FORD: I agree entirely with what you say. So if you look at material changes, and we've already got from Argonne an approach for attacking the range of responses because of ranges in material composition or micro structure, is there an insuperable technical guide to overcome to take into account changes in stress, residual stress? Is that an insuperable technical barrier that has to be overcome?

MR. MATHEWS: I'm not saying no. I mean, you can analyze the design, but then you've got to worry about repairs and what have repairs in the manufacturing process done to the stresses that you might calculate?

CO-CHAIRMAN FORD: But you could bend things according to that. You know whether it's been repaired or not.

MR. MATHEWS: You should, yes.

CO-CHAIRMAN FORD: So you can bend things as --

MR. MATHEWS: Yeah, I think people are already doing that in their own minds at their own plants. They're thinking, well, you know, which welds did I have major repairs on the ID. Do I have any? And those are the ones I need to be paying attention to.

And people are starting to do that at their own plants, you know. For the MRP to go and try to catalogue every Alloy 600 weld in the industry would be a monumental task. You know, I think we can provide information to the utilities to work on their own plants.

CO-CHAIRMAN FORD: There's enough data on the effect of stress on the cracking of these alloys, especially 182 and 600. So at least to be able to do a sensitivity analysis of how much it would change if you changes the visage of stress profile by so much. Has that been done?

MR. MATHEWS: Well, stress profiles are built into the way we've done the analysis from crack propagation, et cetera, and sensitivity studies, I believe, have been done on what's the effects and that sort of thing.

CO-CHAIRMAN FORD: And would it explain the possible cracking, that sort of nexus?

MR. MATHEWS: We didn't analyze the cold head situation for a bottom mounted instrument. I mean, we didn't model that yet.

CO-CHAIRMAN FORD: Okay, okay.

MR. STEININGER: Okay. Continue to the

next slide?

CO-CHAIRMAN FORD: Yes, please.

MR. STEININGER: Okay. Again, I just want to emphasize that we're starting off on this rather new approach called the failure mode and the effects analysis, which essentially just identifies the cause of the degradation, the effect, the consequence, the detectability requirement, and the frequency of occurrence of the degradation.

And you can establish relationships between these various characteristics by a block diagram, and we'll get to that in a minute. Anyway --

MR. WALLIS: You use the quality of what goes into each box, and you can have the diagram. That's sort of easy to put out, but then deciding how far you have to go in understanding things in each box is --

MR. STEININGER: That's the difficult road. That's correct.

Okay, and if you go to the next slide, if we try to apply this failure modes and effect analysis to the nozzle, what you'll identify is that you could, in fact, have nozzle ejection due to net section collapse. You could have a cladding blowout due to wastage, for example, which would have happened at

Davis-Besse, or if you did, in fact, have nozzle ejection, you generate a number of loose parts which could produce consequential damage.

Now, there are various failure processes involved that could lead to these various consequences, and I've listed them there. PWSCC initiation at various locations; you can get primary coolant leakage into the annulus, which then could start corroding the carbon steel, and the list goes on and on.

Now, the block diagram that I was talking about a little bit earlier is in the next slide, and I don't think we need to go through the various scenarios that are listed here, but effectively, for example, you could start off with a crack in the weld which subsequently grows and becomes a circumferential crack in the base metal, which doesn't leak into the annulus. So you're not picking it up by a visual inspection.

The circ. crack goes around the nozzle, and you ultimately could lead to nozzle ejection. That's just one example.

Go to the next.

CO-CHAIRMAN FORD: This is a tremendously involved process.

MR. STEININGER: Yes.

CO-CHAIRMAN FORD: Requiring a lot of quantifiable data of a quantifiable quality. Have you done through a similar exercise before for other components in light water reactors to know where -- the rate limiting step in going from the bottom up to the top is? For instance, the quality of the stress corrosion cracking data is going to be one, I would imagine.

MR. MATHEWS: I don't think the VIP walk through exactly this process, but I think they've gone through component by component in the vessel and done similar type of things. How can it fail? What are the consequences of failure? What are the ultimate consequences? At what point do I need to inspect to prevent that failure?

And that's kind of the point of this, is where in this process of degradation should we insert inspection of what type to stop the chain because the core damage is the top of the box and nobody -- you know, we need to stop it before there, and we believe the order would stop it before there, but what we're trying to do is figure out where do you do what to stop each of the degradation chains?

This chart here is a little bit old. I

saw a later one that we had in South Texas last week that we were working on converting to the bottom --

MR. WALLIS: Well, let's look at one thing here. I mean, you've got cracks which form and then there's an arrow which goes into a nozzle leak. I don't know that we have any good basis for knowing how you go from a crack, which is a very skinny thing; it's a fault in the metal and the metal can part, but it's still a very, very small path of flow.

How you go -- the development of a big enough hole from the crack to really call it a leak and how that develops and, you know, progresses, I'm not sure you have any handle on that at the moment.

MR. STEININGER: Well, I think you're absolutely right, and that's one of the reasons why we're --

MR. WALLIS: But I mean, you can draw the diagram the rest of your life, but you have no way of predicting what happens at that arrow. I don't know that you're too much further ahead.

MR. MATHEWS: But let's just say I have an inspection technique that I could insert in the middle of that arrow and terminate the arrow.

MR. WALLIS: That is your strategy. Is that --

MR. MATHEWS: It's certainly one of the things that we will be looking at, what's the appropriate inspection --

MR. WALLIS: You don't have any understanding of anything. You just sort of say, "We'll see where we are in this map in terms of our inspections. We'll use inspections to tell where we are in the map rather than analysis."

MR. MATHEWS: Well, I think we have to have some form of inspection here that would give us information about what's going on in the plant. I mean, it's not a purely analytical sit-down with your computer and convince yourself everything is safe.

MR. WALLIS: No, no, no. They've got to complement each other obviously.

MR. MATHEWS: Yes.

CO-CHAIRMAN FORD: Could I suggest that just flipping through you charts there are a lot of things here that I think there might be questions on that need to be addressed that are central to the way you're going to go in the future, which is preparatory to saying let's have a quarter of an hour break, until 25 to 11. Then we'll get back to discuss this.

MR. MATHEWS: Okay, sure.

CO-CHAIRMAN FORD: Could I just double

check with you? The presentations for the rest of the morning, is it essentially these three extra?

MR. MATHEWS: It's finishing this one.

MR. STEININGER: And there's North Anna.

MR. MATHEWS: The one on the North Anna 2 head.

CO-CHAIRMAN FORD: Yes.

MR. MATHEWS: And then the one from Tom Alley on the inspection and demonstration program.

CO-CHAIRMAN FORD: Okay. So let's hope we can get through before 12:30 because I know this afternoon we have a time crunch.

MR. MATHEWS: Okay.

MR. STEININGER: Okay.

CO-CHAIRMAN FORD: Okay. Let's take until 25 to 11 as a break.

(Whereupon, the foregoing matter went off the record at 10:20 a.m. and went back on the record at 10:40 a.m.)

CO-CHAIRMAN FORD: Okay. Sorry. We're five minutes late because we've been gabbing away here.

Okay. Shall we continue?

MR. STEININGER: Yes.

CO-CHAIRMAN FORD: We're giving you a hard time on this particular --

MR. STEININGER: No, no, no. We admit we don't have all of the necessary information. That's what we have to do: get it. So you're just picking up on that.

Okay. Where was I? I've got my glasses on. Let's see.

Okay. Yeah, failure modes, failure modes and effects analysis. This goes back to your comment actually.

MR. WALLIS: You need to be very careful with the noncredible failures.

MR. STEININGER: Yes.

MR. WALLIS: I was going to ask: are those quantifiable?

MR. STEININGER: Well, it says it requires a strong technical argument and thorough documentation with a high threshold. So we agree with you. That's what it says.

CO-CHAIRMAN FORD: And this will be finished mid-summer. I keep coming back to that.

MR. STEININGER: Yeah, that's correct.

CO-CHAIRMAN FORD: So this situation about where you move from one to the next expanding on the classification, you will need some numbers, won't you?

CO-CHAIRMAN FORD: And that will be in terms of frequency or --

MR. STEININGER: Better be.

MR. MATHEWS: To say a pathway is not credible, you need a very good -- well, it takes a very rigorous argument.

MR. WALLIS: I think you used the wrong word because you can get a better word than "credible."

MR. STEININGER: Low probability?

MR. WALLIS: It's very low probability.

MR. STEININGER: yeah.

MR. WALLIS: "Credible" sort of means no one could imagine it, which is rather different.

MR. MATHEWS: Well, we've already imagined it or it wouldn't be on the chart.

MR. STEININGER: Well, let's look at a bottom head nozzle, for example, at BWR. You know, a bottom head nozzle can't eject completely because of the platforms there. So it's a not credible event.

For the bond to head nozzle on a PWR, could be ejected. You could have a nozzle ejection on a PWR bond to head nozzle. So one is not credible, and these obviously are credible. That's what I think we meant.

Physically you can't establish the event.

MR. WALLIS: It's impossible?

MR. STEININGER: Yes. That's what I think the author meant.

Okay, and then there's also the classification is not applicable, and this goes back to Larry's earlier comment. We go through this sequence of events. You put some action in early so that you don't get to the place where you don't want to be. So we would call that as a nonactionable, and obviously there are actionable inputs that you have to deal with, and that's all part of the overall plan.

And then finally you have a whole range of a number of you have been bringing up other factors that are involved in this whole process of FMEA, you know, stress intensity. There's environmental fatigue, fabrication practices of the nozzle.

You know, Peter would like for us to try to ferret that out. It's not clear that we can.

The condition of the inside surface cladding, primary water chemistry factors; the list goes on and on.

Okay. Next slide.

Okay. One of the things that's very crucial in this overall analysis is what you use to actually predict the crack or leak, predict when the crack gets to the point that it's unacceptable, or when do you actually experience a leak?

And we do that by looking at all of the field data or any lab data, and we apply an appropriate Weibull analysis. I think everybody is familiar with that.

An example of that is on the bottom, which is what we have used in our MRP 75. We have plants here which have manifested nozzle leakage at the top of the head, and we have plotted that on this Weibull curve.

We also have 42 other plants which did not, which did not experience any kind of head leakage, and we --

CO-CHAIRMAN FORD: Is this the --

MR. STEININGER: No, the next slide.

MR. POWERS: Is the Weibull distribution of any significance or it's just an empirical correlation?

MR. STEININGER: It's just empirical based on data that we have available from the field.

MR. POWERS: Does the curve ever get extrapolated or is it just fitting data points and you interpolate in between?

MR. STEININGER: That's correct. And I think you'll see this in MRP 75 or the technical basis document.

MR. WALLIS: You're really stretching things if you say the lines have much to do with the data really. There's far more series that you could concoct that would look better than that.

MR. STEININGER: Probably.

MR. MATHEWS: Well, this was a Weibull that was constructed with a given slope based upon --

MR. STEININGER: Lab data, other data.

MR. MATHEWS: -- other Weibull data on Alloy 600. You could put a different slope on the curve.

MR. STEININGER: And the other thing that I want to point out and I want to emphasize, like I said, there's 42 -- if I understand it correctly, there are 42 plants here in this plot which the plants actually did not exhibit leakage, but we put them in as though they had a leaker. This is one way that we've actually established conservatism in the overall process.

MR. WALLIS: What's the axial coordinate here?

MR. STEININGER: Cumulative fraction of

leaking nozzles of circ. crack near top of the weld.

MR. SHACK: It's effective degradation years on the X axis and the fraction of leaking welds on --

MR. WALLIS: Oh, it's degradation?

MR. SHACK: It's degradation years.

MR. WALLIS: Oh, I see it, way down on top of the cooling tower, right.

MR. MATHEWS: You said axial thought, didn't you?

MR. SHACK: Well, it's the horizontal axis.

MR. WALLIS: I thought it was part of the EPRI logo.

MR. STEININGER: It's becoming that.

MR. SHACK: It's becoming part of the EPRI logo.

(Laughter.)

MR. STEININGER: Okay, and the next slide.

Now we actually go through -- this is kind of the involved process that one has to go through just for simple nozzle ejection, and as you can see, you start out with the assessment. For example, the plant lab experience with PWSCC for Alloy 600; assessment of the processing fabrication differences;

compilation material properties; actual field experience for leakage.

You then go into your Weibull analysis, and you just go from left to right, as you can see the thought process here. You define your probability of detection or the detectability limits associated with leakage, for example. You have to assess what is the allowable circ. crack flaw size for the nozzle, and ultimately what you end up doing, as Larry indicated earlier, is you calculate a change to the core damage frequency, and you compare that change to what's allowable.

Maybe "allowable" is not the right term to use, but what is presented in Reg. Guide 1.174. And if you don't meet that recommendation, 1.174, you go back into the process to see what you can, in fact, change in order for you to meet that requirement.

For example, you may need better probability of detection, for example.

CO-CHAIRMAN FORD: Now, have you gone through this process?

MR. STEININGER: For nozzle ejection, yes.

CO-CHAIRMAN FORD: For nozzle ejection because of circ. --

MR. STEININGER: Correct.

CO-CHAIRMAN FORD: -- of the tube.

MR. STEININGER: And we went through a simplified variation of this at MRP 75.

CO-CHAIRMAN FORD: Did I ask -- I realize I'm jumping the gun here in terms of recommendations as to what we present at the fall meeting, but it would be very useful --

MR. STEININGER: We're not going to a full meeting.

CO-CHAIRMAN FORD: Pardon?

MR. STEININGER: Are we going to a full meeting?

PARTICIPANT: Fall.

MR. STEININGER: Oh, fall meeting.

MR. MATHEWS: If he asks, we will come back. Okay?

MR. POWERS: We already had that.

MS. WESTON: As in May.

CO-CHAIRMAN FORD: As in May.

MR. STEININGER: Oh, May meeting. Got you.

CO-CHAIRMAN FORD: My accent.

MR. STEININGER: I thought it was like tomorrow or something.

CO-CHAIRMAN FORD: My point is that this

is a great schema, schematic, having gone through this. Now, you have data for filling in these boxes. So if you're going to come up with the full or single dancing thing within a few minutes, somehow you should be able to show draft one of the actual use of this, actual applications, and a graph is worth 100 vugraphs, and show you as working through that because it's going to be --

(Laughter.)

MR. ROSEN: I'm having trouble understanding why Reg. Guide 1.174 is appropriate as a standard against which to measure your increase in core damage frequency that comes out of this.

Reg. Guide 1.174 has a spectrum depending on the core damage frequency for the plant, low, for instance, South Texas, very low core damage frequency estimate now. You are saying that that kind of plant might have a different reaction to what you come out of this than a plant that has a higher core datum. Is that --

MR. STEININGER: If I remember correctly, I thought 1.174 lists changes to core damage frequency, and if you have this amount of change you're okay.

MR. ROSEN: It's a function of the core

damage.

MR. STEININGER: Right, exactly. And if you have this amount of change it says NRC requires management review before you can do anything, and if you have this amount of change it says you're probably dead in the water, something like that.

MR. ROSEN: It's a delta CDF on the Y axis. You've got CDF on the X axis, and so that says that depending upon where you are on the X axis of a given plant, you can take different delta CDF. And you're suggesting applying that same schema to --

MR. STEININGER: Yeah, and I think the value we use is one times ten to the negative sixth change in CDF. If we're within that, we think we're --

MR. ROSEN: So it's really a number. It's not --

MR. STEININGER: It's a number. It's a number.

MR. ROSEN: You're not using the Reg. Guide 1.174 --

MR. STEININGER: No, no, no.

MR. ROSEN: -- schematic. It's a standard.

MR. STEININGER: Right.

MR. ROSEN: But delta CDF which is different --

MR. STEININGER: Right, delta CDF.

MR. ROSEN: So it's not going to be variable across the plants as a function of their CDF.

MR. MATHEWS: We hadn't looked at it in that way I don't think. We were just trying to -- we were targeting to get --

MR. KRESS: That's consistent with 1.174, at that level.

MR. ROSEN: At that level, but not a variable number depending on --

MR. WALLIS: I think you'll find that the uncertainties are large. You just don't have enough information in these boxes to be very sure of things, to really be sure that you report the uncertainty in the CDF. And if you do Weibull fit to the data you showed us on the previous curve, that's not a very certain curve. There's a lot of uncertainty about extrapolating that at all, and that's going to be reflected in what you report as a CDF.

MR. MATHEWS: Well, again, we have to appropriately account for that as the input to the PFM work and how that flows through the core damage frequency.

MR. STEININGER: You can sample the uncertainty associated with the Weibull plot, for example, when you do the analysis.

MR. WALLIS: That may tell you where you need to do some more work.

MR. STEININGER: Exactly. Okay. Getting off the nozzle ejection, go to the next slide, which is a hastily developed logic chart associated with this process as it relates to wastage on the top of the head, and that's obviously an area where we do have a lot of missing data, and as Peter knows, we're going out with an RFP to help us fill in many of the blocks that are stipulated here.

But, again, we did, in fact, do a probabilistic analysis for wastage at the top of the head, and that's documented at MRP 75. I mean, you can question the degree of uncertainty associated with the analysis, but it is there, and that's what we're going to have to reevaluate.

MR. WALLIS: Don't you have to do leakage before you do wastage? If you don't know how to assess leakage, leakage is a precursor to wastage. So how are you going to fit that in?

MR. STEININGER: Well, mild leakage, the degree of leakage is obviously going to affect --

MR. WALLIS: Yeah.

MR. STEININGER: -- the degree of wastage over a period of time. The degree of leakage is a function of the crack morphology, the crack geometric characteristics.

MR. WALLIS: Where does that appear in this --

MR. STEININGER: It's not in here.

MR. WALLIS: -- box diagram?

MR. STEININGER: It's not in there because we don't right now --

MR. WALLIS: You guys --

MR. MATHEWS: Isn't there something, I believe, in the planned additional boric acid testing --

MR. STEININGER: Yes.

MR. MATHEWS: -- that's going to speak to that?

MR. WALLIS: All right.

MR. MATHEWS: That program that we're launching. You're working on some, too, right?

MR. ROSEN: Well, to be kind, what I would say, Graham, is that it's inside this block that says "establishment of boric acid corrosion wastage rates," and all of that leakage --

MR. STEININGER: There's a lot that goes in that.

MR. ROSEN: There's a lot that goes in that block.

MR. STEININGER: That's right.

MR. WALLIS: What, do you mean the cracks go in there as well?

MR. STEININGER: Yes.

MR. WALLIS: All precursors go in there, too?

MR. MATHEWS: Leakage is a function of crack size, et cetera.

MR. ROSEN: You can go back to rabbit trail (phonetic), what Dave just laid out.

MR. STEININGER: Okay. The next slide.

So now we get down to the particular areas that we are working on or will be working on. Obviously the crack growth rate is a significant parameter. A number of people have already mentioned it.

We had an expert panel established to give us our best estimate as to what we should expect for crack growth and Alloy 600 base material. They are presently working on coming up with an expert judgment on what to expect in weld metal material, 182 and 82.

MR. ROSEN: Would Peter Ford recognize the names of any of the people?

MR. STEININGER: I would think so.

MR. MATHEWS: No, John Hickling (phonetic), do you know John? Peter Scott. I mean, there's --

CO-CHAIRMAN FORD: The answer is yes.

MR. STEININGER: Raj Pathan (phonetic), yeah, you know everyone.

MR. SHACK: Round up the usual suspects.

MR. MATHEWS: Yeah, that's exactly right. Lock them in a room and say, "Come on in here."

MR. POWERS: You didn't get it right the first time, right?

MR. STEININGER: And they are meeting. Bill, I think they are meeting at the March 28th or 29th, I think, here in Washington, D.C. -- I'm sorry. May, May, May.

PARTICIPANT: No, April.

MR. STEININGER: April.

MR. MATHEWS: I thought they were, yes, next week.

MR. STEININGER: And I think that's where they're going to have to figure out exactly --

MR. POWERS: There's a very broad

uncertainty distribution even in the meeting dates. The data is going to be really broad.

MR. MATHEWS: It's next week.

CO-CHAIRMAN FORD: Just to run it by me and others, the curve that's used for disposing of the cracks or disposition in the cracks is the 95 percentile of the data; is that correct?

MR. MATHEWS: It was 75th percentile.

CO-CHAIRMAN FORD: Seventy-fifth percentile.

MR. MATHEWS: I believe that was included in the latest flow evaluation guidelines that the NRC issued.

CO-CHAIRMAN FORD: Okay.

MR. STEININGER: And that was using MRP 75, right?

CO-CHAIRMAN FORD: Okay. Just to remind me.

MR. MATHEWS: It was MRP 75, yeah.

MR. CULLEN: Bill Cullen from the Office of Research.

The curve that's being used now officially is out of a Stroschneider (phonetic) letter from November, the year 2000, and I don't know where it is in the MRP scheme of things, but it's higher. It's a more conservative curve.

Is that right, Alan? No, maybe Alan is going to correct me on that.

MR. HISER: Actually we have issued revised flow evaluation guidelines. I don't remember the date on that. That incorporates the MRP 55, which we do, and the NRC has not completed its review of that report. So it's an interim curve at this point within those guidelines.

MR. STEININGER: But you haven't given us comments on that yet, have you? On MRP 55?

MR. HISER: No, we're still working on that.

MR. STEININGER: Okay.

MR. HISER: With relaxation requests and other things, it's --

MR. STEININGER: Yeah, I understand.

Okay. The next slide.

This was pointed out earlier today, I think, by Peter. Stress intensity factors is an important parameter, and as you probably know, NRC has done a lot of calculations on calculating the stress intensity around the weld, for example.

We've done that. We've compared notes, and from what I understand there's good agreement between NRC calculations, their contractor and ours.

MR. WALLIS: Well, my comment on this is there's an enormous amount of history of people studying cracks and stress intensity and so on. There's a huge technical base you have here. So you should be in reasonably good shape.

To get to your next slide --

MR. STEININGER: I think we're in better shape there than probably anywhere else.

MR. WALLIS: -- then you have a problem.

MR. STEININGER: Yeah, the next slide is where --

CO-CHAIRMAN FORD: No, no, no. Don't go on to the next slide yet. These are all calculations.

MR. STEININGER: Yeah.

CO-CHAIRMAN FORD: Now, as far as I remember, the only good base for evaluating those finite calculations are for pipes, from the BWR work. There's been a very small amount of work done on double V notch or very large pipes. What is the amount of data for more complicated J welds as a function of weld heating, welding speed, et cetera, et cetera? Is there any qualifying data for these calculations regardless of who does the calculation?

MR. MATHEWS: You're not looking at the

experts here.

MR. STEININGER: Yeah. It's beyond my knowledge base.

CO-CHAIRMAN FORD: Because the way I'm seeing the arguments going, hey, our calculations are really your calculations, but who is to say the calculations are any good for these particular geometries, which are very complex?

MR. STEININGER: I will say that what we hope to do in the North Anna examination is to do residual stress -- not residual stress -- stress intensity measurements, residual stress on the nozzle.

MR. SHACK: And there are measurements that were made by EDF and the Japanese back in the early '90s.

MR. CULLEN: That's the same answer I was going to give.

CO-CHAIRMAN FORD: And that was going to be my follow-up question. I know undoubtedly the EDF has done them, but I know the Japanese have done it. Have you made use of that data, those data?

MR. STEININGER: It's beyond my knowledge base. I don't know. We'll have to get back to you.

MR. MATHEWS: Probably, but I don't know.

CO-CHAIRMAN FORD: And the Japanese, I

know it was for --

MR. SHACK: They're reported in PWSCC workshops that EPRI held in, you know, '93-'94 time frame.

MR. MATHEWS: A lot of that had to do with steam generators thought.

MR. SHACK: No, no. This was when nozzle head cracking first appeared, you know. You have to remember the first incarnation of the problem.

MR. MATHEWS: Okay. And I'm sure the people that are working on it are aware of all the information that has been reported. Now, whether that data has specifically been factored into their models, I can't say that.

CO-CHAIRMAN FORD: And a follow-on question to that is: how is the uncertainty of these calculations factored into the prediction of the amount of crack growth? Because in one of the documents that you produced later on, I noticed that somebody said stress intensity has got not much to do with it, but I don't understand. One of your documents which I saw and was reading says --

MR. STEININGER: Yeah, I was hoping you didn't see that. I didn't write that.

CO-CHAIRMAN FORD: Stress intensity was

not that important or was not a major input to the calculations, and I wanted to know the foundation for that statement and whether it was, in fact, relevant or not.

MR. STEININGER: Well, on this whole area of stress intensity factor, that's the bottom bullet, I think. The one you're referring to is the bottom bullet.

I was going to try to skip over that one. I'm sorry.

MR. SHACK: Well, if you believe the EDF data, Peter, it goes like K to .1 power.

CO-CHAIRMAN FORD: Well, yeah.

MR. STEININGER: Pretty flat.

MR. MATHEWS: The crack growth rate curves have a stress intensity factor dependence built into them, the ones that we have, but I guess what this bullet is saying is that when you look at the impact of changing that stress intensity factor dependence, it's not nearly as important as other parameters on determining the impact on the probability of nozzle ejection.

MR. STEININGER: Yeah, I think the uncertainty associated with stress intensity is the secondary factor. I don't think it's -- the probability of nozzle ejection is not being driven by the uncertainty associated with stress intensity factor. That's what I think the author was trying to say.

MR. SHACK: Yeah, you know, they vary with the yield stress of the weld, and if you look at the range of yield stresses that you could expect and how that affects the stress intensity factor, it changes your ejection probability by a factor of two, which considering all of your other uncertainties.

CO-CHAIRMAN FORD: It's just that statement by itself really worries me. It doesn't go according to history at least.

MR. STEININGER: It rubbed me the wrong way. I agree.

CO-CHAIRMAN FORD: Okay.

MR. STEININGER: Okay. If you go on to the next slide, which caused considerable discussion --

CO-CHAIRMAN FORD: Well, could I just --

MR. STEININGER: Sure.

CO-CHAIRMAN FORD: The NRR, do they believe that? When you say you're evaluating this report, does that worry you, that last statement?

MR. HISER: Well, regarding our review of the report, MRP 75, we provided preliminary comments to the industry. The industry, I believe, the December-January time frame withdrew the report. So we stopped our review.

CO-CHAIRMAN FORD: Okay, fine.

MR. STEININGER: Okay. Well, if you go to the next slide, which is the one that's probably going to generate even more discussion, that is the status report on boric acid corrosion testing. What have we done heretofore?

Well, essentially we thought we understood the process. We documented what we thought we understood in MRP 75, which is essentially a crack through the nozzle, leakage up through the annulus, boric acid, primary coolant sitting on the top of the head, and a top-down corrosion into the vessel, and that's what's presented in MRP 75.

And a probabilistic analysis associated with that process, a probabilistic analysis similar to what we do for nozzle ejection.

Subsequent to that, we actually established an expert panel to review the methodology and the conclusions, documented MRP 75, and that expert panel came back with a series of recommendations which we have documented or I should say used to write our request for proposal that's going out.

Has it gone out or will go out?

MR. MATHEWS: I think we've got some proposals back in.

MR. STEININGER: Yeah. Okay. So --

MR. MATHEWS: We haven't written a contract yet, but we're getting close, I believe.

MR. STEININGER: So that's the situation. We had the expert panel. They gave us the recommendations. We wrote the RFP.

CO-CHAIRMAN FORD: Well, looking at your first sub-bullet, analysis to understand the thermal hydraulic and chemical environment along the leak path, are there experiments in your RFP? And presumably, you know, somebody is awarded the contract, in that RFP does it call for thermal hydraulic calculations and follow-up work on what the chemical environment is?

MR. STEININGER: Yes. Do you have it with you?

MR. MATHEWS: It's broken into about four or five phases, and Phase 1 deals with steel corrosion in a stagnant or low flow primary water conditions.

MR. WALLIS: But you haven't got to that

yet. You've got to look at how the crack develops into a leak and how the crack gets big enough to have a big enough leak long before these other things happen.

The thing that puzzles me is why, for instance, at Davis-Besse we can get extensive wastage on one nozzle and the adjacent nozzle there is no wastage. So physically what is different between those two nozzles?

MR. MATHEWS: We believe it has got to do with the flow rate into the corroding area.

MR. WALLIS: Why?

MR. MATHEWS: Why what?

CO-CHAIRMAN FORD: Why is the flow rate important?

MR. MATHEWS: Well, the flow rate influences the amount of cooling that's going on and the state of the boric acid on top of the head at that point in time.

CO-CHAIRMAN FORD: Okay, but we hear this argument about evaporated cooling into a huge heat sink. It doesn't physically seem to make sense. Are the data to back up this for the same heat sink?

I know they have been done on a small specimen, but for a large --

MR. MATHEWS: Lab data I do not know. We've done finite element heat transfer modeling to model that and shown that it's in the .1 gpm rate. Through this geometry, you can cool the head sufficiently through evaporative cooling in the local area to maintain a liquid state.

CO-CHAIRMAN FORD: But you can't have one gpm.

MR. STEININGER: Point, one gpm.

CO-CHAIRMAN FORD: Oh, .1. I'm sorry.

MR. STEININGER: That was what was presented in MRP 75, and those were the results of a finite element model of the whole head with heat transfer through that.

CO-CHAIRMAN FORD: I've heard people saying with .1 gpm you would have tons of boric acid in the head.

MR. STEININGER: And they did.

(Laughter.)

CO-CHAIRMAN FORD: but that was cumulative over five years or so. I mean, can you get that flow rate?

MR. WALLIS: Well, my problem is how do you get from a crack? You know, the previous slide was a crack. So how do you get from a crack to a .1

gpm leak? There's a lot of things that have got to happen in the intermediate.

PARTICIPANT: That's right. It's got to grow.

MR. MATHEWS: And obviously we haven't gone through the detailed analysis.

MR. WALLIS: What I see missing in all of this is you have all of this stuff about cracks, and then there's this stuff about once you get enough of a leak, how does it at the head, but how do you go from that crack which hasn't leaked yet to a leak which is big enough?

CO-CHAIRMAN FORD: I guess what you're facing is at least two members here are reasonably technically competent.

(Laughter.)

MR. POWERS: Okay. Now, which two are we that are reasonably technically competent?

CO-CHAIRMAN FORD: The silent majority. There's another part to that statement.

Well, Graham and I, I think, are technically competent and yet we're having a gut feeling that there's something missing.

MR. MATHEWS: Is the thing that you're perceiving as missing is the flow rate as a function of crack size, crack morphology?

CO-CHAIRMAN FORD: Well, that; whether you can, in fact, cool down a thick, huge heat capacity low alloy steel even though it's a surface phenomenon I know you're talking about. Can you really do that?

Just a gut feeling tells me --

MR. WALLIS: I don't have your gut struggle. I think it's quite possible to do that, and I'll believe it when I see it. I believe that, you know, these guys are competent enough to do it. I'm inclined to believe their result.

But the problem I have is I don't know how you go from microscopic crack to this big leak. There's an awful lot of things that can happen in between. It may take years.

MR. MATHEWS: We think it does.

MR. WALLIS: But we don't know.

MR. MATHEWS: We agree. Well, that's the point in our crack growth rate testing, which there's been quite a bit of crack growth rate testing in base metal, and we've developed an MRP 55 to determine how those cracks will grow as a function of the stress intensity factors that are there in the nozzles, and that crack will grow, and if it grows through wall, then you can get a leak, and when it grows bigger, you can get a bigger leak.

Now, the details of that leak versus crack size, you know, I'm not sure we're going to try to go to those because there are so many different things that could be going on here.

MR. WALLIS: But does your crack growth analysis include the crack opening once it has gone through?

MR. MATHEWS: Well, it would have to if we're trying to predict the flow versus crack size.

MR. WALLIS: Is three an influence between the flow going through and the way in which this crack opens that doesn't want to influence the other?

MR. MATHEWS: Yeah. Well --

MR. WALLIS: And that's where this chemical environment --

MR. MATHEWS: The flow is certainly a function of how open the crack is and how long it is.

MR. WALLIS: And the chemical environment inside that crack as the flow is going through and evaporating and whatever it does in there. Presumably it evaporates inside the crack itself

MR. MATHEWS: Yeah, most of the pressure drop would be inside the crack.

CO-CHAIRMAN FORD: I'm sorry. The

question came up at the last full meeting when you gave a presentation, Larry, that from managing this situation, you have got to be able to predict why one nozzle wasted and the other one didn't in some sort of engineering terms.

MR. MATHEWS: Yeah.

CO-CHAIRMAN FORD: In terms of gap between the two components, the tube and the pressure vessel, or whatever the things that you can measure are. Can you predict why one nozzle erodes or corrodes and the other one does not?

Is that the end objective of this RFP?

MR. MATHEWS: That is certainly part of what we're going after in this RFP, is to understand the corrosion dynamics in this geometry and how it is influenced by all of the parameters, the flow rates, the chemistry, temperature, everything else, how all of those things feed into the corrosion dynamics.

And if you understand all of those details and we can refine whatever models we have or build new ones to try and account for what's different about Nozzle 3 and Nozzle 2. Why has three got a big cavity and two has got a small cavity and some other one has no cavity? Most of them have no cavity.

And so we need to understand that the

details of the corrosion dynamics, and that's what this program is aimed for. We've got the low flow conditions. We've got the expert panel said at least for the cavity formation, you need to take into consideration things that might be going on with impingement and/or flow accelerated corrosion and erosion.

And so those things because you can get a high velocity out of a tiny crack, and so we have Phase 2 is dealing with high flow primary water steam conditions. What happens to the corrosion rate of low alloy steel under those conditions?

And then some more separate effects tests in the liquid state, and then finally using all of that information to design appropriately and conduct some full scale mock-up testing. That's what the program is laid out to do right now.

CO-CHAIRMAN FORD: Okay.

MR. MATHEWS: And if it doesn't tell us why one does it and the other one doesn't, then we're still missing some data, but that's where we're going after, is to fully understand the corrosion dynamics in this geometry.

CO-CHAIRMAN FORD: And this prediction algorithm that you'll come up with will be finished in you said two years. So in May 2005 or thereabouts.

MR. MATHEWS: Probably. We have a proposed budget that goes through the rest of this year and all of '04, and it shows the full scale mock-up testing in '04.

MR. STEININGER: Okay. The last slide. Next. The last slide, Jim.

I think the operative bullet to look at is the second to the last one because that's our schedule, and as I indicated earlier, we expect the safety assessment to be done and a revised inspection plan by summer of 2003.

And you're right. If you're thinking about the wastage, it's not going to be done, and whatever is not done we'll have to attribute the appropriate uncertainties and conservatively take that into account.

CO-CHAIRMAN FORD: Okay. Thank you.

MR. MATHEWS: Preemptive.

MR. STEININGER: Okay. Do you want to continue on then?

CO-CHAIRMAN FORD: Yes, please.

MR. STEININGER: Okay. We'll go to the -- yes?

CO-CHAIRMAN FORD: Yes, you've got two

more?

MR. STEININGER: Well, one more from me and Tom.

CO-CHAIRMAN FORD: So you're going to cover the --

MR. STEININGER: Well, I'm going to cover the North Anna Unit 2 vessel head destructive examination, and this should be very quick.

The head is in the middle of the desert somewhere in Utah.

MR. MATHEWS: Clive, Utah.

MR. STEININGER: Where is it? Clyde?

MR. MATHEWS: Clive, C-l-i-v-e, is the town.

MR. STEININGER: Okay.

MR. MATHEWS: If you could call it a town.

MR. STEININGER: Okay. Jim, if you could just jump to the third, we'll skip the second. There's not need to go into the second. It's just waving the flag. No, the one before this.

Now, we've all said this a number of times today, but I'll have to say it again, and that is the process that we've been involved with for the last year or so, two years, has been nothing but surprise after surprise. People got rather upset, gave us strong direction to try to get ahead of the problem.

And when you try to get ahead of a problem like this, the first thing you identify is you're going to have to start destructively examining some of these things that you're dealing with instead of playing some kind of guessing games.

So the industry committed to destructively examine a portion of the North Anna 2 head, and that's what this presentation is all about. We're in the preliminary phases of it. We just released the contract or we identified the contractor to cut the head; is that correct, Larry?

MR. MATHEWS: Yes, yeah.

MR. STEININGER: So that's essentially where we're at, is that we've identified the contractor that will cut the head, and we're in the process of evaluating the responses to the RFP for the destructive examination of the nozzles themselves, right?

MR. MATHEWS: Right.

MR. STEININGER: So if you go to the next slide --

MR. POWERS: And you're going to try to measure residual stresses, too?

MR. STEININGER: Yeah, that was the plan.

MR. MATHEWS: That was part of it.

MR. STEININGER: Yeah, that was planned.

CO-CHAIRMAN FORD: That will just be by displacement

MR. STEININGER: That I don't know.

MR. MATHEWS: We may ask for innovative --

CO-CHAIRMAN FORD: An X-ray.

MR. MATHEWS: I'm not exactly sure what's in the RFP.

MR. STEININGER: I think the RFP listed a series of techniques that Al Macklery (phonetic) has used in the past and said, "Okay. Give us what you think is the best appropriate technique to use for this configuration."

So essentially what we're trying to do is a comprehensive metallurgical examination of the North Anna 2 head, the failed components; determine who caused the generic implications.

One of the prime goals is to establish an acceptable correlation between the NDE indications and as found defects.

The next slide shows, I believe, a conceptual shipping arrangement. I don't know why this is in here, but like I said, the head is in the desert in Clive, Utah.

MR. MATHEWS: Well, it kind of constrains how we can get two things to take it out of the head.

MR. STEININGER: Okay. Is that actually the way it was set up?

MR. MATHEWS: Yeah.

MR. STEININGER: Because it says "conceptual."

MR. MATHEWS: Well, the insulation is across here, and then there's a couple of shipping things that are boxed around. There's stuff down in here, but they're going to -- I believe they will go in through the top and cut sections of the head, nozzles and all, and reduce those down to shippable pieces and take them to a lab to do detailed sectioning.

One of our concerns with this sectioning process and cutting the nozzles out was to try and insure that we didn't destroy evidence, if you will, in the process of removing the nozzles, and to that end, you can't use water in the cell.

MR. SHACK: You can't do that --

MR. MATHEWS: No, we can't. We can't even use water cooling on a band -- you know, there's no water allowed in this process because of where it is in the cell in the burial site. And so that leaves you with a torch, and so we want to be careful that we don't destroy evidence in the process.

So we're doing mock-ups on the flame cutting and seeing how far away we've got to be to preserve the evidence.

And the other thing, you burn the carbon steel, but the stainless steel melts. So you've got to --

MR. POWERS: Can you use the laser cutting?

MR. MATHEWS: Laser?

MR. POWERS: Un-huh.

MR. MATHEWS: Nobody proposed that. Let me put it that way.

MR. STEININGER: Okay.

MR. POWERS: A more heat affected zone.

MR. MATHEWS: Huh?

MR. POWERS: Like a smaller heat affected zone.

MR. MATHEWS: Well, I think most of the people feel like we -- I can't oxy -- well, it's not oxyacetylene. It's a very powerful flame torch.

MR. WALLIS: So you make sure that if it's a heat affected zone when you do this it's small enough and then grind it off, and then you can look at something which has not been affected by your cutting person?

MR. MATHEWS: Well, we're going to take enough carbon steel around the nozzles of interest out so that when they take big plates out of several models and then cut those down some other --

MR. STEININGER: And then they take the chunks to a band saw someplace.

MR. MATHEWS: And the details of that the vendors are working out right now, and you've got to do it in a containment. So they have to build a containment building around it, things like that.

Anyway, we're going to section out nozzles and we're going to insure that our target was that the metal interface in the area of interest doesn't go over 600 Fahrenheit because it hasn't seen that for quite a while. So we want the flames, you know, far enough away that we don't destroy it.

We're building mock-ups to demonstrate those cutting techniques right now. In fact, the demos may be going on this week, I think. It's very soon. The demos will be done, and then they'll go to Utah and cut it.

MR. STEININGER: Okay. Go to the next

slide. Okay. WE're there.

These are the objectives of the destructive examination. First under the formation of the circumferential flaws in the outer diameter of the nozzle base material in that position relative to the flaws of the J groove weld, and I'll show you a schematic later on, what I'm talking about there.

Determine the most probable cause of initiation, propagation of the weld false. Characterize the final nozzle annulus operating environment prior to shutdown, and identify the associated corrosion mechanisms by analysis of the deposits found in the annulus.

Next slide.

Examine the previously repaired Nozzle 51 that exhibited visual evidence of renewed leakage in the following of the subsequent outage. Determine both the modes of degradation that resulted in leakage and the leak path through the pressure boundary.

Facilitate development of better understanding of the actual capability of current inspection techniques and technologies to detect the OD circumferential cracks in the base material, axial circumferential cracks in the weld material, et cetera.

That's what I mentioned earlier, to try to establish that relationship between physical reality and what NDE is telling us.

And if you go to the next slide, you'll see looking up towards Nozzle 54 a depiction of where we found cracking. That's looking up from the bottle on Nozzle 54.

And then if you go to the next slide, there's the three dimensional picture which puts this all together. It puts the indications at the bottom of the nozzle in relation to the indications that were picked up by NDE, and you can see that if you go to the far right, if you connect the bottom indication to the top indication, it's kind of -- thanks, Larry -- how the circ. crack -- well, it appears to be how the circ. crack formed, and it started in the weld material, and as you can see, it starts to propagate in the base material, and did it in a position such that you don't have resultant leakage into the annulus.

So if this turns out to be true, that's something that's, you know, something that you don't want to see because --

MR. MATHEWS: This and similar nozzles, if you think back to MRP 75, one of the basis premises of

MRP 75 was that visual inspections on the top of the head were an adequate inspection technique. This and similar nozzles which have developed circumferential flaws right near the root of the weld without penetrating into the annulus and developing leakage on top of the head certainly call into question the viability of a visual inspection as a long-term inspection technique.

MR. ROSEN: It's called the Stealth crack.

MR. MATHEWS: Yes. It's hit --

MR. ROSEN: Below your radar.

MR. MATHEWS: Right.

MR. STEININGER: This is scary.

MR. MATHEWS: And so because of that we said, well, we've got to pull 75 back as far as saying a visual inspection is the only thing you really need to do, and we're going now -- and we recommended that all plants do over the next few years a volumetric or an under the head NDE to find the base condition of their plant.

And in the process then we would be revising MRP 75 to come up with a recommendation that takes into account these phenomena, but in order to do that well, in the long run we really want to understand what happened here.

So we're pulling this nozzle and several other nozzles out to not only understand how you can grow one up through the weld and into the tube, a Stealth crack, if you will, but also to determine what we can about the propensity of these welds to crack. What is the actual cracking mechanism that was going on in this head?

And so we'll take several nozzles out of this head. I think six is our target, and we've picked out particular ones based on the NDE results and go section those and figure out what's going on there.

MR. STEININGER: Okay. The next slide gives you an example of how we tried to prioritize what we had to go after. What I've done here is I've shown what penetration we're going to go after and hopefully what kind of results that penetration is going to give us, what kind of information and how that information satisfies which objective that I just read to you.

CO-CHAIRMAN FORD: You get that Nozzles 51 and 63, repair weld. According to the incident report, it mentioned that this was repair welded with Alloy 52; is that correct?

MR. MATHEWS: Yes.

CO-CHAIRMAN FORD: And this is the alloy that's going to be used for all replacement heads.

MR. MATHEWS: Right, 52 or 152.

CO-CHAIRMAN FORD: One, fifty-two, yeah. so the news is not bad. Either it's the weld itself, 52, will crack easily when it's not environmentally assisted crack, or it will undergo cracking during the welding process.

MR. MATHEWS: You mean hot cracking?

CO-CHAIRMAN FORD: Hot cracking or -- yes.

Obviously I'm assuming that this analysis will show which of those bad messages it is.

MR. MATHEWS: We're going to find the leak path on these nozzles that were repaired on this one nozzle. One nozzle was well repaired and then leaked subsequently.

The utility believes that the weld repair -- and I think the vendor does, too -- the weld repair where they -- what they did was they overlaid the old weld, the 82-182 weld. They overlaid that with 52 weld metal. They did not remove --

CO-CHAIRMAN FORD: -- the leak path because they both leaked. So the leak path was through the hot cracked weld, 52 weld.

MR. MATHEWS: Right.

CO-CHAIRMAN FORD: Into a preexisting crack in 182.

MR. MATHEWS: Well, no, no. What the utility and the vendor believe, I believe, is that the weld repair did not cover all of the 82 material, and that the leak path is probably in the butter.

Basically you've got stainless steel clad that you're looking at at the bottom of the vessel. You've got stainless steel clad and then you've got a 182 butter material, which you should have roughly an oval of 182 butter material, and then you've got a weld to the tube of 82 or 182.

When they overlaid the previous weld with the new 52 material, the thought now is that they had seen flaws that they thought were out in the cladding when they PTed it because they did not fully understand the size of the weld and the butter that was there.

And so when they've gone back and etched it, and indeed, there is I believe it's 182 material outside the oval of the 52 overlay that they performed to seal the cracks, and so the thought is that they didn't seal the crack, didn't stop the leak path because they didn't go far enough out to get under the stainless.

CO-CHAIRMAN FORD: And that occurred in both welds, both repair welds, 52 and 63, I guess, the next one down. Yeah, 51 and 63.

MR. MATHEWS: I'd have to go back to the details, but --

CO-CHAIRMAN FORD: This is obviously going to come out one day after --

MR. MATHEWS: And that's our objective, is to go on these two. One of the objectives for those two nozzles is to find if that one is leaking. I can't remember -- whichever one is leaking, and maybe both of them. We're to find that leak path.

Was it through the new 690 material? Was it through the old butter that was not covered up by the weld repair?

CO-CHAIRMAN FORD: But regardless, Alloy 52 and 152 and 182 are not easily weldable. They're not easy welds to make. How extensive are the weld qualification process for items of this size, assemblies of this size?

MR. MATHEWS: I believe they've done quite a bit of demonstration of their welding processes now.

CO-CHAIRMAN FORD: Presumably from France; is that correct?

MR. MATHEWS: No, I think the guys who are doing these overlays have done their own. They had to qualify their own welding process.

CO-CHAIRMAN FORD: Okay. The reason I --

MR. MATHEWS: Men you've got to demonstrate your process before you weld on my plant or anybody else's.

CO-CHAIRMAN FORD: All I'm questioning here is you've got two weld repairs done. Both are thorough at 52 and both, assuming we don't find it in that covering, both have failed by one mechanism or other.

MR. MATHEWS: ell, I thought only one of them leaked again.

MR. STEININGER: The other one, 63 was masked. So they weren't sure whether there was leaking or not.

MR. MATHEWS: Okay.

MR. STEININGER: I have to remember that.

MR. MATHEWS: But I'll be honest with you. I think they feel quite confident that the 52 did not cover the entire 82-182. They've etched the surface, and as I recall they're quite confident that they did not.

CO-CHAIRMAN FORD: When is the examination finished? Did they say?

MR. MATHEWS: I don't know how long the hot cell stuff is going to take. I don't know. We're hoping it's by the end of the year, I think. I'm hoping it's by the end of the year, but I'm not in that bid process.

CO-CHAIRMAN FORD: Because there's a lot of plants thinking of to begin replacing heads involving this weld.

MR. MATHEWS: The 52?

CO-CHAIRMAN FORD: Yeah.

MR. MATHEWS: Absolutely, absolutely, and we need to know if that was the source of the leakage, but you know, I think everybody that has looked at the data feels quite confident that they did not do a repair that covered the entire 82-182 weld.

I'm sorry. Go to the microphone. That's true.

MR. SIMS: William Sims, Entergy Operations.

The leaking nozzle, they also pulled a boat sample on that to see the 52 and 82 material that's still left exposed.

MR. MATHEWS: Yes.

CO-CHAIRMAN FORD: They have pulled a boat sample?

MR. MATHEWS: Yes, yes. I forgot that. They did pull a boat sample on one of these that was subsequently leaking, and that's, I believe, where they got the information that clued me in that they didn't fully cover the original --

CO-CHAIRMAN FORD: You have the boat sample presumably?

MR. MATHEWS: Yes, but the boat sample did not capture, if I recall correctly, did not capture the leak path, but it did capture enough information about the materials to say the overlay did not cover the original 82-182 weld completely.

CO-CHAIRMAN FORD: And the boat sample contained 52 or the crack weld?

MR. STEININGER: That I don't remember.

MR. MATHEWS: There may have been some hot cracking. I don't know. I'll have to go back and dig that out, but you're right. Fifty-two and all of these nickel alloys are difficult stuff to weld with.

MR. STEININGER: Okay. If you go to the next overhead, you'll see the plate sections, depiction of the plate sections that we're probably going to take out and then took the individual nozzles out of the plate sections.

MR. MATHEWS: You know, this was the

original, and the details may depend on the mock-ups and how close we come to whatever nozzles of interest.

MR. STEININGER: And that's really all I have. The RFP I don't believe for the destructive examination has gone out yet.

MR. MATHEWS: Yeah, I believe that was waiting on the details of what nozzles are going to be available.

MR. STEININGER: They're working on it as we speak. Okay?

MR. SHACK: How difficult is the eddy current inspection of those welds? I mean, do you get a lot of artifacts the way you do in eddy current inspection of the steam generator?

MR. MATHEWS: Well, Tom's presentation is going to talk about a demonstration program, and I think it depends -- well, he'll tell you it depends a great deal on the weld surface condition.

MR. STEININGER: If it's really rough, you get a lot of liftoff. So you get a lot of artifacts with liftoff. That's all I know. That's my knowledge.

MR. MATHEWS: If it's ground smooth, which a lot of these welds are, --

MR. STEININGER: You see, a lot of these

are ground welds.

MR. MATHEWS: Yeah.

MR. STEININGER: So for the new heads you have to make that determination, you know: leave it as welded there or are you going to ground it off so you can inspect it?

MR. MATHEWS: But even nowadays the even as welded condition is a lot smoother than it used to be.

CO-CHAIRMAN FORD: Tom, could I ask you roughly, bearing in mind the density of questions we're having here, how do you long you reckon you will be? I'm talking about break for lunch now or wait.

MR. ALLEY: I probably have about 30 minutes worth of material, but then again it depends upon the questions that you pose. There's been a lot of NDE questions. So I really don't know how to answer that.

CO-CHAIRMAN FORD: What's the view of everybody? Do you want to go for lunch now?

No, keep going.

MR. ALLEY: Okay. I'm Tom Alley with Duke Energy, and I chair the Alloy 600 ITG inspection working group.

So we're here today to present an outline of the inspection committee's activities over the last year, maybe even going back two years to give you an idea and a feel for the demonstration process, the techniques, and what we've done to do that.

I want to go back and cover a few of the CRDM issues, a little bit of the background. We've heard some of that already. So I'll be brief on that.

We have produced a visual exam guidance document which I'd like to introduce you to briefly.

The MRP approach to the NDE demonstrations, how the demonstrations are organized, processed and thoughts that went into the demonstration protocols and inspections themselves.

Go over the 2001 demonstration process and results, the 2002 demonstration process and results, and then future activities.

We've already heard a little bit of background with regards to the initial industry issues that we had that prompted 9701 response, which is cracks initiating on the ID of the tubes. This was the European experience. The demonstrations and protocols then mostly involve the eddy current examinations of the tube IDs supported by ultrasonics.

And as has already been mentioned, the events at Oconee with tube OD cracking and then subsequently later on weld cracking caused us to identify need to modify the NDE demonstrations that were done years before, and we're also doing it in a mode that required rapid development and deployment and adaption of existing equipment to respond to an industry need that was identified at Oconee.

We've already had some discussion here again that the visual evidence and leakage on the head vastly differed from what we initially thought. We initially thought there would be large piles of boron on the head when these nozzles tended to leak, and instead at Oconee we saw about a half a cubic inch. So there was a paradigm shift there with regards to what we expected.

The first phase of the MRP demonstrations that were available to support the fall outages of 2001, that was a rapid effort that took place in about three months to try to get that off the ground and go on --

MR. WALLIS: Why did you think you'd find more leakage?

MR. ALLEY: It was postulated that the leaks would --

MR. WALLIS: Would grow very rapidly?

MR. ALLEY: Just the pressure and the

moisture and going through the --

MR. SHACK: You've got to remember .001 gpm gives you 15 pounds of boron per year.

MR. WALLIS: But you're going to get to that big a leak from a crack.

MR. ALLEY: Well, .001 gpm isn't exactly gushing.

MR. ALLEY: We really expected to see a lot more boron on the head than what we saw at Oconee. That was somewhat of a shift in what we expected to see.

MR. WALLIS: How big a hole does that correspond to?

MR. SHACK: Point, zero, zero, one? Depends on the stress state, but you know, a half inch crack, something like that.

MR. WALLIS: No, but how wide?

MR. ALLEY: These cracks are very tight, and they meander through the material. It's not like a fatigue crack where it's straight across. It's got pretty much of a Lambert flow through there.

MR. WALLIS: -- through the media?

MR. ALLEY: I don't know how to answer your question, but they don't tend to leak very much from what we've seen so far, and Larry can maybe address that better than I.

But the first phase of the MRP demonstrations were oriented toward the detection of safety significant flaws, the big axial flaws and the circumferential flaws is where the initial focus was.

The second phase, which was a year later, we started looking in the J groove welds because by then we had the well cracking experience. We wanted to get more information on the depth sizing and things and the tube metal itself.

The next slide is just a brief introduction to the visual examination guidance that was published. We had a meeting in August of 2001. One of the main topics in that meeting was to present visual evidence what utilities had seen on top of the head during these visual inspections. We certainly got a number of phone calls at Duke with regards to what did you see, how did you see it.

This small boron deposit, this popcorn, you know, what's popcorn? We got a lot of questions like that. So the MRP initiated a project at that point in time to go around and collect pictures that people had of various experiences they had and make sure that we get that communicated to the industry so that personnel that were going to go on top of the head to do inspections were beginning to see what other folks were detecting.

That document is now periodically updated. I think we're probably working on Revision 3 now. It doesn't really have a time schedule. It's whenever some visual events tend to indicate there's something different here.

Lessons learned, we've learned about paint. We've learned about dye penetrant developer sprayed on nozzles and things. We try to communicate those lessons learned to the industry.

There's a good picture of the popcorn presentation there in the top slide. And the lower slide is just what industry refers to as spaghetti strings. We see the boron is --

MR. WALLIS: It kind of looks like a leak, but when is it not a leak? How clean does it have to be before you say it's not a leak? That's the question I would have.

MR. ALLEY: On the nozzles themselves, the industry is pretty much settled in on a description of no indication at all or a masked nozzle or a leaking nozzle. A masked nozzle would be a nozzle that contains boron deposits around there that could have come from other locations on --

MR. WALLIS: -- has to tell you something about magnification, you know, using with your telescope or whatever you're suing?

MR. ALLEY: Most of these are done visually or a camera on a stick. There are some robotic examinations that are done.

MR. WALLIS: They're pretty crude in terms of resolution.

MR. ALLEY: Yes.

MR. ROSEN: Well, I don't think so. The ones that are done by a robotic crawler are actually very good, the ones I've seen.

MR. ALLEY: Yeah, it's whatever technique you can use to get up there and get the best view.

MR. MATHEWS: I think the gap is like 30 mils or so, and it looks like a canyon on some of the robotic crawler -- in fact, you have to kind of back off and take a little bit further look so that you don't fool yourself. Things that look like they're a grain of sand looks like a boulder on some of them, depending on the technology you're using.

MR. SHACK: What's the spaghetti one? I hadn't seen that one.

MR. ALLEY: I don't know. Can you show that up again? And that's upside down, I believe. We can turn it over, but --

MR. WALLIS: It has been extruded from a hole.

MR. ALLEY: Yeah, and we've seen that at several different locations or different utilities that had experienced this spaghetti string looking deposit that's coming from the annulus area.

Again, we wanted to communicate that to the industry. The first time somebody saw it and referred to it, everybody was wanting to know what's spaghetti strings. So we put these in a visual guidance again and showed pictures of that.

MR. ROSEN: That's the first picture of that I've ever seen. Is it rare?

MR. ALLEY: I won't say it's rare. It's not as common as the popcorn type deposits, but there have been, you know, more than one occurrence of this.

MR. WALLIS: You're probably got macaroni and all kinds of things.

MR. ALLEY: Yeah, we've got all kinds of names for things.

So we do have a document that we -- and a CD and a videotape -- that has gone out to the industry. People review that before their inspectors go in to do visual inspections of the head.

MR. WALLIS: Well, you're saying that this is the sign of a leak. Now, you're implying that anything that comes out of the leak and solidifies will be stay there and won't get blown away. Suppose you have a leak that's tossing out particles or boric acid but they're not sticking. You wouldn't see that, would you?

MR. ALLEY: Well, you'll see other signs of boron deposits on the head.

MR. WALLIS: You would? I don't know. I don't know. I can imagine a hole which is simply spewing out bullets instead of spaghetti.

MR. ALLEY: We certainly haven't seen any of that, nor have we seen that in the NDE results that indicate that we have nozzles that are acting like that, that we don't have visual evidence of.

MR. WALLIS: Well, I know, but you see the point. I mean, we don't really know all of the possibilities when you get a leak in the form of the solidified or otherwise boric acid is coming out.

MR. ALLEY: And we recognize that. That's why this document has been revised twice now, because we continue to learn. As we do inspections, we continue to learn and want to communicate that to the industry.

MR. SHACK: but you've got a lot more volume now. Did you find anything in your volumetric inspections this spring that would indicate a through wall crack that you didn't see visually?

MR. ALLEY: I don't understand your question.

MR. SHACK: You did a lot of volumetric inspections in the spring inspections. Did you find any through wall cracks that did not produce a visual indication?

MR. ALLEY: No. We have some that are being debated, but again, NDE is not exact science. So it's debatable as to whether or not the crack went right up to the edge or actually went through wall and we're still having some of those debates.

I can only think of one case where that's really being debated. Can you think of another?

MR. MATHEWS: Well, the other situation is the one that just doesn't leak, like North Anna, the Stealth crack.

MR. ALLEY: Right.

MR. MATHEWS: And you know, you can find it with NDE/UT, but if it doesn't penetrate the annulus, you won't have a leak.

MR. ROSEN: Right. It hasn't gone through the surface.

MR. MATHEWS: Right.

MR. ROSEN: So there's no leak path to the surface.

MR. MATHEWS: Yeah, exactly. So it takes some other technique besides visual to find it, and that's why we're saying that we've got to go back and look at the basis for 75.

MR. ALLEY: And to skip from the visual document, the approach that MRT has taken to demonstrations, we work very close with the reactor vessel head working group. That group defines to the NDE committee relevant flaw mechanisms, the SEC or BWSCC, fatigue, whatever those mechanisms might be. They communicate that to the inspections committee. They define the inspection locations in volumes, are interested in weld metal tubes, define the range of flaws that they wish to address in the mock-ups.

The inspection working group works on the approach that we will take to demonstration and we'll go into some details on that. Mock-up design and procurement, we'll go into some additional details on that.

Specification for the flaws in the mock-ups, the realism of the flaws in the mock-ups --

MR. WALLIS: Are you going to be trying to duplicate spaghetti and popcorn in these experiments?

MR. ALLEY: We have skipped here to the volumetric stuff. So now we're talking about the flaws as they appear in the nozzles and the tube and the weld. This is for ultrasonic purpose and eddy current purposes now for a visual.

MR. WALLIS: Okay. So you're still on cracks then.

MR. ALLEY: We're on cracks.

And then we developed a demonstration protocol of the schedules to work with the various vendors. There was a Tiger team that was put together of key individuals from both the working head group and the inspection group.

MR. WALLIS: Do these give false indications sometimes?

MR. ALLEY: Certainly.

MR. WALLIS: How do you sort that out?

MR. ALLEY: It's a very difficult task.

MR. WALLIS: It could be that many of these flaws which were reported earlier this morning are simply false indication.

MR. ALLEY: Well, typically in an NDE you would like to have more than one piece of information that you rely on when you're going to make conclusions with your NDE for that reason. We don't always have that luxury, but we certainly look for that.

You like to see the visual signs of leakage on the head supported by volumetric examination that finds flaws. You feel very confident about those results.

If you only have one NDE discipline, then your confidence in a result can tend to be --

MR. WALLIS: So you really want to detect them before they leak, don't you?

MR. ALLEY: That would be the preference, yes. Again, you like to have eddy current results and ultrasonic results. You like to have overlaying results because there is the potential for false calls, and it's not necessarily a small potential.

So the Tiger team got together, which was key individuals from the head working group and the inspection working group to design the next generation of mock-ups, and again, we'll get into some more details on that.

If we look at the demonstration process, there's several characteristics of these demonstrations that have been consistent ever since the 9701 response. One of those is tha these are blind mock-ups. The inspection vendors are asked to examine these mock-ups without knowing the location, size, and orientation of the flaws. We demonstrate the procedure so that it's application of the procedure. We make sure that the procedure is followed and it contains the essential variables.

We try to demonstrate the best available techniques. As we mentioned earlier, this is an evolving inspection, and it is changing with every outage season actually.

The ASME codes should drive out the technique and personnel qualifications. This is not a qualification process. We are not out there trying to qualify vendors, and as I'll mention later, nor do we have an acceptance criteria. Those are left up to code committees.

We're trying to demonstrate the state of the art with regards to inspections. We're trying to define the limits of the inspections, but we're not trying to qualify the person at all.

MR. WALLIS: Do you have some specifications for the sensitivity of these detection techniques?

MR. ALLEY: We don't specify sensitivity levels. The vendors work with their test pieces and mock-ups to understand the sensitivities. What we do is report back to the utilities and the end users of this technology what these techniques are capable of delivering.

We tried not to design the test. We leave that to the vendors. What we're trying to do is define the boundaries of the test.

MR. WALLIS: So you report to them that they failed to detect ten percent of the flaws. They don't really know whether this is the fault of the way the personnel did the test or the sensitivity of their device or something else.

MR. ALLEY: Well, again, what we do is we look at their procedure and make sure they followed the procedure. The calls that are made on whether a flaw is real or false or the size or the depth or the length is spelled out in the procedures. We do monitor that process to make sure that the procedures and the calls are done in accordance with the process that they've outlined, and again, we've defined the boundaries of that process and the results.

MR. WALLIS: So you're talking about -- I'm a little bit puzzled. This procedure demonstration, there are no acceptance criteria.

MR. ALLEY: That's correct.

MR. WALLIS: And you don't qualify the people or the technique

MR. ALLEY: That's correct.

MR. WALLIS: At what point does the industry take responsibility?

MR. ALLEY: Well, the ASME code committees need to drive that out. What we're, again, trying to do, and these procedures are evolving. They're quite a bit different today than they were two years ago.

We're trying to define the boundaries of the procedure, and these demonstrations are set up to do that. The acceptance of that procedure for use on these heads is utility specific, and we'll get into a little more details with regards to that as far as the information utilities are provided here.

CO-CHAIRMAN FORD: So when the order goes out to inspect, for instance, as it just has or for the fall outages, who sets the criteria for the people and the technique?

MR. ALLEY: It's normally worded that the techniques will be demonstrated through the MRP protocol.

CO-CHAIRMAN FORD: So you do set the acceptance criteria.

MR. ALLEY: Well, the acceptance criteria is that the boundaries have been defined, but not what those boundaries are. We don't say that you've got to have a minimum detection limit of ten percent through the wall. We don't get to that.

What we're saying is that you have to define what your boundaries are as part of this process. You need to understand we've got maybe four players in this ball game. So there's not a lot of vendors that are out there going through this protocol.

CO-CHAIRMAN FORD: So there's no acceptance criteria of the crack depth, seven inches plus or minus, that has been done by a qualified person.

MR. ALLEY: No, sir.

CO-CHAIRMAN FORD: And there's no information on the probability of detection.

MR. ALLEY: No, sir. Again, we were trying to set the boundaries of this exam. We did have a discussion, which we'll talk about perhaps in a minute, with the Tiger team about probability of detection. That actually requires a different set of mock-ups with different flaw orientations and different numbers of flaws and sizes of flaws.

Again, we're pushing the boundaries of

these inspections right now just trying to define the limits.

CO-CHAIRMAN FORD: So when are you going through your decision path that you showed on the evaluating cracking and then applying eventually Reg. Guide 1.174?

There's no uncertainties at all then.

MR. ALLEY: Normally what's looked at is the minimum detection limit, and we detected that 100 percent of the time, but what we didn't do is go back and repeat that exam ten, 15, 20 times to make sure that it's detected every single time. Again, that's where you start shifting protocols when you start addressing the POD.

We're trying to set the boundaries of the examination now. It may be later that we do address POD, but to try to do all of that at one time and develop the techniques did not seem to be a very good goal.

So when we report, we would report minimum detectability. Then normally the inspection committee and these people looking at assessment would assume that false highs or however they want to do that, and the statisticians can draw some POD from the flaws that we've got here, although it may have a fairly wide variance.

MR. SHACK: In MRP 75 you assumed a failure to not detect at like .08. Does that number --

MR. MATHEWS: I thought it was much higher than --

MR. SHACK: Much higher than that?

MR. MATHEWS: Yeah. I thought the volumetric failure to detect was much higher than that. I'd have to pull the document and look.

The visual was -- I know on the visual it was like only a 60 percent probability of detection, and then if you missed it the next time, it was like 20 percent of that. So you only had like a 12 percent probability of picking it up a second outage.

On the volumetric, he had put in some kind of POD curve based on vessel stuff, but I thought it was more than an eight percent. It might have been eight percent. I'm not sure. I'd have to pull that out for the peak. I mean, that was just an assumption.

CO-CHAIRMAN FORD: Alan, when you get up later tomorrow, I guess, will you be addressing these issues?

MR. HISER: These issues, can you

enumerate what "these issues" --

CO-CHAIRMAN FORD: Well, the issues that I just brought up, the question of what acceptance criteria is that the NRC is expecting.

MR. HISER: Well, we have reviewed the demonstrations that the various vendors have been able to perform. We have reviewed the MRP documents that specify what the performance was, and we have found those to be acceptable to providing, you know, the reasonable assurance kind of level of inspection.

CO-CHAIRMAN FORD: Okay.

MR. HISER: So bottom line, we found the inspections and the way they've been able to demonstrate those to be to be acceptable.

MR. ALLEY: We know the ASME is working on this, and that's usually an organization that drives out in the industry the personnel qualifications and accepted standards for things. So we're looking to the ASME to drive that out if it's going to happen.

Again, what we're trying to do is define the boundaries of the exams.

MR. HISER: And at this point the NRC has found those boundaries to be acceptable. The problem is the ASME code is not able to turn as quickly as the industry is and we're able to do.

CO-CHAIRMAN FORD: So do we keep pointing in the other direction as to it's the NRC, no, it's the MRP, no, it's the industry, no, it's ASME?

MR. HISER: Well, I think the MRP provides a report card on what the vendors are able to do, and we find that the grades so far have provided acceptable inspections.

CO-CHAIRMAN FORD: Okay.

MR. HISER: Ultimately the ASME codes should be the ones that should become a more automated process within the ASME code, but we're not there yet.

CO-CHAIRMAN FORD: Okay. Thank you.

MR. ALLEY: Okay. To carry on, the demonstration process, the protocol that was developed, the vendors collected data on the mock-ups and reported the findings. We evaluate the measure versus the true values of the flaws.

The detection of the number of flaws versus total flaws; the location with respect to pressure boundaries. Sizing results are documented. False call performance is documented.

The NDE center documents the essential variables. Again, we talked about this in the procedure. There's things in the procedure, the way you set your sensitivities, the transducers that are being used, angles, frequencies, those are essential variables as defined by ASME and some other areas. Those essential variables are documented as part of the procedure review.

We verify that the vendors are actually using the procedures and the essential variables that were reported in the procedures.

MR. WALLIS: I have no idea about this process. Is this a process where the technician manipulates a lot of things, and he flips on a screen and has to interpret them, or is there a computer that analyzes all kind of stuff and gives him an image of what the flaws look like in some way?

MR. ALLEY: Probably more the first point, as in they see, as you see, blips on the screen. That's all computer enhanced and all of that, but they have to -- in their procedure, they have to spell out their decision making process, and it has to be consistent. It has to be applicable to A inspector or B inspector or C inspector. They have to follow the procedure.

So the procedure will say: if you see a blip in this location and it has this orientation and this definition to it, you call it a crack or you call it a false call.

Those are the essential variables in the analysis part of the procedure.

MR. WALLIS: -- ultimate judgment of the person.

MR. ALLEY: Well, in the application of the procedure it's not as much personal judgment as it is the application of the procedure. The procedure spells out the decision making. We try to keep it immune from this black box, and we don't look in it and pull an answer out.

The procedure has to spell out the logic that you follow to get to that answer, and that has to be consistent form one person to the next. Theoretically that procedure should be able to be followed by any inspector and they would get the same answer consistently.

It's the same basic protocol that's followed with the ASME Section 11, Appendix 8 PDI process. You demonstrate the procedures. You demonstrate the adequacy of the procedures to do it. You take out as much of the human error or human judgment part of this as you possibly can.

And then to summarize, the results are given to the utilities.

MR. POWERS: Well, I guess I'm -- why the emphasis on getting the human judgment out? There are only four vendors that are doing this. One guy is just really good. He looks at and is communicative about what he sees.

MR. ALLEY: Well, you'll certainly find utilities expressing an interest to have one inspector or one person on their site versus another. So it gets to be a word of mouth idea, but what we're trying to demonstrate here is the capabilities of the equipment and the capabilities of the procedures, not the capabilities of the individual.

If the procedures and the equipment are capable of detecting and locating sizing and detecting these flaws, then we have demonstrated that we have adequate techniques to do that.

The next part of that may go into the personnel qualification piece of this, how someone applies the procedure, but right now we're trying to demonstrate the capabilities of the procedures and the techniques.

MR. HISER: Dr. Ford, just one other point. Where the NRC gets involved in this, for in-plant implementation of inspections we have a temporary instruction that's used by either the residents or regional staff to oversee and evaluate the implementation of the inspections. They go back and verify that the essential variables that are used at the plant are consistent with what the vendor demonstrated.

So there is that level of review and evaluation as well that the NRC does on these inspections.

CO-CHAIRMAN FORD: I was hoping to see a plot of actual crack depth and location versus measured crack depth and location.

MR. ALLEY: I have some results to share with you, but we don't have that plot. That's the POD data you're actually looking for.

CO-CHAIRMAN FORD: But such plots do exist.

MR. ALLEY: They exist with some techniques and some processes. That's true. That was not the goal of this process, to define a bounds of probability of detection as indicated in a least squares fit and all of that. That was not the goal of this demonstration process.

CO-CHAIRMAN FORD: Well, reassure me that, for instance, if someone goes in and looks at North Anna or any reactor and they size a crack, what makes me think that I should believe that?

MR. ALLEY: They have demonstrated on these mock-ups that their sizing has a certain error associated with it. We have enough different size flaws in there to say that they found this flaw and that they size it X. We have data to support the fact that they had the capabilities to do that.

What we don't have is the error defined associated with that.

CO-CHAIRMAN FORD: Okay. So one of the four teams goes in and does such a measurement.

MR. ALLEY: Un-huh.

CO-CHAIRMAN FORD: And it agrees to within a certain tolerance of the actual --

MR. ALLEY: Well, that's some --

CO-CHAIRMAN FORD: -- and then they're okay.

MR. ALLEY: That's some of what we're hoping to drive out when we cut up these North Anna pieces. I mean, ideally you'd like to have the destructive analysis to go along with the NDE findings. This environment is very tough to do that, and so we don't have that analysis, and that's what we're hoping to get out of the North Anna heads.

We are asking all of the vendors to go

through and reexamine the North Anna nozzles prior to sectioning so that we will now be able to get a better feel for what we're actually seeing versus what we're actually detecting, and it may be that we evolve to this point you're talking about now.

Right now we're pushing the boundaries of the capabilities of the vendors to even get sound energy in these things and get data out. So we're trying to define those boundaries.

CO-CHAIRMAN FORD: Okay.

MR. ALLEY: I mean, you're talking probably a more mature program here versus one that's still evolving.

MR. WALLIS: Doesn't it really depend on how you're acoustically coupled to the thing you're looking at?

MR. ALLEY: Certainly, and that's one of the things that the demonstration has done, and this has been a very valuable experience for everyone involved in this. And I've got some pictures later on that will show you we simulated the nozzles through the heads with the J groove welds that cause distortion on these nozzles. They're not perfectly round on the ID, and what we saw many of the vendors do as part of this process, they were at one time scanning in the circumferential direction in what's called a raster scan. They would scan the increment and scan the increment, and what we saw was the way they were losing coupling when they would go over some distortion in the weld.

Now most of the vendors are scanning in the up and down direction. Okay? So those are the things that were driving through as a result of this demonstration process. This is not only to demonstrate the techniques. It's to improve the techniques, and we've got some things I'll talk about later on that we're doing to even further that some more.

As we mentioned before, it's a very complicated weld examination volume. It's very, very difficult to inspect the weld metal itself. It's very, very difficult to inspect through the tube into the weld metal.

They're asymmetrical welds, which adds the whole geometry factor to it. So it's just not a very easy environment to inspect.

There's a whole host of different probes and carriages and schemes of which you can go about inspecting. There's open tube probes. This is when the internals are pulled from the drives and you have an open diameter tube that you can now inspect. When you have that luxury, you can now deploy a big scanner that's got multiple probes and multiple transducers and eddy current probes and all of that stuff on one scanner and actually go in and interrogate the volume.

In service we typically use blade probes, and a blade probe is like a probe on a Venetian blind. We have to get in between the other components in there, and some of these areas I think Al will talk about tomorrow. I think some of these relief requests have to do with restricted areas. Things are not perfectly concentric. So there's the thermal sleeves and the lead screws and the stuff will push to one side or the other and you jam blade probes and these types of issues we're having to deal with in actually implementing these things in the field.

MR. ROSEN: Isn't it another confusion factor that each nozzle is different in terms of where it is on the circumference? The degree of ovality is changing --

MR. ALLEY: That is certainly an issue.

MR. ROSEN: -- as you go from the center to the outside periphery.

MR. ALLEY: Yes, and then one of the things that we also wanted to demonstrate here is the ability to map the weld because you've got to know where you are on that weld itself. And, again, they're asymmetrical.

There are some that are on the higher slope, lower sides, and of course, the one on number one nozzle is pretty concentric. So all of those variables make this somewhat difficult.

And probes are designed to accomplish specific objectives. The specific volumes, flaw orientations, detection techniques. There's quarter traps, tip diffractions. There's just a number of different schemes that we can use to interrogate this volume.

MR. WALLIS: All of these are qualitative arguments. I'd like to go back a bit before. I used to have some sort of a quantitative demonstration of what's actually being measured versus what's there. What are the sources of error, and so on?

That could probably be put into one or two slides.

MR. ALLEY: I've got some summary slides to show you some typical results. We can certainly compare the true versus the indicated size on a given flaw, but again, what we don't have, in a statistical word, you'd like to run that a number of times to be able to see what that error band is.

We know that the vendors have oversized or under sized flaws. We have information and data to support that, but in reality the way you apply this, too, is typically this is a detection. If you detect these flaws in these nozzles, most utilities are going to invoke a repair immediately. So it's almost a detection game.

Whether you size or under size or oversize a flaw to a relative degree doesn't really matter in reality. We repair them.

MR. MATHEWS: There have been a few that have been left in service for one cycle, but believe me, the UT data get scrutinized to the hilt to come up with is it okay to leave this flaw in service for a cycle. Is it going to grow through wall or grow 75 percent through wall?

And the NRC is buying off on that.

CO-CHAIRMAN FORD: So the ASME 11 book are relying under the flaw -- it doesn't exist.

MR. ALLEY: The only place we have a --

CO-CHAIRMAN FORD: If you find a flaw, you replace.

MR. ALLEY: The only place we have a --

MR. MATHEWS: I said some have been left

in service. Very shallow ID flaws may be left in service for a period of time.

MR. WALLIS: Okay.

MR. SHACK: The next, shallow axials?

MR. MATHEWS: Yeah, I don't believe there's any that have been left in service.

MR. ALLEY: Yeah, shallow axial flaws which were typical of what we saw back in the 9701. There is some analysis to allow you reasonable times to reinspect those flaws, but once you get on the OD of the tube and then the weld metal of the tube, detection really is what you're trying to accomplish.

Okay. More than one probe, as mentioned before, can be used to examine a volume, particularly when we're dealing with blade probes. It's a decision to make with regard to which blade probe you want to deploy in trading off the sensitivity of one blade probe versus another.

CO-CHAIRMAN FORD: Just to go back to Graham's point, if you have such a presentation at the full committee meeting in a couple of weeks' time rather than all of these word slides, a graph of real versus observed or observed versus actual --

MR. ALLEY: Okay.

CO-CHAIRMAN FORD: -- it would be very

helpful.

MR. ALLEY: Okay. Let's regress just slightly and talk a little bit more about the 2001 demo process. Again, we were looking for the safety significant flaws in the two base metals.

The mock-ups consisted of two different mock-up blocks or samples. One was the stub-in pieces off the Oconee penetration tubes, and I've got a picture to show you there.

The concept behind that was to demonstrate that the ultrasonic techniques were capable of detecting a cracked HIP, and this was a real PWSCC. So you actually did -- the vendors did hand scanning on this block to show that they could detect the cracked HIPs, which is the primary mode that we're using for detection.

We had a good range of flaw sizes in the Oconee pieces which you'll observe in just a minute. Then we had a full scale mock-up, and that full scale mock-up contained EDM notches, which are not particularly challenging in the NDE world.

At the same time, this is where we started taking into account distortion issues, access to the nozzle, scanning rates, patterns, those sorts of mechanical devices probably as much as ultrasonic devices were demoed as part of that.

MR. SHACK: Now, these EDM notches, did you try to squeeze them down, tighten them up at all?

MR. ALLEY: This was the first round. So these were EDM notches, and we did use squeeze notches on the second round, which I'll discuss that in just a few moments.

We had flaws located relative to the weld. We had some cluster tight flaws, notches. In this case we call them flaws, but notches. We had triple point indications or notches in the triple point area. Again, I've already mentioned we used EDM notches, and the initial demo here was blind, but immediately after the vendor turned over the results, we unfolded the scales on the keys to the blocks. We were able to now negotiate with the vendor with regards to what they detected and what they found, a very helpful exercise in developing the techniques.

MR. POWERS: I don't understand what you mean, "negotiate." I mean you either found something or you didn't.

MR. ALLEY: Well, you can try smaller probe size. You can try a different frequency. Why don't you do this? Why don't you do that? Trying to work with the vendors at this point in time, showing them what they missed and trying to explain to them why they missed it.

This first round of demos we started in the fall of 2001, actually went on for about six months. We envisioned first that we would have these blocks and we'd run these in a week, and I think the NRC actually was invited on many of these demos and came down and witnessed, and you stood around a lot because the vendor would go in and do some of the inspection work and then have to go back and tweak a probe.

So this process went on and on and on. This block was shipped all over the country; these blocks were, trying to get the techniques developed.

So when I said "negotiate," that's what we were trying to do, is basically push the technology and the development of the technology. It was a learning experience.

Okay. The next slide will show you the Oconee in-stub pieces. This was the ends of the tubes that were removed at Oconee as part of the repair process. You can see the flaws that were contained on these tubes, ID and OD flaws.

MR. WALLIS: Now, I can see a whole lot of sort of vein like things. Those are all flaws?

MR. ALLEY: That's PT results from --

MR. WALLIS: Anything there which doesn't look like a homogeneous substance is a flaw?

MR. ALLEY: All the bleed-out there that we see in the dye penetrant. This was a dye penetrant picture of the stub-in pieces only, Oconee unit. Those are all --

MR. WALLIS: It's riddled with flaws.

MR. ALLEY: Yes, it is.

MR. WALLIS: And you're looking for one flaw?

MR. ALLEY: Well, we picked out flaws that were oriented at 45 degrees, the ID flaws and the OD flaws, and we asked the vendors to take their probes and manually manipulate their probes on the surface to see that they could detect the tips of these flaws. That was part of --

MR. WALLIS: --looking for rivers from a satellite. I mean, you can see them, but if they're small enough you won't see them.

MR. ALLEY: True.

MR. WALLIS: So there must be something that you can specify about the resolution or the sensitivity or something. Isn't that a requirement?

MR. ALLEY: It's looking at --

MR. WALLIS: You don't have any specifications; is that right?

MR. ALLEY: It's looking for the tips. I mean, they needed to demonstrate that their techniques were capable of finding the tips, and it wasn't always done.

Excuse me?

MR. WALLIS: Atomic size tip?

MR. ALLEY: No, we picked out a flaw in here, the 45 degree off-axis flaws to demonstrate that they're capable of doing that. Again, this wasn't to define minimum detectabilities. This was to show that they're getting sound energy to the cracked tip and they're able to see resident energy off of that tip.

MR. WALLIS: It just sounds so qualitative.

MR. ALLEY: This was the first cut through these demos. So if they can't find crack tips, they're not going to perform on any demonstration. So the idea here was you find the crack tips first. Then we'll go to the next round. So this was kind of a screening process. It actually worked very well for that.

MR. MATHEWS: And most of those -- is this the same? Well, these are two different -- most of those that all those flaws on the OD, most of them were not through wall by any stretch.

MR. ALLEY: No.

MR. MATHEWS: Marked through wall flaws of various depths, and they picked out one or some.

MR. ALLEY: The off-axis flaws is one we were very interested in.

MR. MATHEWS: Yeah.

MR. SHACK: You should have been around in the days before they looked for the crack tip reflection if you really wanted to see a qualitative argument.

(Laughter.)

MR. ALLEY: The only thing in NDE worse than finding something is finding nothing.

MR. SHACK: Amplitude drop and all of those exciting parameters.

MR. ALLEY: Yeah. Then the next slide just shows the full scale mock-up that was constructed. Again, this had EDM notches in it, but you can see here that we tried to emulate some of what we had seen in the field. Here are some cross-hatches with a circumferential flaw on the 45 degree slope, and the inspection vendor has some difficulty not in detecting that, but in trying to resolve the axial flaws from circumferential flaw.

We had another circumferential flaw over flaw number three there. It's a bit challenging. It's got little cross-hatches on it as well. Again, for the speed of trying to get this done for the fall inspections, these were just all of the EDM notches that we put in place.

You can see a picture of that block over on the side there, and you see that that's full scale.

MR. WALLIS: So these flaws, these are not -- it can't be like the real flaw.

MR. ALLEY: These are notches.

MR. WALLIS: And they're much more microscopic than the real flaws, aren't they?

MR. MATHEWS: Yes.

MR. ALLEY: Yeah.

MR. MATHEWS: The goal was to demonstrate the ability to detect the tip of a PWSCC flaw on a real PWSCC flaw. That was the goal with the two stub pieces from Oconee that had PWSCC flaws in them.

Then using that technique in a mock-up with notches, the purpose of the notch -- mock-up with notches was to demonstrate the ability to deliver sound to the location, with the presumption, if you will, that if you get the sound there and you can see the tip, then it will work.

MR. ALLEY: Yeah, the notices were not challenging, but again, it was somewhat challenging to pick out the axials versus circumferentials when you have all of these axials lined up with a circumferential flaw cutting through it. That was a bit challenging.

And we had WesDyne, Framatome, and Technatome actually participated in these mock-ups. We also had eddy current mock-up which I didn't show here. it was an eddy current mock-up with a J groove weld that just had three flaws located in it. So we had some ability to do the eddy current.

The results were distributed by the MRP. Vendors were capable of detecting the crack tips on the Oconee tube ends after enhancing their procedures. So to me that was the successful part of this demo. The vendors came in at first and tried to find crack tips on those tube pieces and couldn't find them. So we changed the procedures and the techniques associated with that until they were able to find them.

Then you go to the full-scale mock-ups. that was a very valuable experience.

Vendors were able to detect the flaws in the full scale mock-ups. As I said, those notches are not very challenging.

Again, I had already mentioned that we did multiple demos. This process went on for a very long time. We changed inspection requirements.

CO-CHAIRMAN FORD: Just to go back, you said you changed the criteria and then they found it.

MR. ALLEY: We changed probes, changed -- I don't recall specifically what we changed now, but the probes and the depth of focus of the probes and the frequencies and the technique that was used, those were changed as part of this demo process.

When the vendors first came in and scanned the blocks manually, they couldn't see the crack tips.

CO-CHAIRMAN FORD: Right.

MR. ALLEY: So they throw that technique away and got another technique and came out and started doing that.

CO-CHAIRMAN FORD: You didn't make it easier for them to find it. They had to go away and sort it out for themselves?

MR. ALLEY: Yeah, we were able -- "we," EPRI was pretty instrumental, I think, in giving them some guidance in what they needed to do to do that.

CO-CHAIRMAN FORD: Okay.

MR. ALLEY: So the EPRI NDE center is kind of managing this system for us.

CO-CHAIRMAN FORD: So you educated them of it and --

MR. ALLEY: Used the 45 degree shear wave (phonetic), you know, that kind of thing.

The results were demonstrated periodically as we had a chance to update this or something new happened in the demonstration process. We updated the industry on where we were.

The next slide is just a table that shows typical results. The vendors still treat this as fairly much proprietary as far as what angles and what probes and what frequencies they're doing. There's certainly a commercial aspect to them having developed most of these techniques.

Again, the goal of MRP was not to develop these techniques. The vendors needed to develop that.

Just to give you a feel for the types of results that we were able to get, you can see a number of different techniques or flaw sizes that were used across the top. The A, B, C, D, E, F, which is scaled on the right-hand side, shows you the orientation of those flaws, the techniques and whether they were detected and whether they were sized successfully.

These are the kind of tables that went out along with additional information to the industry for all of the vendors that went through the examination.

So that was the first round of demos done very hurriedly and done with notches and what we could get our hands on very quickly.

MR. SHACK: Were the Framatome people using the same techniques that they used on the French reactors? I mean, were they --

MR. ALLEY: Well --

MR. SHACK: They run with cracks.

MR. ALLEY: The initial approach that Framatome used at Oconee, for instance, when we found Oconee 1 with some issues, they deployed the techniques that were developed as part of 9701: eddy current ID, rotating probe, and went in and did that. And the performance of that was not anywhere near what it is today. So those techniques have changed.

Now, the eddy current techniques are still the same, but the ultrasonic techniques have changed quite a bit in the last two years.

Again, what the French were looking at was eddy current detection and then a very shallow focused ID flaw for sizing, and it was backed into sizing. If you didn't see it, you would assume it was the minimum detection limits of the probe. So that kind of broad brushed approach to the 9701 was very successful in that program, but in this program since the flaws are oriented from the OD and coming in, that approach was not as successful. So we had to change.

Now, for the 2002 demos, we replaced the EDM notices with CIP flaws, which is cold isostatic pressure. We actually EDM the flaws in place and then put it in autoclave and slam the flaws shut and make a very tight flaw.

We were able to have depth sizing, length sizing, and location with respect to the weld. We had an increase population of flaws, many more flaws in the blocks. We had blocks manufactured to have flaws in the attachment welds. We had wanted to identify flaws that reached the triple point, and the triple point is the point where you have the two materials, the weld metal and the buttering, all meeting at that one point up there, which is the spot at which you have to get across the triple point in order to leak into the annulus.

So, again, there's several different schemes about how you might go about addressing this problem. One is if I don't see any indications to the triple point, then I don't have leakage. If I don't have leakage, I can't have circumferential flaws.

So there's a logic approach for a while. We wanted to get some information on that.

The effects of cluster flaws we know is part of the 9701, that many of these nozzles contain crazed type IDs, shallow clusters. So what would happen if we had a flaw line beneath that? So we wanted to include that in the next round of demos.

So the Tiger team, to go back to that real quickly, the Tiger team did design the next round of mock-ups. These were the goals of the mock-ups.

We wanted to maintain a blind. We wanted to demonstrate the sizing capabilities. We wanted to maintain a full scale mock-up. We wanted to establish inspection thresholds. What's the minimum detectability?

Again, we talked about the POD. That was not part of the goal of this process. We wanted to provide practice blocks, and we wanted to include the craze cracking.

So those were the high level goals that we approached going into the next round of demos.

The mock-up flaws must be representative and appropriate for the NDE methods to be demonstrated. For UT we needed specular reflection off the flaws. We needed tipped fraction responses and corner trap responses. So we needed to make sure those were included in there.

For eddy current, we needed a realistic electromagnetic properties and crack widths.

The goals as realistic reproduction of key detection and sizing variables. So any differences were monitored and considered during the demonstration process. Again, numerous NDE methods were being applied, a number of different probe frequencies and schemes were being applied.

The CIP flaws we considered. The Tiger team considered all different flaw making techniques.

MR. ROSEN: What's sift?

MR. ALLEY: CIP, cold isostatic pressure. We basically put it in an autoclave and just put so much pressure in there that we're able to slam these notches shut and get a very tight flaw.

We reviewed all of the different flaw making techniques, fatigue cracks, thermal fatigue cracks, mica disks, EDM notches, CIP flaws, HIP flaws, which is hot isostatic pressure, and we settled in on the CIP as being a good approximate for the eddy current. They are very tight and no unrealistic electromagnetic features. They didn't give us false calls, in other words. They were appropriate for UT. They gave good tip responses, which again tip response is the primary detection mode now.

The reason that we use CIP rather than a true SCC flaw is because we can control the dimensions of that. We machine the notch in it. We know how deep it is, how long it is, and the orientation of it before we put it in an autoclave to slam it shut, and that way we've got good sizing ability to know what it is.

If it's a true SCC flaw, we really, because of the sonic uncertainties, you don't understand what the true bounds are. So that was one of the primary goals.

MR. POWERS: But the trouble is now you don't know anything about the detection of true flaws.

MR. ALLEY: Well, the true flaws, as I mentioned before, they meander, and they sort of break up and scatter and work their way through the material. So there's some ultrasonic uncertainties associated with that.

In defining the boundaries of the exam, we wanted to make sure that we eliminate those uncertainties.

MR. POWERS: I understand that, but the

result is that the skeptic says, "Great. This is an inapplicable."

MR. ALLEY: It's inapplicable?

MR. POWERS: Doesn't have anything to do with reality.

MR. ALLEY: Because the true flaw may not be truly represented?

MR. POWERS: Doesn't look like that at all. It meanders and goes around, gets diffused, and there are a lot of things that fool the detector.

MR. ALLEY: That's why we're very interested in the North Anna results. The only way to truly understand detection versus true in real life is to cut flaws up, and that's what we're going to accomplish with the North Anna. We should be able to answer that question better for you once we have sectioned the North Anna components and can compare the true ultrasonic responses to the true --

MR. POWERS: And the scenario --

MR. MATHEWS: We simulate some of that though. We did try to simulate some of the branching, et cetera, by intersecting multiple flaws in the EDM before they were squeezed, et cetera.

MR. ALLEY: That's correct.

MR. MATHEWS: Some of that was captured in the way some of these flaws were manufactured, and plus what do you call it? The irregularity of the flaw face, I think, was tried to be captured in some of the flaws or maybe all of them.

So they do the best they can to create a flaw that will represent what's in the field.

MR. POWERS: And then the question is whether that best you can is good enough. Now, the problem we have with the North Anna is here's one that's unusual, unique, and whatnot. So you get done with that, what do you have?

MR. ALLEY: You've got several different orders of uncertainty, and one is uncertainty in the technique itself, which is where we need to have clearly defined rules for how we can define that, which is what the CIP flaws accomplish.

The other is the physical boundaries of the technique itself, and that's what you're asking. What are the physical boundaries when physics starts to distort the answer?

And, again, the only way I know to accomplish that is to cut samples up. This protocol here is not designed to answer the physical boundaries. When we start pushing the physics beyond its abilities, we can't define that in this protocol here.

Does that answer your question? You still look confused.

Do I continue?

CO-CHAIRMAN FORD: Please.

MR. ALLEY: Again, what Larry mentioned was we actually went in and machined the notches so they would have some faceting to them, again, to try to emulate a flaw that would tend to meander through a material.

We did have branching in several of the flaws. We also found out from studies that when the notched tip collapses, it actually forms a little Y where the material collapses, and it gives us two real good branches there to get tip refractions off of. So those flaws worked very well for that.

We did use accelerated corrosion cracks. We had some mock-ups that we used, weld metal to accelerate the cracks. We used this mostly with the eddy current, which I'll get into in a minute when we show you the eddy current blocks.

We were able to use the SCC flaws for eddy current because eddy current, you have almost no depth information on eddy currents. So the actual depth of flaw is not as important in that.

Again, just to kind of go through what the Tiger team had --

MR. POWERS: How did you make your accelerated flaws?

MR. ALLEY: Weld metal in the tube that's then put in an autoclave. So the weld metal has a lot of residual stress, and you put it in the autoclave and then put it in the environment. It got slow to start, and then it went pretty well. So we got a little behind on that process.

I'll show you a picture of one of those in a minute.

CO-CHAIRMAN FORD: I'd like to finish by about five to one, 11 minutes to one.

MR. ALLEY: Okay.

MR. WALLIS: Mr. Chairman, are we doing now what we would normally do after lunch on the program or do we have something after lunch as well? Are we doing Part 5 now or four or what?

CO-CHAIRMAN FORD: We did Part 5.

MR. WALLIS: We did Part 5. So we're doing this afternoon's session now.

CO-CHAIRMAN FORD: Yes.

MR. ROSEN: Why are we doing the afternoon session now? I thought we would go to lunch. I thought we were going to go to noon when you took the poll at 11:30.

CO-CHAIRMAN FORD: Well, I know that. that's why I asked the question. Do you want to have lunch at half past 11 or --

PARTICIPANTS: Or not at all.

(Laughter.)

MR. MATHEWS: He didn't phrase it that way.

PARTICIPANT: This is the way it's working out.

CO-CHAIRMAN FORD: Could I suggest Jack reminds me that you might have problem getting lunch in the cafeteria?

PARTICIPANT: Yeah, if you wait long enough they all go home.

CO-CHAIRMAN FORD: Sine you're just starting the 2002 topic, maybe this is a good time to break if that's okay with you.

MR. ALLEY: Very good, yeah.

CO-CHAIRMAN FORD: And then let's go into recess now until half past one, and then we'll start up again at half past one.

(Whereupon, at 12:28 p.m., the meeting was recessed for lunch, to reconvene at 1:30 p.m., the same day.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(1:33 p.m.)

CO-CHAIRMAN FORD: Okay. We're back in session.

You're all well fed. Mike says I'd better keep you awake now.

Okay. Tom.

MR. ALLEY: Okay. Where I am is 2002 mock-ups. The next slide, I think. Let me get the video here and where I am on the same page.

Okay. Yeah, what the Tiger team has decided to do in the 2002 mock-ups is have axial circumferential and off-axis tube flaws. Now, I use "flaws" to describe notches before, but these are actually the CIP flaws.

We had approximately 20 flaws, up to 100 percent in depth, ranging in length from 1/100,000 to three inches. We had cluster flaws in the tube, 25 flaws up to 20 percent deep, 1/100,000 to 1/250,000; axial circumferential flaws in the attachment welds. We located them at the well head and weld to tube interface, and flaws approaching and through the triple point. So, again, it was one of the inspection philosophies here was being able to look at that triple point. So we wanted to be able to define the capability to do that.

The next slide is just a graphical presentation, and this is typical because, again, these blocks are steel blond (phonetic). So we did hand this out to the inspection vendors and had time to show a representation of the flaws and the locations and what we're trying to accomplish.

This isn't the actual drawing of the block, and it shows the orientation across the weld. You can see the little clustered flaws, 14 and 15 up on the right-hand side. That was to look at the detectability through the craze crack along the ID that we saw on the left-hand side. You could see some cross-sectional views of flaws that would be in a circumferential direction and in the axial direction.

I'll have a few more details on this as we go along.

The J groove welds, this is a similar view for what was proposed to build and construct in the J groove itself. You could see flaws along the lower part of the weld, through the weld, axial --

MR. ROSEN: It would help me if you could point out as you're going along what you're talking about.

MR. ALLEY: Okay. We've got defects that

would essentially be in the circumferential location even though it's on an off axis. You just talk a lot about the off axis, but it's following the weld root area.

We've got the axial flaws that would go down through the weld approaching the triple point. We've got flaws up through the triple point. These are in the weld metal.

MR. WALLIS: How do you make those flaws?

MR. ALLEY: Those flaws in the weld metal were made by notches, and then collapsed.

MR. WALLIS: Notches and then you squeeze it all together again?

MR. ALLEY: Yeah.

MR. ROSEN: Can you put the red dot on the triple point?

MR. ALLEY: The triple point would be right here.

MR. ROSEN: Right there.

MR. ALLEY: So, again, you're thinking this is probably on the ID. This is on the OD of the weld. So it's a --

PARTICIPANT: OD of the tube.

MR. ALLEY: I mean the OD of the tube, even though it looks like the ID. Exactly, you've opened up what's called a C scan view. So we've got a variety of flaws proposed in here.

The next slide is just a copy of what we call the J block, which is, again, the tube weld -- I mean the tube defects that we put in here and the location. You can see the full scale mock-up here on the side, and we actually suspend it off the floor. So we have to manipulate the equipment underneath it and then access up to the bottom of the tube and scan the tube.

These defects are in the tube themselves. So you'll see OD circumferential, ID circumferential. We see the axial flaws here, both OD and ID. This particular block was manufactured as a piece and then welded in place. We were able to --

MR. WALLIS: Excuse me. These flaws are straight, aren't they? They're relatively simple geometry?

MR. ALLEY: Well, we talked about before we've fastened them as much as we can. You have to machine the notch in, and then we can collapse them. So there aren't absolutely straight specular reflectors. They've got some twisting and turning to them. We've tried to emulate branching in some of them. They're just graphically shown here as being straight to show the orientation.

And then it's very important to us that we did some work to show that the tip, as I mentioned before, when it collapses it actually forms a little Y. As all of that material collapses, it's very important because the vendors rely on cracked tip detection as a means for detection and sizing the flaw. So now we have a couple of tips up here that we can now detect with tip responses. If it was just a specular reflector, we wouldn't get a very good tip response off of that.

So that's the ones that are in the tube material themselves. The next slide, again, shows the K mock-up, we call it. This was the one with the weld metal defects that are located here, and then we've got these defects are shown growing this way You' can't really see it in this slide, but they're shown growing circumferentially around the nozzle and up through the weld.

So there are actually two blocks there for that, and those, again, were ship flaws.

We did UT tests on the inside of the tube to try to detect these. Again, we're interested in seeing how far in the weld metal we can see things, and we did eddy current inspections from the wetted surface to see the interface of these flaws to where they interface to wetted surfaces.

MR. ROSEN: How do you put the pressure on the outside of this thing to close the --

MR. ALLEY: It's done in autoclave.

MR. ROSEN: You make this whole part and put it in the autoclave?

MR. ALLEY: Well, there's kind of a -- usually we end up having to crop it off here and crop it off somewhere else and weld it together and reassemble it. We make sure that the area that contains the effects here is what goes through the treatment, and then we'll manufacture that in place. We can't put that whole block in.

So it can cause us some sonic concerns out here and some sonic concerns down here, but that's not the area of interest for us.

MR. ROSEN: So you put it in the autoclave and you take the autoclave up to a couple thousand psi

MR. ALLEY: Yeah, I forgot.

MR. MATHEWS: Forty-five thousand.

MR. ALLEY: I've forgotten what the pressure is, but it's --

MR. POWERS: Are you doing your own or are you having somebody do it for you?

MR. ALLEY: EPRI does this for us.

MR. POWERS: Oh, okay.

MR. ALLEY: One of the few facilities to do this is at the NDE Center. So we're able to do that there. But we are very confined as far as the size of the flaw. I think its axial length, and I'm not sure what volume we're able to accommodate, but it's --

MR. ROSEN: If it's something to 45,000 psi, it's too big.

MR. POWERS: There's a guy up in Worcester, Massachusetts that uses a bell off one of the U.S. battle ships, and so it has either a 14 or a 16 inch bore on it for doing both HIP and CIP. So if you need a bigger one, there are bigger ones around.

MR. ALLEY: Yeah. CIP works well for us. We found the HIP actually will fuse some of the flaw characteristics back together again. So sonically we're kind of locked into the CIP process.

MR. ROSEN: After all of this work, you've gone back and fused --

MR. POWERS: It might make them look realistic.

MR. ALLEY: That would be debatable.

Okay. The next slide is going to show the mock-up that was designed for the eddy current inspection, and here we just have a plastic representation of the vessel and the nozzle, and we've machined into this receptacles, square receptacles for these coupons. We're able to grow these coupons in the laboratory.

As I mentioned before, they contain actual SCC cracks. Then we're able to take these coupons and imbed them in this sample and then run the eddy current probe around the sample. This allows us to mix them up and change them around and keeps some blindness to these tests.

But we are actually using SCC samples for the eddy current.

MR. ROSEN: So that's fairly clever.

MR. ALLEY: We have our moments.

MR. MATHEWS: Except these weld beads are straight instead of curved, you know.

MR. ALLEY: Yeah.

MR. MATHEWS: But it is a way that you could shuffle things around and give each guy a different test.

MR. ALLEY: We're able to vary the width and the length and the orientation of the flaws this way because we grow them in the laboratory, and then we can transport them over to the sample. We don't have to worry about trying to grow them in that sample, which would be a very difficult task to do.

The next slide just shows the close-up.

CO-CHAIRMAN SIEBER: That makes an interface though of materials, right?

MR. ALLEY: Yeah, but the --

CO-CHAIRMAN SIEBER: It's very hard to get a sonic.

MR. ALLEY: This is an eddy current.

CO-CHAIRMAN SIEBER: An eddy current.

MR. ALLEY: Yeah. So we're just interested in the service, and the flaws, if you'll put the next slide up, I'm not sure you'll be able to see them in the view, but we can show it and see.

We've got -- well, yeah. See, there's a flaw right there, which is in one of the beads of the weld. The flaw is actually contained right in there. So we're able to imbed that from the eddy current. You know, we can just window in on that area and test that coupon.

MR. ROSEN: Is that difficult on the surface that you see in the field?

MR. MATHEWS: It's pretty rough.

MR. ALLEY: It's pretty rough actually.

There's probably some vessels out there that aren't that rough, but most of them we find the condition is much better than that. Some of them have been ground smooth. There are just various states of condition on these J groove welds, which is an issue we continue to wrestle with.

Okay. You can change it to the next slide. We'll start going over some general rolled up results from what the vendors were able to accomplish.

Again, for Vendor A, if we look at the blade probe UT or the penetration tube, now, blade probe, again, is one transducer on a very flexible metal stick. It's actually split up the side of the nozzle. So we have to combined different blade probe results which I'll show you a table of that in a moment. but we were able to detect flaws it raised from 15 to 100 percent through wall were detected as part of this process.

When they're oriented perpendicular to the beam direction, we're able to detect flaws 15 to 100 percent through wall when they're oriented parallel to the beam direction.

MR. WALLIS: Now, does that means you do not detect them if they're 12 percent or just you didn't investigate that?

MR. ALLEY: No, they were not detected if they were less than --

MR. WALLIS: They have to be bigger than --

MR. ALLEY: That's correct. That was the minimum detectability.

MR. WALLIS: Is the resolution limit.

MR. ALLEY: That was the minimum detectability for those flaws. We had flaws in the blocks that were smaller than that that were not detected.

Okay. Now, it's important -- excuse me?

MR. POWERS: How is the probe coupled?

MR. ALLEY: It's just water.

MR. POWERS: You immerse --

MR. ALLEY: No. They've got a little squirter that comes at the back of the probe and just sprays the coupling on the nozzle to the blade probes.

Now, the rotating probes are usually done with a boot or something on the bottom that flood the tube. It's important to note here one of the things we wanted to try to understand better was just beam direction orientation because with blade probes to go in and try to do the same level of examination you would do with the rotating probe, which has seven or eight different probe packages on it, you would have to do eight separate exams.

So you begin to swap off what you're able to accomplish with a given exam. Are you looking for circumferential flaws or axial flaws, and are the detection capabilities of one flaw for a flaw that's not oriented right for that direction of sound? You like for the sound to come in perpendicular to the flaws all the time, but what happens if it's coming in the same direction of the flaws? What's our detectability?

There's two philosophies in doing this, and again, this gets to the utility specific part of this. It's certainly the prior information we had on MRP 75 said you've got to have an axial flaw before you can have leakage to the annulus and get a circumferential flaw.

So some utility said, "I'm going to go look for axial flaws. I'm going to look in this direction to find the large axials because if I have no large axials I can't have circumferential."

Other utilities have said, "Well, I'm going to go in and I'm going to look for the safety significant circumferential flaw." So they want to look in this direction.

So immediately the question is: well, if you didn't find any circumferential flaws, what kind of detectability do you have for the axial flaws looking in the other orientation? That's part of this mock-up. That's why you see the notes in here indicating the flaw direction and the beam direction.

So we found that we had very good detection capabilities with the off axis probe. So the circumferential probes did fairly well. For the axial flaws and the axial probes, did fairly well with the circumferential.

CO-CHAIRMAN FORD: In the new revision of MRP 75, you start to calculate the amount crack to grow; you assume that the crack grows 15 percent, through wall thickness.

MR. MATHEWS: That would factor into the reinspection frequency. Where do you start and how long can you grow?

CO-CHAIRMAN FORD: That's right.

MR. MATHEWS: And I'm not sure 15 would be the number we'd use. It may be something bigger. I'm not sure, but when you're trying to figure out what the reinspection frequency is, you'd start there and grow from there. I would think that would be a way to do it. Makes sense.

MR. ALLEY: So we saw on Vendor A the blade probe performance, the open tube. Rotating probe performance, again, was a little better, 13 percent to 100 percent, again with the ideal orientation, and with the non-ideal orientation we had 15 to 100 percent.

You'll see these numbers pretty consistently through here, which tends to indicate to some we're probably pushing the boundaries of the technology.

Vendor B, we see the same numbers, 15 to 100 percent for blade probe and 15 to 100 percent for the non-optimum orientation blade probe. Open tube, we see down to ten percent here for this particular vendor, perform perhaps a little better, although we're starting to get, you know -- the five percent is starting to get kind of in the grass.

MR. ROSEN: What does the E in TWE stand for?

MR. ALLEY: The through wall extent.

MR. ROSEN: Extent.

MR. ALLEY: Then the open tube rotating probe, tube to weld interface. One vendor chose not to try to qualify detection. Vendor A chose not to try to qualify detection of flaws in the weld metal with the tube scanner.

Vendor B selected to try to demonstrate that they had the ability to see through the tube into the weld metal. So we saw that we were able to see tube to weld metal interface flaws when the flaws extended up to the triple point. So that big, long flaw that we showed in that mock-up when you asked where the triple point was, you're able to detect that at the interface. The flaws that actually weren't that large and went through that interface you were unable to detect.

The weld metal is highly attenuative and very, very difficult to examine, and what we're finding out is even under the best of conditions right now to get sound energy through the tube and into the weld metal and get any kind of detection there is quite a challenge.

CO-CHAIRMAN FORD: I recognize, Tom, that you're not qualifying people, these vendors. If he chooses not to do it, then do you use him?

MR. ALLEY: Well, it depends on your philosophy again. I mean, some utilities said that I'm going to use as a basis for my inspection program an examination of the triple point to show that I have no leaking into the annulus and, therefore, no circumferential flaw.

So if that utility used that as an approach, they would go to this demo, and I would think that they would have to have a vendor that would be able to interrogate that interface. If they didn't, then to me then they would have to take an alternate approach.

That kind of leaves some flexibility in the situation as I mentioned before.

Okay. Again, just to reiterate, the weld metal flaws that did not extend up to the triple point were not detected. So if we're seeing anything in that weld metal, we're seeing just a very, very small volume of that weld metal right at that tube interface.

Vendor C looked at blade probe UT as well, 16 percent to 100 percent, 18 to 100 percent. The open tube scanner was 13 to 100 and flaws ranged from 15 to 100 with the open tube scanner that are oriented parallel to the beam direction.

Again, we're seeing a lot of consistency in these numbers. They are from ten to 15 percent to 100 percent through wall for all of these vendors. Now, what that means to me personally is we're starting to push that technique about as far as we can get it. It's very consistent from vendor to vendor, and they're using different transducers and different probes and things that are slightly different. It's each their own approach to solving this problem; yet they're getting the same performance from it. So I tend to think we're probably pushing the bounds slightly.

MR. POWERS: Does it also mean that the test is not very challenging to them?

MR. ALLEY: It's not very challenging?

MR. POWERS: Yeah.

MR. ALLEY: It's very challenging. It's very challenging.

MR. POWERS: If it was very challenging, wouldn't you see a scatter between the best and the worst and things like that?

MR. ALLEY: Well, when I say very challenging, I think that if you look at the open tube scanners, we're using the sheer wave data, time of flight data. We're using straight beam data. We've got about all of the sound energy in different modes that we can put into that volume we're putting in that volume with those open tube scanners, and these are the results that we're getting out.

And I think that's telling us that with

everything we know to throw into that volume, these are the best results we're going to get. And we're seeing that consistently from vendor to vendor.

I will say there's not a whole lot of difference in the way that they have attacked this problem with regards to their techniques, but then, again, those techniques are pretty readily understood by the industry as being the best techniques available to do this.

The next slide gives us just the flaw designations and nomenclature again. This will go along with the table I'll present in a minute. You have these in your handout, although they might be hard for you to read, but it gives you the orientation, the flaws, and the type of flaws that were contained in that mock-up. So this is just a key for the table I'm going to show you next.

This is just a representative sample of the results that were obtained. The reason I wanted to show this to you is not necessarily to communicate the exact results that we achieved with this vendor, but to show you all of the variations that we have and the inspection capabilities that were there.

You see the A, B, and C type flaws that were referenced in the previous slide. You see down the left-hand side the axial blade probes, the circumferential blade probes, the open tube scanners, you see different increments in the open tube scanner. You know, we're looking at do we take five degree slides through these probes or three degree slides through these problems. It basically doubles the inspection time for the utility.

So if the utility wanted to take a farther B cut through it, what does that do to the detection limits and the ability of the system and the performance of the transducers to increase those increments?

So we tried all of these different variations. So this table here was just to basically highlight to you that it's a very complex set of results that are used when an individual utility would go in to select a vendor.

The next slide I wanted to talk briefly on the eddy current demonstrations. One vendor chose to demonstrate eddy current at the time of the 2002 demonstrations. We've got very, very mixed results with regards to eddy current.

As we've already alluded to earlier, detection is very sensitive to the weld surface conditions, and we'll give you some data that supports that conclusion.

The ground surface condition, we had smooth surfaces of the welds to do the eddy current inspections on. We were able to detect 1/160,000 inch long flaws with about 3/10 of a mil in width.

To contrast that, on the unground, as welded surface conditions, we did detect a flaw that was a half inch long roughly by two mils wide. We also missed a 1.5 inch long flaw that was five mils wide. Okay? So we're very sensitive to surface condition with the eddy current.

And EPRI right now is working on increased sensitivity with array (phonetic) probes and some other probes that we're trying to deploy to help eliminate some of these issues, but what we're finding out with eddy current is that there's going to be aswamp between the false call rates and the detection limits of what we have and what we're able to find in reality.

We could go in and we could increase the sensitivities and increase the gains of these probes so that we found everything and just paint the surface black, but that doesn't help us decide what's real and what's not real.

So there's this constant swap in eddy

current in trying to find this middle ground here where you've got good sensitivity for the flaws you want to find, but you're not out there increasing your false call rates to a point that you can't manage the false calls. We've got some work to do in eddy current.

CO-CHAIRMAN FORD: Is there any, quote, control on the grinding that has to be done in order to make this be more sensitive?

MR. ALLEY: Well, there is no grinding that we do in the field because if we grind in the field, we induce cold work in the weld, and that's going to cause us a lot of problems with crack initiation. So we're stuck with what we were delivered during the original manufacture.

CO-CHAIRMAN FORD: Okay.

MR. ALLEY: So, you know, one of the challenges that goes to a utility if they want to do the eddy current examinations or to look at the surface conditions of their welds and make certain that that's a good exam philosophy for them to adopt, and if it's not, then they need to go to the volumetric exams of the two materials.

So, again, it's pretty much utility specific.

MR. MATHEWS: Correct me if I'm wrong. I believe that long flaw that was missed was on one of the rougher samples.

MR. ALLEY: It was a very rough sample. I mean, this is the extreme, but it does give you an idea.

Future demos. The Technatome folks are going to demo eddy current of the attachment welds. That's scheduled for next month. We've already completed the volumetric exams there, open tube and blade tube scanning capabilities for one of the vendors there.

Framatome is going to eddy current the attachment welds. We just completed kind of a preliminary scan last week with the Framatome scanners deploying the new EPRI array eddy current technique. They had some scanner problems, some contact problems. So they've gone back to work on that some more.

There's other surface methods that are being looked at by the various vendors out there. Framatome and WesDyne both are looking at a thermal imaging process where they induce a laser thermal field in the weld surface, and that's affected by the track, and you get a thermal image back.

So they're both working on the deployment of that.

WesDyne is looking at the UT end of the tube to weld interface steel. Again, that's looking at the critical point. They're trying to increase sensitivity of that area, eddy current of the attachment weld and, as I mentioned before, thermal imaging.

B&W Canada has recently come onto the scene as far as inspection capabilities for pre-service inspection of new heads. We basically invoke the same requirements for pre-service inspection that we do for in-service inspection. So we're able to baseline what's out there.

One of the biggest issues we have to deal with right now in the inspection community is we don't have a baseline of what was originally manufactured. So that's a lot of the issues the utility has with doing eddy current today and doing penetrating exams today, is that we know the crack growth rates in the weld metal are difficult to manage. Yet we know that these weld metals contain point type defects and little defects in them that have been there since the day they were manufactured.

So we continue to wrestle with how we're going to handle that. Now, we're going to get ahead of that on new heads, as I'll mention here in a minute, but B&W Canada is scheduled next week actually to start doing the UT examination of the mock-ups, and then in May they're looking at doing eddy current exams.

Future activities for the inspection committee. We have a new set of mock-ups under construction. We got a lot of feedback from the vendors that indicated that the mock-up process that we use now gave them a very good opportunity to train people. They go out in the field and they may not see a flaw for two or three exams, and we've got blocks in here that have got 30, 40, 50 flaws in it.

So we'd really like to have the key to these blocks so that we can train people on what we have. We thought that was a very noble cause.

We're going to manufacture another set of mock-ups that can be used as blind mock-ups, and we're going to turn over all of this data to the inspection vendors in hopes that they will be able to train people and improve their capabilities.

Replacement head inspections. We've issued -- is the letter issued now, the pre-service letter? We've got a letter either issued or pending to be issued recommending the pre-service requirements for anybody having a head manufactured now, which will include surface weld, eddy current, PT, volumetric of the tube.

We're also going to do equivalent studies. We believe there will be no acoustic differences between Alloy 82 and 182 and the 52 and 152, but we're going to build a miniature set of blocks into acoustic studies on that so that we now feel very comfortable in using the demonstration process that we have demoed for the Alloy 600 on the new fabrication. So we're in the process of doing that work.

Now the mock-up drawings are already in place, and then as we have mentioned before, we're very much tuned to what's going on with the North Anna head. We've asked the inspected vendors to provide inspection data or rescan the tubes that are going to be destructively analyzed. I think it's vitally important that we're able to compare the truth to the indicated.

So in summary, the MRP has an organized and comprehensive approach to the recent industry events. We believe we've made considerable progress considering the short amount of time we've been working on this. We didn't have techniques for doing this two, two and a half years ago. I think we have come a long ways with the demonstrations and the development of equipment.

The demonstrations are an ongoing process. I don't see it coming to an end any time soon. We're getting ready to go through another round as you saw on the future correction, and we don't see that coming to an end.

We realize that there needs to be increased emphasis on the attachment welds and inspection frequencies. We're working on a rate probe right now, eddy current, to do the J groove welds and improve inspection capabilities on that.

And that concludes the comments I have for you.

CO-CHAIRMAN FORD: Tom, thank you very much.

I believe, Alex, you would like to make a comment? A couple of minutes. The industry --

MR. POWERS: let me just ask one question. This was very interesting and nobel effort to develop and test the capabilities to detect cracks, but you're still doing it with artificial cracks, cracks not produced by chemistry, but you're going to apply it to looking at structures that, in fact, have root cracks, root cracks produced by chemistry.

When do we get a report card or how do we go about getting a report card that says, "Gee, these guys inspected all of these locations and they got 99.3 percent of all the cracks"?

MR. ALLEY: That's going to be very difficult because you'd have to cut up samples essentially to understand what you missed. I think it's pretty easy -- I won't say it's easy because it's difficult just from an access standpoint, but it is an easier question to prove that you saw what you saw. What's difficult to prove is that you didn't see something that's out there, and the only way to do that is just to take good samples and start cutting those up because we don't have a way to know that there's anything in them.

So that half of that question is doable, and I think the North Anna piece is certainly a component to that. The other half of that I just don't understand how you would do that. I don't understand how you would understand what you've missed.

The other that I think is an important comment to make with regards to real flaws versus fabricated flaws, and that is we continue where we have real flaws and where we have removed real flaws from service and understand what they are. We continue to compare the ultrasonic signals, the wave forms that were generated from real flaws to those from manufactured flaws, and we have very good correlation of the signal responses of the manufactured flaws to the real flaws.

So we continue to try to get better and better information with regards to showing that the fabricated flaws have similar responses to the real flaws.

MR. POWERS: The difficulty is there doesn't seem to be -- I mean, I never see a plot that says, "Here is the realness of my fabricated flaw, the fraction of realness," you know, some measure of, you know, what a real flaw looks like versus a fabricated flaw. I've never seen anything like that. I never know. They say, "Well, it's a good characteristic," but you know, I'm a very generous person. I'll say that something is good that Peter here would say that's bloody awful or some equivalent expression.

MR. ALLEY: Well, again, what we have done is we have taken ultrasonic responses. I believe we took some off of V.C. Summer actually and did acoustic studies looking at the way forms and the way that that data was generated by and compared that to the manufactured flaws to make sure that the way forms appeared the same.

We do those where we have the opportunity to do that. We have some data on that. I don't know how extensive it is, but we do have some.

MR. MATHEWS: And it seems like in the PDI process where they were coming up with how you build the lots of samples you've got to have for doing PDI. They went through extensive discussions with Dr. Doctor and others at the staff about what's an acceptable way to build the flaws to put into the samples to do your PDI testing, and so some of that was, you know, I'm sure used in the thought processes of the people who were designing these flaws.

MR. ALLEY: And, again, for the qualification and demonstration process you have to know the dimensions of that flaw to be able to answer your other questions that you have about how accurate are the results. So you've got to weigh the accuracy of the information that you're treating as truth.

MS. WESTON: Tom, are the heads that have been replaced, candidates for looking at actual flaws of those you might have missed?

MR. ALLEY: Certainly North Anna is. That's one of the things we want to do with with North

Anna. I don't know that there's any work proposed right now on any of the other heads to do anything like that.

Certainly the Duke head, I know, we fixed all of the flaws we found. We ground them out. They're on chips on the floor. So I don't know what opportunities we'd have.

The North Anna head certainly presents us with a great opportunity, and we're going to seize that.

MR. MATHEWS: And the nice thing about North Anna -- well, I won't call it nice. The North Anna 2 head was replaced in an outage in which there was a lot of inspection done, and then the decision made to replace. Most of the time when you're replacing the head, you've planned it.

We're not going in and spend two or $3 million to inspect something that's going to the garbage dump, and so you don't have that last cycle inspection result unless you go pay to do it.

CO-CHAIRMAN FORD: Are there any other questions for either Tom or Larry?

(No response.)

CO-CHAIRMAN FORD: Okay. Alex.

Thank you very much.

MR. MARION: Thank you.

For the record, my name is Alex Marion. I'm Director of Engineering at NEI.

And during the discussions this morning, I realized that it may be informative and useful to you folk to get a sense of what we have in place within the industry to take a more holistic view, an integrated view of how industry deals with the management of materials issues moving forward.

And let me just make it very clear that when the EPRI materials reliability program was formed, the basic objective was to position it to be totally proactive, and as you heard this morning, looking at the regulatory documents that have been issued over the past couple of years, specifically three bulletins and an order, it's very difficult for a group like the MRP to be proactive in that kind of environment.

Now, here we are today with new findings coming out of the South Texas project, and we have to wait and see what the results of the analyses are and then determine what the generic applicability is going to be, et cetera. And, again, we're in a reactive mode in dealing with the planned experiences.

Last summer as a result of the Davis-Besse event, questions were raised among the industry chief executive officers sa to whether or not the industry was dealing with these issues with the proper perspective. Are we looking at them as completely as possible, as objectively as possible so that we can determine what needs to be done and then apply the industry resources to do that, and can we position ourselves to deal both with the reactive element of these issues, as well as the necessary proactive element?

And from those discussions an executive task force was formed and a working group, and the initial thrust of the effort was to conduct a self-assessment of the industry programs, of the major industry programs dealing with materials performance issues.

And the self-assessment was completed. Findings and recommendations were communicated to the industry chief nuclear officers, and we've developed a guideline document for a more balanced and a more integrated, industry-wide management scheme for materials issues moving forward.

And that document was just distributed to the chief nuclear officers last Friday for their review and approval, and we hope to get their support to endorse a formal industry initiative that establishes this new management process in an integrated manner as the industry moves fowards in dealing with materials issues in the future.

This is not in any way a criticism of any of the programs, and it does not in any way suggest that the existing programs have to change drastically, but what we're trying to accomplish with this effort is to position the industry overall to be more proactive when -- let me give you an example -- when an issue occurs at a plant.

The first question that comes to mind: what do we know about this degradation mechanism? What do we not know? What do we need to do to improvement our intelligence base so that we can move forward with the right course of action in terms of inspection and repair mitigation, what have you?

And as you can appreciate, some of these are very complex, technical issues. As we talked about today, a lot of information needs to be brought to bear if you're going to make the right decision.

So clearly operating experience and improving your knowledge base on this degradation or these degradation mechanisms is very important, and we're hopeful that we can position the industry and deal with a lot of this information on an international level to make our actions in the future much, much more completely informed.

Our goal is to be sufficiently proactive so that we can prevent events at plants or incidents at plants, as Chairman Diaz likes to characterize Davis-Besse, at a minimum, and that's what we hope to achieve. And I thought it would be of some interest to you to get a brief discussion of that.

And that completes what I had to say. I don't know if you'll have any questions about the effort or not. Our intent is to have this new process in place effective the first of 2004.

CO-CHAIRMAN FORD: Thank you very much, indeed.

MR. MARION: Thank you.

CO-CHAIRMAN FORD: Any questions?

(No response.)

CO-CHAIRMAN FORD: I'd like to thank the industry presentations, representatives. Thank you very much, indeed.

We're going to change now to the NRC and Bill Cullen.

MR. CULLEN: All right. Let's go here because we've got the TV and we've got the handouts and we've got everything else.

For the record, I'm Bill Cullen from Materials Engineering Branch here at the U.S. NRC's Office of Research.

Just a quick word. I joined this agency just a hair over a year or so ago, and within about 30 days after I started we got notification about Davis-Besse.

MR. POWERS: Oh, so you were the responsible party here.

MR. CULLEN: Something like that must have happened.

So this is my first presentation in this go-round in front of the ACRS, but about 25 or so years ago when I was a contractor to the NRC, I had a few opportunity to appear before the then ACRS.

I've got several things we're going to talk about today, but they do all fall into the very general categories of CRDM cracking issues, which of course we've been talking about virtually the whole morning.

And then in the second almost half of the presentation I want to talk a little bit about some of the specifics on Davis-Besse and what the Office of Research is doing to address some of the issues raised by that.

So moving ahead here, there's a half a dozen or so individual items. We're going to talk a little bit about the research that we're currently funding in those areas that are shown; a little bit more on some additional programs that are not funded by the NRC, although we may participate in some of these efforts, but these are efforts in other countries and by other groups that really do bring an awful lot to bear on the topics that we're talking about here.

I want to talk a little bit to get a little more into some specifics about some things that I feel could be done or could be certainly thought about to be done here in the U.S. to look at some heat-by-heat analyses of the tubing materials that are in some of our plants; look a little bit at a topic that has been mentioned and, in fact, somewhat extensively this morning, but no mention of this topic could be extensive enough for my liking. I think that stress analysis of these penetrations offers an awful lot of potential for our understanding of what it is that is going on in these things.

I'm going to talk a little bit about the potential for NRC-industry collaboration, a potential that -- and I'll be very honest about this -- is not approaching activation nearly fast enough to satisfy me, and I'm going to try to make a point of that when we get to it.

And then I'll close with a fairly extensive discussion on some of the findings that the industry has provided to us on their examinations of the Davis-Besse cavity and specifically what that means to the NRC and to the Materials Engineering Branch as research, in particular.

Also, just as a little bit of an advertisement, I'm going to talk up here about some LLTF, lessons learned task force, issues that they raised about stress corrosion cracking in the Alloy 600 and then the boric acid corrosion issue. But down here -- and you'll hear about both of these things in a much more detail tomorrow. One of my colleagues, Danny Santos will be talking specifically tomorrow about the LLTF recommendations on the barrier integrity or on leakage, and that's another issue that was raised somewhat extensively this morning and I think will be a good deal talked about tomorrow on the leakage issue and what those recommendations mean and what we might be led to in that particular area.

Okay.

MR. POWERS: Let me -- I mean, you've given me quite a list of research activities that you're involved in either as a principal or as a partner and a few research activities that you'd like to be involved in.

And what I'm struggling with here a little bit is why are you involved at all. I Mean, isn't this an industry problem? They've got to fix it. All the NRC has to do is say prove to me that your vessel has sufficient integrity for me to let you keep running.

MR. CULLEN: It sounds to me like a question you have asked before.

MR. POWERS: I'm practiced at this question.

MR. CULLEN: You've practiced this question. We've practiced our answer.

There are two reasons. One is that we must do an ASP, an accident sequence precursor analysis. IT's a congressional requirement, and for that ASP analysis, we have got to do calculations of the properties, the situation, if you will, at the Davis-Besse plant, starting from one year before this was found up until the time that it was found.

In order to do that sort of calculation, there's a lot of information that we need about the shape and the size and the characteristics of the cavity and of the exposed clad. That's why I, in particular, as a materials kind of guy, am very, very interested in the findings that the industry has produced in showing what those findings are and what they mean to us.

It is not my position, however, to present these findings to you, to discuss them. You are absolutely correct in that regard. It's an industry problem, what it was that they found there and what it was that led to that. It's their responsibility to create the root cause.

The second reason that we're involved in this thing is that it is of enormous interest to a great percentage, great fraction of our stakeholders, internally and externally, the licensees, the general public, and for that reason we are doing a reasonable amount of research that addresses some of those specific things in which we have an interest.

MR. POWERS: It seems to me that what your stakeholders want could be adequately served if you worked as a clearinghouse and reviewer of information generated by the industry. I'll give in to you on Item A(2). You need some information, but the rest of it, I mean, it seems like all you have to do is read Corrosion and Corrosion Science and keep --

MR. CULLEN: Were that the case. Well, a couple of ways of responding to that. One is on this issue of corrosion -- and, again, there will be another opportunity a little deeper into the presentation to get into this a little bit more -- I was quite aghast, is a reasonably good word, in the middle to later part of March when I went into the research to try to dig out some of the properties of corrosion of low alloy steel and boric acid solutions, and while there is quite a lot that has been written, EPRI had put together the "Boric Acid Corrosion Guide Book," with which you are familiar, and there's a lot of experiments that are discussed in there. Virtually none of them model accurately the Davis-Besse experience.

Now, you've heard this morning -- and it's correct -- EPRI has an RFP out on the market now to create some mock-ups, among other things, that would perhaps do that somewhat after the fact and will add to our research base, and we in the Materials Engineering Branch also have a corrosion -- work as a corrosion program that I certainly want to admit, if you will, that it was spurred on by the Davis-Besse experience, but our program is not Davis-Besse specific in any sense of the word. It is more generically more broad based, broad brushed look at corrosion of low alloy steels.

MR. POWERS: I don't think the Chairman wants to spend an enormous amount of time on my little heartache here, but what I will comment is that when I look at this slide I cannot understand where you're trying to go with this corrosion program, what you're trying to achieve, what capabilities you want to have. Okay?

It looks like a bunch of things that you're plucking up to respond for the current incident, which it's worth responding to the current incident, I suspect, but I'm more concerned about the next 25 years where I'm visibly looking at things that have license removal and stuff like that.

MR. CULLEN: Well, I would agree with you that it is not in our mandate at all to address licensee specific issues and solve that issue for the licensee. We all understand that quite well.

But when some of these issues either cause us to recognize that there's a more generic substrate that underlies that, then I think that it is our business to go about investigating that generic substrate, and there are some other things that bear on this, too.

I tend to think that we do have some mandate to resolve issues that are of concern to a reasonable fraction of our stakeholders, and I think this is certainly one of those things.

Okay. Let's move on a little bit here, and I do want to discuss one of these issues that maybe falls into this category. We are doing a structural integrity assessment of the cavity and the exposed clad at the Davis-Besse plant. That information is very specifically absolutely required by the ASP analysis, and it is for that that we are doing this predominantly.

MR. POWERS: Where do I go to find some documentation that says what's required and how well it's required to understand it?

MR. CULLEN: What's required? Are you asking for the statement of work that was generated for that program?

MR. POWERS: Maybe that's the document.

MR. CULLEN: That's the first thing that comes to my mind, and certainly tha t--

MR. POWERS: Somewhere somebody has said to do this ASP I've got to have this information, and it has to be this good.

MR. CULLEN: Well, asking the question that way I'm not quite the right person to answer it, and I don't see anybody from the group doing the ASP that would be qualified, but I suspect they also have a statement of work that is required. Pat Bernowski's group and Gary DeMoss specifically is crunching the numbers and gathering the data.

We have, you know, a fraction of the input to that that I will describe somewhat briefly somewhat deep into my presentation here, and then as I've said now, I'm going to show some of the results that the licensees has provided to us about what they found in that cavity and what it really means, and then some other things that are spinoffs of all of this and why we are doing those things as well.

Okay. Expanding a little bit now on one of these items from the second slide, we have had for a great many years an environmentally assisted cracking program going on at Argonne National Laboratory, and this involves some tasks that are very specific to what we're talking about today: stress corrosion crack growth rate testing of nickel based super alloys both in BWR and PWR water because many of these alloys are used in both types of reactors, although we're here today to talk about the cracking in the PWR much more.

We are doing more than just looking at stress corrosion crack growth rates. In most cases we're also taking a look at some of the other properties of these alloys that can be brought to bear, may have meaning for understanding the mechanisms of the stress corrosion crack growth process.

This program has been ongoing; this task in this program has been ongoing since about 1997; has generated a couple of NUREGs, which are certainly available, and we've been talking today a lot about stress corrosion crack growth rate in Alloy 182, and what I can point out is that we are due to receive a report on stress corrosion crack growth rates out of this Argonne program about a year and a half or so from now.

And then after much more testing has been completed, we're going to get another NUREG with the schedule in late 2005.

I can see a question coming.

MR. POWERS: I'm going to ask another question I'm practiced at.

MR. CULLEN: Go for it.

MR. POWERS: But I never get an answer to this one. Maybe I'll get one now.

We have 600 we don't like because of cracks. Now we have 690 that we like better because at least it's slower to crack. But my European friends, they're just ape over 800. Why aren't we excited about 800?

MR. CULLEN: I don't know the answer to that. I'd be happy to try to find that out. I'm aware that in the German plants particularly in some of the Belgium plants they --

MR. POWERS: They got religion over this subject.

MR. CULLEN: Now, they are using that in steam generators. I am not aware of its use in larger diameter, thicker section penetrations, but I'm guessing a little bit on that answer.

Does anybody have any idea? Keith?

PARTICIPANT: Germans' use of steam generators.

MR. CULLEN: Yeah. Let me paraphrase Keith's answer, which was the same as the one I gave. We know it's being used extensively in steam generator tubing and retubing, but again, I'm not aware of any use of that allow in thicker sections. It's pretty expensive stuff, and that may be a reason that --

MR. POWERS: How expensive is it relative to pulling out a steam generator and putting it back in?

MR. CULLEN: It certainly --

MR. POWERS: I mean, it seems to me you can spend an awful lot on an alloy if you don't have to change your steam generator out every 20 years.

MR. CULLEN: Yeah, that's just not something that I can comment on at all.

MR. POWERS: I was just curious.

CO-CHAIRMAN FORD: I've got a question. When you say evaluating strength, is that specifically for this question about low temperature embrittlement?

MR. CULLEN: Not at this point. What I was referring to there is that as you know, Peter, there's some dependance or proposed dependance of crack growth rates on yield strength, of grain boundary carbide coverage, things like that.

Let me jump ahead to something I was going to say because I know this is very high on your mind. Can I give a little bit of a preamble though?

I'm not sure that everybody in the room understands what you mean by the low temperature degradation, but about a year or so ago, in the summertime of last year, there was a couple of publications generated by what's now called Bechtel-Bettis Atomic Power Lab, where they presented some results of a low temperature degradation in fracture toughness, in fracture toughness of Alloy 82 and some of its near neighbor variations.

That degradation happened under some rather specific set of circumstances. It was at 130 degrees Fahrenheit that the degradation maximized. It was also maximized in very highly hydrogenated water. Normal hydrogenation would be around 30 to 50 cc's per kilogram of hydrogen. This degradation really kicked in at higher hydrogen concentrations. If memory serves right they were up in around 150 or so cc's per kilogram when it got to be really strong.

So this was a degradation in fracture toughness in Alloy 82 and some of its kin.

There also is a rather well know ductility dip cracking issue, which is a weldability issue. Okay. First off I was talking about a hydrogen assisted cracking issue. Now I'm talking about a weldability issue, also in this same alloy, and that data largely comes out of what we know is Lockheed-Knowles (phonetic) Atomic Power Lab. So it's basically the nuclear Navy people that have generated the bulk of the work to establish the problems with Alloy 52, 152, and similar materials.

Some of these same problems are also found, by the way, in 182 and also in 690. I think that's important to remember, but the problem with stress corrosion cracking tends to disappear as the temperature increases.

So at reactor operating temperatures, this is a nonexistent problem. So there's two things going against this problem under normal operation. One is the temperature is too high. The other is that the hydrogen is too low. So we're not likely to get this degradation or I certainly wouldn't think we would get this degradation under normal operating circumstances, but this may be an issue of where there's smoke there's fire.

My position, and I'll speak really for myself, is that we want to stand back a little bit, continue to watch the work that is generated by the nuclear Navy, watch the work which is generated by the industry and make our own decisions about whether or not this really appears to be an issue that may have safety importance.

The other thing that we're going to be finding out starting quite soon is that the first of the French plants to replace their heads is coming up for their ten-year inspection rather shortly, later this year, next year. I'm not sure, but very soon is the answer.

We're going to get the first evaluation, if you will, the first information about the performance of these replacement heads from the experience that the French will have in these inspections, and of course, you know they've been replacing heads at the rate of three, four, five a year. So they're going to be generating an equal number of ten-year inspections from now over the next ten years.

So we will be getting an awful lot of information, precursing information that should be very, very useful to us. Again, I have a few more things I want to say regarding that, but it all bears on what I think we will be able to find out going forward on this issue of Alloy 52 and 152.

So going back to Peter's question, to try to bring closure to that now, Peter asked me whether or not we're evaluating strength in the sense of the low temperature degradation and toughness, and the answer here is no. We are evaluating strength within our program simply as correlative information to the stress corrosion cracking determination on these particular materials.

CO-CHAIRMAN FORD: I don't doubt. I agree with you entirely. You're not going to get it at operating temperatures. My concern is more accident conditions. We might have a --

MR. CULLEN: Starts, shutdowns, standbys.

CO-CHAIRMAN FORD: Well, also thermal shock situation during an accident.

MR. POWERS: But if it's hydrogen embrittlement -- is that what I understand it to be?

MR. CULLEN: I would not use the word "embrittlement."

CO-CHAIRMAN FORD: I don't know if it's hydrogen embrittlement in the classical mechanistic sense. It is associated, as Bill rightly says. You've had hydrogen absorbed into the material. When you have the high chromium content, energy changes and, therefore, your plasticity changes, and it's a known fact as Bill says.

MR. POWERS: But it seems to me that certain events -- the hydrogen can't organize itself to do whatever it is that it does in the face of sudden events like pressurized thermal shock and stuff like that. I mean, it gets up to high temperatures.

The hydrogen is either desorbed or it has diffused kind uniform (phonetic). It's no longer creating anything that's vulnerable. You suddenly cool it. That hydrogen can't move fast enough --

MR. CULLEN: That's correct.

MR. POWERS: -- to respond. So it couldn't affect a pressurized thermal shock event.

CO-CHAIRMAN FORD: Maybe I'm using the wrong word, pressurized thermal shock, because maybe you're getting something in your mind about mechanism of pressurized thermal shock. I'm talking about a thermal shock on, for instance, the stub tubes into the top head, and if you had a burst of cold water, regardless of how you got it, could you get a thermal shock on a pre-cracked stub tube sheer-off?

That's purely my scenario. I think it's rather low possibility, but it's interesting.

MR. CULLEN: But I think it's our job to try and think about these sorts of --

CO-CHAIRMAN FORD: The worst case scenario.

MR. CULLEN: The right temperature, the right stress, and the right hydrogen content, and then we could have a bad problem.

CO-CHAIRMAN FORD: The other question I

wanted to ask you about that first line and then we'll get off it is PWRs. I understand why you're working on BWRs. Is there anyone in research or in NRR looking at the question of cracking of BWR bottom head penetrations?

MR. CULLEN: I would say not looking at, so far as I know.

CO-CHAIRMAN FORD: Evaluating?

MR. CULLEN: Yeah, we're aware of the one issue -- I think it's only one -- in Japan to this point. That was a rather small flaw. They found it; they disposed of it.

I know from a research point of view, we are not doing any specific research other than trying to maintain an awareness.

CO-CHAIRMAN FORD: I'm sort of inviting Al to say something.

MR. HISER: Oh, boy. We'll talk about that tomorrow.

CO-CHAIRMAN FORD: Fantastic.

MR. HISER: How does that sound?

MR. CULLEN: Okay. Items B and C I put on here because I want to create a lead-in to a great deal more discussion I want to have a little bit later on. We are doing some testing of materials removed from Davis-Besse, both the Alloy 600 from nozzle number three, which is the heat that appears to crack the most predominantly and Alloy 182 from the near neighbor nozzle J weld.

We're doing this sort of testing simply to create data on what may be susceptible materials and add that to the overall database of Alloy 600 and Alloy 182 stress corrosion crack growth rate.

The LLTF made a number of recommendations. A great many of them fall into the stress corrosion crack area. One of their recommendations was to create or write a critique of the susceptibility model. This also came down to us as a user request from NRR. I've completed this report a couple of months ago. It has been circulating internally, been revised, and will be available much more generally within about three or four weeks. And certainly I can see that it will get sent down to you.

I'm going to talk about this a great deal more four or five slides down the road because I want to mention some of the things, some of the issues, some of the additions, improvements that might be possibly made to the time at temperature susceptibility model that was talked about a good deal this morning.

There are two other deliverables that are both coming forward from here. One is to write a report, collect the worldwide Alloy 600 cracking experience and produce that report late at the end of this year and another to collect the boric acid corrosion experience worldwide and produce that report later on in 2004.

CO-CHAIRMAN FORD: Just to make sure we're talking about the same thing, the report talked about on C-1 is the Rev. 1 of MRP 75?

MR. CULLEN: No, no. This is absolutely independent. Do you mean the susceptibility report?

CO-CHAIRMAN FORD: Yes, your C-1.

MR. CULLEN: No, that had nothing to do with MRP 75. That was something generated entirely within the MEB.

CO-CHAIRMAN FORD: No, but it's the model that was used.

MR. CULLEN: Oh, it's the model that was used, yeah. I'm sorry. Yes, yes. Yeah, I'll show the usual chart that you expect to see in a few minutes.

CO-CHAIRMAN FORD: Okay.

MR. CULLEN: Okay? And talk about some of the things that I think could be done to fix that up.

Okay. There are a number of additional programs that, as I said in my prologue, we're aware of; we're participating in to some degree or other. We are not funding any of these things.

I think it's important for everyone who's interested to know a little bit about these things. The Japanese are doing an awful lot of crack growth rate research on the alloys in which we have an interest.

As you might expect perhaps, it's a little bit difficult sometimes to find out about this data. I'm going to make somewhat of an effort using the appropriate international channels that we have here available to us at the NRC.

MR. POWERS: Just ask our subcommittee chairman. He spends half of his time in Asia.

MR. CULLEN: Ah-ha, there we go. But there's a lot of data that the Japanese are generating that would be very, very helpful. Some of the data from this electric joint research project which is now completed actually is beginning to show up in the literature.

In fact, we'll talk about the postpones conference that I was going to have towards the end of March. There was going to be one paper in there with some of the results from Alloy 182.

There is a much larger program, the national nickel based alloy material project which continues through 2006. It's a multi, multimillion dollar funded program, almost exclusively directed at stress corrosion crack growth rates, and at this particular point I have no knowledge, cannot find any knowledge at all on when we would expect to get any results out of that at all. I'd like to find that out somehow.

Another thing that's going to provide a lot of data is the International Cooperative Group on Environmentally Assisted Cracking, ICGEAC, which is in the beginning stages of conducting a round robin on Alloy 600 crack growth rate testing.

At the present time the specimens for testing have been distributed. Some tests have been completed, and we will begin to get the first of the data next month.

MR. POWERS: And you say we're not participating in this one?

MR. CULLEN: We are members of the ICGEAC, both the NRC -- I mean, I attend those meetings. Argonne Laboratory people attend those meetings. There is 100 or so people that attend those meetings worldwide. So we participate in the meetings.

Argonne is actually participating in the round robin, and they will use NRC RES funding to pay for the testing.

MR. POWERS: Okay. So we're -- that's good.

MR. CULLEN: Yeah, we're an active participant on the same plane with everybody else.

MR. POWERS: That's good.

MR. CULLEN: Okay. The Phase 1 of the test was just to collect data on how people did the testing and shake down a test routine that everybody could use.

Phase 2, which is the one that we're in right now is to test a 30 percent cold-worked Alloy 600, then compare those results and prove the methods and do a follow-on test. Thirty percent cold-worked Alloy 600 should crack fairly expeditiously, shall we say? The test should last about a month or so, given what the specific test parameters are. It should not be an impossible onus on any laboratory.

In Phase 3, we will go on and test Alloy 182. So we will get a good deal of data on both Alloy 600 and Alloy 182 out of this particular round robin experience.

MR. POWERS: And what do we do with that data?

MR. CULLEN: We will throw it up on that curve, that data plot that you saw earlier this afternoon and I'm going to show next, and I'll talk about that, again, in just a couple more minutes.

Just very quickly and qualitatively, there's also testing underway in France, Spain, Sweden, and perhaps in other places that I have not heard about. These are individual labs or individual agencies that are doing their own test programs, and again, we would expect that over the long haul that data also ought to be made available.

We're currently in a dialogue to obtain some of the mock-ups from replacement head fabrications. Specifically we're working with Duke Energy to get a mock-up that was created just prior to the Oconee 3 head being fabricated.

We will use that mock-up as a test bed for residual stress determination, for obtaining materials on which to do testing. Of course, those materials would be Alloy 690 and Alloy 52-152. I'm not exactly sure what the weld materials were that went into that head.

Okay. I'd like to take two slides and

digress a little bit about what knowledge might be gained from some of these heads that we're discarding for one reason or another. As an example to start with here, if we look at the head that came off the Davis-Besse plant, there are three alloys in there, in that head, that are also used in other plants.

Now, as it turns out those other plants are Oconee 3, Ark. Nuke. 1, Oconee 1, and -- oh, I'm sorry. This one here is a heated material that is actually not found, but it's a heated material that may have some sensitivity or susceptibility to stress corrosion cracking.

Now, these plants over here in which these materials are found are all having their heads replaced. So there's no particular need to learn something specific about stress corrosion crack growth rates in these particular heats of Alloy 600 in order to apply that information to these heads. That's a nonstarter.

So the conclusion here is that specifics about those particular nozzle heats from Davis-Besse are not applicable in the long term.

However, that's not the situation with the North Anna 2 head. We saw over here a listing of all of the heats of Alloy 600 that were found in North

Anna 2 and where those heats show up in some of these other plants.

Now, as we just learned this morning, North Anna 1 is also replacing its head, as is Surry 2, but these other plants, Sequoia 1 and 2, Watts Bar, Catawba, McGuire, don't have any immediate plans. I think Sequoia has got a long term, maybe 2006 plan.

But what the implication here is is that if some licensee would like to have specific crack growth rate data in order to use in some sort of a disposition presumably of a flaw that they have found, they know where to go and get that information.

So there's a great deal to be learned, to be obtained potentially at least from some of these heads that are coming off, and I think it serves everybody well to kind of keep a little matrix, as the MRP is doing, by the way. All of this information came from documents that were provided to me by the MRP, and I just want to point out that this potential for learning, very helpful information does exist.

CO-CHAIRMAN FORD: Bill, we often ask the question can you identify the heat in a specific head penetration, and you get mixed answers. You're saying you can. But every particular tube penetration --

MR. CULLEN: Okay. I've got to stop short of saying we can. I've heard also the same anecdotal information that you have, that the individual licensees probably have this information. Certainly in the case of the BMW plants we know for a fact that the pin by pin information does exist, has been documented.

For some of the other vendors, I have not had a qualified vendor representative look me in the eye and say, "Yes, we know exactly what is in penetration number such-and-such at plant so-and-so."

But I would tend to think that that information is available. Now, we may have a problem with a few heads that were fabricated by vendors that are now out of business, but other than that, I would tend to think that the information is available and that is what I have heard.

Okay. Just a quick word. I think most of you were aware that we were supposed to have a conference March 24th through the 26th, but due to the geopolitical situation, to use a politically correct term, that conference was canceled when we found out that several representatives from foreign countries that we really needed to have attend in order to have a complete picture about what the worldwide situation was were not going to be permitted to travel to the

United States during that particular time period.

We again polled these people last week, and there are still a handful who are not permitted to travel even within Europe at this particular point. We're going to continue to keep polling the people who said they're going to attend and others as well, and when the restrictions have been lifted, when the coast seems a little more clear, we'll get about rescheduling this conference so that we can bring together all of the people who have good information on the inspection, on crack growth rates, on repair issues, on plant operation issues, get them all into one room for three or four days, and have a real good meeting to try and come up with a good evaluation of where we are and where we are going, in particular.

Okay. I've got three or four slides I want to present here that talk a little bit about the NRC sponsored work on stress analysis, and I said again in my prologue that I really feel like this is very, very important work. As far as I know, this sort of work is being carried out by a mere handful of vendors here in the United States. I can only think of three: Structural Integrity Associates and Dominion Engineering, both of them doing work for the licensees, and EMCC, which is doing work under contract to the Materials Engineering Branch. Of course, this is the EMCC results that I'm going to show to you.

Fortunately from what I have seen, all three vendors are generating results which are more or less the same. That in a sense may be good news, but I do lose a little bit of sleep wondering whether all three of us are wrong.

The question was raised this morning how is it that you calibrate this stuff. Has this stuff ever been calibrated?

I felt the answer was only partial. There was some mention, Al Hiser mentioned correctly, and I mentioned that there had been some experimental verification of these computation algorithms done by Electricite de France in the early 1990s, but most of that work, in fact, I think, even all of it was done on pressurizer nozzle designs.

The residual stresses were measured using the X-ray techniques, which is quite a reasonably good method, gets only the elastic part of the strain, not the plastic part, but it's a reasonably good way to evaluate residual stresses, and the agreement was at least in the publications I have read stated to be rather good.

I am not aware -- and if somebody does know, I'd appreciate hearing that information -- I am not aware of any extensive, well qualified, calibrated work, if you will, on a full scale CRDM nozzle, which would be typical of a power reactor head. That is something that I personally would like to do. We've got the heads coming off that allow us the potential to do that kind of thing. We're also exploring the possibilities of doing that kind of thing in some mock-ups.

And I am aware that the industry is also at least thinking about that. David, do yo u know where you are in your thinking? Is it more positive than just thinking at this point?

MR. STEININGER: I remember talking to Al McElry about whether he was going to put something like that in the RFP, and he indicated at that time that he was.

MR. CULLEN: Okay, all right. So --

MR. POWERS: This is one of those things that you do once or is it something that you have to do all the time? I mean, is it a one shot deal or is it answers all of your questions or does it have to be --

MR. CULLEN: I think the answer from an

idealistic standpoint, the answer is you do it once and you're done.

However, there are so doggone many variables that you will be doing an almost infinite number of cases once, and what I'm thinking, what I'm alluding to is not only the fact that you have the geometry problems or the geometry issues. What's showing up here just as an example is the number one nozzle, the absolute center nozzle. That's the only axi-symmetric position in the whole head.

You've got all of these nozzles that are on the side-hill. Each one of them has -- well, not each one of them. There obviously are some multiples, but a great many of them, maybe eight to ten combinations, all at different inclinations.

Then you've got the potential issue of how these things were actually assembled. During the course of the assembly, how many weld beads were ground out and laid back down a second time or a third time or whatever?

Then you have the issues of repairs. There's a lot of issues which I think you could or a lot of considerations that you could basically sum up by saying geometry differences that you really need to have a look at in order to get the whole big picture.

We may get to a case or to a situation, a time frame with the ever increasing computational speed that we have available to us where this might not be such a big deal no matter what the differences might be for a nozzle that you'd like to know about in particular. You could devise the input necessary for that, run that into your computer, go home for the night and come back the next morning and you've got the answer.

Right now, this whole business, which I'd like to describe briefly at this juncture, all three of the vendors that I've mentioned earlier proceed in roughly the same way. Using finite element techniques, you cast a weld bead, a single weld bead. You allow it to cool, contract, build up the strain. You do that calculation. Then you put down the second weld bead, allow it to cool, contract, and put down its strain, and so on and so on.

You build up this weld bead in the way that is shown in this figure provided by AMCC, and at the end you then have a couple more steps that you have to do.

This entire thing is then -- again, numerically you simulate the hydro test, the 1.25 hydro test that is applied pre-operation, and that gives you then the final stress state that obtains in that particular nozzle weld.

MR. POWERS: If the finite elements are no more dense than what's shown on your figure, this is a few minutes on a good machine.

MR. CULLEN: This whole process of casting these in bead by bead, allowing the cooling, the contracting for which you need stress-strain properties for the whole temperature curve, thermal conductivities for the whole temperature curve -- it's a good thing you're sitting down -- takes about a month on a two megahertz personal computer.

MR. POWERS: Oh.

MR. CULLEN: Okay?

MR. POWERS: On a PC.

MR. CULLEN: Well, yeah.

MR. POWERS: Oh.

MR. CULLEN: That's what's available to us. we don't have Crays underneath our desk unfortunately, or whatever.

MR. POWERS: A few more Crays. I've been marketing machines lately.

MR. CULLEN: But you get the drift of what I mean.

So that's where we are with these

calculations these days.

A couple of examples. An example of the axial stresses. Now, red is bad; blue is good. Red is tension; blue is compression. And you can see that as far as axial stresses -- now, axial stress in this direction causes circumferential or would drive circumferential cracking -- is maximized here right at the toe of the weld on the outside diameter, which by itself would not be a particularly problematic area.

What would be a little more problematic is that you've got another elevation in stress right up here which is above or at the triple point of the weld, and if you get a crack growing up in here, emanating from that particular elevation in stress, admittedly it's not so high as down here at the toe, bt it is in positive territory. That's the one that could drive a circumferential crack.

But that's not the whole story. There's more than just axial stresses in there. There's also hoop stresses, and hoop stresses would tend to drive the axial cracks, and as you know, we've got as we heard this morning at least by current count slightly more axials than we do circumferentials. So the size of the high tensile area is quite a bit larger, extends essentially throughout the entire volume of the weld, with the exception of this toe back here near the clad, and well up into the Alloy 600.

So that's why at least in the center position we can understand why we're getting a good many axial cracks.

The last slide in this series is that if you compute both the axial, the circumferential, and the radial stresses, it turns out that the resolution of these stresses is on an inclined plane. I'm kind of waving the laser here in parallel with the arrows, which I presume are visible to you more in front of the screen. But what this says since a crack tends to grow normal to the principle stresses is that cracks should grow perhaps somewhat along -- these would be a circumferential crack now -- perhaps along about a 45 degree incline plane.

I'm not talking here about the fact that in a side-hill nozzle that the cracks are growing in a kind of oval, which is on an inclined plane. I'm talking about through thickness they're also on an inclined plane.

Remember this particular modeling is for the center hole position, which is the axi-symmetric. You know, there's no side-hill in this particular case, but we don't know whether this is the case or not because all of the cracks that have been found to date have been ground out and repaired.

However, with some of the heads now coming off, we again have the potential to find out whether or not these stress calculations are predicting correctly the inclination of the cracks.

MR. ROSEN: Bill, these are great pictures, but I don't think you'd be showing them to us unless you thought stress mattered, and what we've heard over and over again is just tell me how long the stuff has been at a given temperature, and I'll tell you what the problem is or if there's a problem.

And now what I think I hear you saying or getting ready to say is stress matters.

MR. CULLEN: Yeah. I really believe that. I saw the slide this morning that stress is a secondary consideration. Crack growth rates are the primary consideration. I don't disagree with that conclusion at all. But --

MR. ROSEN: Crack growth rates are the primary -- you mean --

MR. CULLEN: Well, crack growth rates are temperature dependent.

MR. ROSEN: Yeah, temperature.

MR. CULLEN: You know, through the

temperature dependence of the crack growth rates. I thought that -- correct me if I'm wrong. I can't remember whether it was Larry or David that had that slide, but I think the inference at least -- do I have it right? -- was that the stress was secondary to the crack growth rates or did you say stress was secondary to temperature?

MR. MATHEWS: It was a secondary impact on the core damage frequency relative to the --

MR. CULLEN: All right. Well, so we're more than once removed.

The message wants to be here that crack growth rates are temperature dependent. They are the most important consideration in the calculation, if you will, of susceptibility of an individual plant.

But I'm here to say that I think stress is important. The message I'd like to deliver is that after all, we call this stuff stress corrosion cracking. If we didn't have stress to start with, we wouldn't be here, folks. If these guys 30 years ago understood all of the ramifications of residual stress and also figured out some way to get rid of all or most of it, we wouldn't be here today.

MR. ROSEN: Well, I'm going to say that up until now I've been thinking that all I know is the effect of degradation years, and I'm at a given spot and I'm cool.

Now what you're saying is stress matters and we've got some indication here particularly if the South Texas stuff turns out to be cracking that maybe stress matters more than we thought and might even matter more than effective degradation years.

MR. CULLEN: That would be my opinion, and I'm pleased to get a little bit of validation back here.

MR. ROSEN: Well, I'm just trying to see if I'm putting these tea leaves together here into a pattern.

MR. CULLEN: Well, I think you are, but I'm a materials kind of guy, and in away, I think it's a bit funny for me to stand up here and talk about stress, which is not my business. I mean, I'm saying it's the other guys who should have a lot of business.

I mean, certainly we've got materials problems, too, but, yeah, I think we could benefit a lot more from understanding how the stress varies as a function of the geometry issues that I've talked about and a lot of other things, and then how these two are going to play together to calculate the potential for cracking a plant.

Boy, they're lining up back there now.

MR. ROSEN: We have these ant hills in Texas, fire ant hills, that if you just take a big stick and you poke it once or twice, you want to get out of the way real quick, and that's what I just did.

MR. MATHEWS: This is Larry Mathews.

I guess we've never said stress is irrelevant, and we've never said material properties are irrelevant. We all know that both of those play into the stress corrosion cracking.

All we've said is that we don't know enough about them at the time we were making these rankings and trying to figure out which plants ought to be doing what kinds of inspections; that we would assume they were similar, if you will, and we would rank plants based on time at temperature.

Not to say that if you're below some threshold you can go home and everybody else has got to a problem, but to simply say this is the ranking mechanism to determine at what point people should be thinking about doing inspections.

It's not a model that is, you know, unequivocal; that, you know, if you calculate 8.2 you're okay, and if you calculate 8.3, you've got a pending disaster. We've never said that.

It's just a ranking model. That is all it has been, to help us rank when we ought to be doing what kinds of inspections. Okay?

CO-CHAIRMAN SIEBER: It seems that there is an underlying assumption that the stresses were similar in --

MR. MATHEWS: Yes. All of these nozzles were put together, not identical properties clearly. All of the materials were put together, not identical, but they were all 600 and they were all welded with interference fits and J groove welds, and there will be variation from nozzle to nozzle on the same head and from head to head, and depending on who's manufacturing it.

But we just didn't have enough information to try to home in and say, "Okay. Here is the point, and if you reach here, you've got a problem. Before that, you don't."

It was just a mechanism to help us rank the plants for inspection, and that's all we were really trying to do with the time and temperature, not to reach, you know, here's a threshold. Below that you absolutely don't have an issue.

And stress is a factor in all of the models that we've used in our PFM work, probabilistic fracture mechanics work. The material properties are, too, but I'm not sure we're modeling everything, but certainly all of this stuff goes into the model. We're not ignoring any of it.

MR. SIMS: Going back to the statement about stresses though and proving it in the industry --

PARTICIPANT: You have to identify yourself.

MR. SIMS: William Sims, Entergy Operations.

The B&W units in general have stress relieved all of their nozzles except for their large bore CRDM nozzles, and they have not had any -- there's only been one B&W nozzle failure in the entire industry.

And the CE fleet, on the other hand, they did not stress relieve the nozzles after fabrication, and there have been, you know, several of those nozzles fail.

So there is correlation between stress and probability of failure due to PWSCC, but I think the bottom line goal of the MRP is to take that part out of the equation because with B&W, the CRDM nozzles that we had, they were actually center ground on the

OD surface of these nozzles. It caused higher stress and actually the fabrication process of straightening the tube cold-worked the tube back and forth and caused high residual stress.

But if you hold everything constant and only change it due to temperature, then we're bounded by the rest of the plant. So I think that's what the MRP's final goal was.

It is highly dependent on stress for each of these locations.

MR. CULLEN: Bill Shack had it right this morning when he said -- he made the point that in these nozzles --

MR. POWERS: This is dubious, to begin with.

MR. CULLEN: It's very difficult in any given nozzle, subject to issue of triaxial constraint, to get the stress higher than the yield stress of that particular nozzle material. True statement.

And since the yield stresses of these nozzles vary over a 20 to maybe 25 KSI range at best, then, yeah, that does confine you to a fairly, fairly narrow range of possible stresses in these nozzles.

You have your choice. You can either have a high stress or you can have a higher stress, and that also tends to make the stress issue a wee bit secondary to the crack growth rate or temperature issue.

While we're on this business of finite element analysis at the nozzles, a couple other questions that were raised this morning that I can give at least a partial answer to.

One, we talked about leaks and leak rates and who's working on that kind of thing. EMCC, the same vendor that's doing this work for us, is also doing leak rate calculations.

Now, as anybody who has been in the steam generator business can tell you, leak rate calculations have a spread in variability that is just astounding, depending on what assumptions you pump into that. For a 45 mil or 60 mill thick piece of steam generator tubing you can get leak rates which cover a couple of orders of magnitude under otherwise reasonable assumptions.

And if you think that's bad, try doing that same calculation on a .62 inch thick CRDM nozzle with a stress corrosion crack in it, and it gets, you know, pretty dicey.

MR. POWERS: Offhand, I'd say the experimental data on the leak rates for at least one thickness of steam generator tubes also has huge spreads.

MR. CULLEN: I'm not sure which specific set of data you're talking about, but I'm not at all surprised by that kind of a statement.

All right. So I think I tried to deliver a few minutes ago the message, if you will, that if we had learned a long time ago how to manage the residual stresses in these things, we wouldn't be in such a bad position as we are today.

That's a message that applies going forward as well, and I do know that the vendors who are working on the replacement heads for domestic plants are concerned about that, but there are at least two vendors that are involved. I don't have any detailed evidence from either one about how specifically or what they are doing specifically to mitigate stresses. That is proprietary information. There's a good reason that I don't have that.

But it does raise in my mind the concern about whether or not those two vendors are doing things with a reasonable similarity or reasonable end results, and that brings me to the issue of whether or not we're going to have to be vendor specific in our modeling of these replacement heads.

The last issue that I want to raise is that people, myself included from time to time, talk ad nauseam about the cryptomium like properties of Alloy 690 and the fact that that's going in our replacement heads and that should solve all of our problems.

A lot of other people will say any material placed at or near its yield stress and left in a warm environment for a long period of time is going to crack, and that may well be the case with Alloy 690 also. We just don't yet have the kind of experience that we need to have.

Certainly in laboratory tests it is much better than Alloy 600 and the Alloy 152 is much better than its corresponding Alloy 182, but those are lab tests, and I'm not so sure --

MR. POWERS: When you say "better," do you mean better or slower?

MR. CULLEN: Slower. I don't mean faster crack growth rates. I mean a better quality material, less susceptible, slower crack growth rates, however you want to say that.

But we do have some of these issues, the low temperature degradation and toughness and things that may come back to haunt us in another way that we haven't yet quite figured out.

Peter, I'm not so sure exactly when you want to break, but I'd like to stir up a couple more ant hills before a break if that's at all possible.

CO-CHAIRMAN FORD: Sure. You're just going to go through this?

MR. CULLEN: This one and if you'd like me to do one more quick one, I can do that.

CO-CHAIRMAN FORD: Okay.

MR. CULLEN: But this one will probably be --

CO-CHAIRMAN FORD: Well, this one will really stir up ant hills.

MR. CULLEN: No, no, it's not.

(Laughter.)

MR. POWERS: I'm sitting here waiting.

MR. CULLEN: I've got something to say about that. I don't like what I hear.

Okay. In the middle of last summer, June or July, I proposed to the industry, specifically to EPRI and Christine King, that we've got so many common interests in the whole nickel based alloy business that we would really benefit from a much more close NRC-industry collaboration on all of these issues.

Of course, that went over very well. We had a great conference call in September. We had another great conference call in November, and out of the November conference call we developed seven particular tasks on which we were going to have NRC-industry collaboration.

Since that time we have not heard word one, and I am here to whine about that very plainly. Any backing that I can get from the ACRS that can be provided to kick this along would be very, very welcome.

I don't need to go into reading all of these things, but, in particular, the failure analysis of the North Anna RPV head. We put this line item into our budgets for 2004-2005. Christine King provided me with Craig Harrington's initial plan for doing this kind of work, and beyond that I have not heard a single thing from the industry until what we just heard today, but I'm not at all sure how it is that we're supposed to collaborate with the industry, if indeed the industry even wants our collaboration, on failure analysis of the North Anna RPV head.

MR. POWERS: Well, it seems to me that that particular one poses real challenges for the independence of the agency. I mean, we've been reasonably happy with the idea of collaboration in the industry when it consists of going out and getting data, and then each side goes and takes the data and analyzes it as they see fit.

But now you're saying here let's collaborate on the analysis of the data, and I think that poses real conceptual challenges on the proper role of the NRC as an independent regulatory body here.

MR. CULLEN: What I hear in your voice and in your concern, and I would agree with one interpretation that I believe you are making of the word "collaboration," which you know, involves working closely with producing results to which we both agree, losing our independence. That is not at all what I would propose, what any of us would propose.

But I really would like to get the opportunity for the NRC to get its own look at the North Anna head, to do things that perhaps the industry would not choose to do that might serve the particular purposes that we have in mind.

I'm not suggesting that we do a second time what it is that the industry would propose to do. My sense of the word "collaboration" would have a synonym that's more like coordination.

Remember that our business in the Office of Research is to do confirmatory research, and that is one of the things that I think we could do with pieces of that North Anna head.

Another thing that I believe we could do would be to take a look at some of the inspection related questions that we might have specifically. Perhaps the industry would choose to look at them. We would want to look at them also in a confirmatory way or even using our own initiative or for reasons that would fall into the category of anticipatory research.

So I realize that there is an implicit danger when we would begin to work closely with the industry that we might lose our sense of independence, but that is something that we just have to go into these programs and be very careful of.

There are a great many precedents for the NRC working with industry even to the extent of co-funding. I'm not sure what mechanism, what financial mechanism might be involved here. It could range to something as reasonably intricate as co-funding. It could simply mean funding our own independently chosen vendors to execute statements of work that we would put together on our own.

Does that response reasonably satisfy your concern?

MR. POWERS: Well, I caution that I would work on my language here.

MR. CULLEN: Okay.

MR. POWERS: Because I think you can set this up as a reasonable collaborative program if that program consists of, the collaboration consists of acquiring the data.

But the analysis of the data has to be independent, it strikes me.

MR. CULLEN: Absolutely.

MR. POWERS: It absolutely has to be independent.

MR. CULLEN: No, there is no question about that.

MR. POWERS: And so I'd be cautious about the language that I use here.

MR. ROSEN: As far as backing up your whine, is there a quid pro quo here, I mean, where they send you a quid and you send them a quo?

MR. CULLEN: No, I don't detect that. At least at the beginning what I would like to achieve, and there are a couple of specific things I can mention here in a second as example, I'd like to achieve better coordination maybe is a better word now, where we might have a topic and the NRC would do these four things and the industry would do these four things, and we would preplan so that they interlace or intercalate a little better.

Now, what I'd like to point out specifically as an example of what I feel is really a lack of collaboration is that we kicked off our boric acid corrosion program -- and I will tell you a little bit more about that shortly -- in the August-September time frame last year. As you've heard this morning, EPRI has put their RFP out on the streets something like five weeks ago, let me say, plus or minus a week or two.

If you look at that industry RFP, it is more broad based than the program that I've put in place at Argonne, but it contains everything in that program that I put in place out at Argonne. Why are we doing this twice? I have no idea.

MR. ROSEN: Argonne will get twice as much money?

MR. CULLEN: No. Argonne won't do their work for the industry. That would be a conflict of interest. Boy, would that get some people excited.

But you know, somebody somewhere is going to do this program for the industry, and they're going to generate the same doggone collection of data that we're generating at Argonne. I have no idea why.

MR. WALLIS: I'm not sure they will. I mean, it seems to me this might be one of those areas where the science is so poorly understood that having two groups working might not be such a stupid thing to do.

MR. CULLEN: I hear what you're saying, and I think that some overlap in a coordinated program is just fine, but why you would overlap 100 percent of the program is a little bit beyond me.

Now, we are having a few things specifically done by the Argonne people that are not in the EPRI program, I'll grant you, but --

MR. WALLIS: Are they going to do the same experiment, exactly the same?

MR. CULLEN: It looks like it if the vendor responds to the EPRI RFQ in the way that it looks like they should. I would say yes.

MR. POWERS: There's nothing like replication to give you confidence, is there?

MR. CULLEN: I mean, that is --

MR. POWERS: We'd love to see replication even once in this field.

MR. CULLEN: That's one way of looking at it, but why would you take a six figure program and do it a second time in its entirety? I'm not so sure why.

Okay. Now, the last one I want to point out here is something that in the area of mitigation testing, that for the present time, as I've pointed out here, this is fully an industry effort. Even though we've listed it in the NRC-industry collaboration scheme of things, for the moment mitigation testing is something that I'm quite comfortable just letting the industry go for it as much as they want to.

Industry is going to look at stress mitigation. They're going to look at environmental mitigation, and I just want to sit back and watch what's happening for the time being.

If it comes to a point where we may need some confirmatory research of something that the industry has shown, then we may entertain proposals to take a look at that, but for the moment, this particular item on mitigation is an industry only item.

The nozzle 46 may turn out to be just an NRC item. I'm not sure about that. Again, we don't seem to have the kind of level of conversation going that I would like to have here, but again, I'll say a little bit more in a few slides from now.

We are harvesting a couple of sections out of the Davis-Besse head in a way that is similar to the way the industry described harvesting pieces of the North Anna head, and one of the pieces that we're harvesting from the Davis-Besse head is Nozzle 46, which had an anomalous UT indication that may or may not be a leak path.

Nozzle 46 also had some circumferential indications in the J weld that were never fully disposed, and I'd like to get about more completely disposing those indications, finding out whether or not they linked up to provide a leaker, and if so, did that leaker create a leak path that, indeed, is the explanation for this, quote, anomalous indication?

The other nozzle that we're harvesting out of Davis-Besse is Nozzle No. 2. That's the one with the small cavity, if you will, "small" being just what, a half an inch in depth, not seven inches in depth. Many people look at that Nozzle 2 as being a youthful version of the -- the cavity around Nozzle 2 as being a youthful version of the cavity that was discovered at Nozzle 3 and may give us some indication, some enlightenment, if you will, on how these corrosion cavities get started.

All right. Shall we do one more thank or shall we break?

CO-CHAIRMAN FORD: I think we should break here.

MR. CULLEN: Let's do it.

CO-CHAIRMAN FORD: Or else we'll have a revolution.

I'm going to recess until half past. We'll start probably at half past.

(Whereupon, the foregoing matter went off the record at 3:18 p.m. and went back on the record at 3:33 p.m.)

CO-CHAIRMAN FORD: Let's get back into session, please.

Okay, Bill. It's all yours again, please.

MR. CULLEN: All right. Now you all know what's coming from the handout. This next slide always gets a few chuckles, but the message that I want to bring today is that here we have crack growth rates in Alloy 600. Alloy 600, depending on its heat treatment, depending on the normal allowable differences in its chemistry, can take on a wide range of crack growth rates as its normal property.

It's nobody's objective to fit a line

through this data. That is not what this line is. It's not a fit. This line is intended to be representative. It's the 75th mean percentile line of data from alloys that actually exhibited a crack growth rate.

I'm not here to go into a long lecture, a long monologue on how it was that all of this data was generated and qualified, but suffice it to say that this particular slide does show that Alloy 600 takes on a variety of possible crack growth rates, spanning a couple of orders of magnitude.

The main reason that I wanted to put this slide up here is to take a more forward look at the data that's going to be added in a couple of years, and I alluded to that or described that briefly on some of the earlier slides.

I described a couple of Japanese programs that generated data that spanned a fairly wide range of stress intensity factors. None of that data is on this plot at the present time. I can't possibly tell you where that data is going to wind up, but suffice it to say that when the results of the Japanese program have been produced and publicly distributed, that we will have quite a lot more data from that that will appear on this graph.

MR. POWERS: One of the problems with this kind of graph, and we get to see a lot of them in the metallurgical business, and we're assured that there are 10,000 reasons why these things show a lot of scatter, and my colleague, Professor Wallis, will look at a plot like this and say, "Gee, this is proof positive that there are some other variables in this thing," and that's what you've alluded to.

Metallurgists are good at coming up with lots and lots of candidates. What we never see is the multivariate plot in which you say, "Okay. Here are the effects not only of stress intensity factor, but everything else included, and here are the ones that are important and the ones that are not important."

Instead all we hear is, "Here are all of these factors that are important, potentially important."

MR. CULLEN: Just a list.

MR. POWERS: Yeah. We never see a quantification of what's important and what's not important.

MR. CULLEN: I described a, quote, critique of the susceptibility model that I wrote and finished up a couple of months ago and said I would make it available to you all in a month or so. There are some of those sorts of plots in there that you're describing, plots of crack growth rate versus yield strength, plots of crack growth rate versus grain boundary carbide coverage.

MR. POWERS: But any time you plot against one of these variables, you're going to have a plot like this. What you need is one of the multivariate plots that says, "Okay. I've set up a model. It could be linear or nonlinear, and here is predicted versus observed, and here is my factor analysis on all of those things that I've included to show you which one makes a difference and which ones are never minds."

MR. CULLEN: I suspect you know the discipline called artificial neural network design, ANNs, neural networks.

MR. POWERS: I have stayed away from that assiduously.

MR. CULLEN: I kind of thought when you used the expression "multivariate analysis" that that would be one of the technologies or techniques --

MR. POWERS: It is a technique that people use.

MR. CULLEN: -- that you were thinking of.

You know, they all fall into the general category of I call it pattern recognition. You can use a variety of approaches. Neural networks is one.

I have just received a draft NUREG report from another contractor that I asked to do a neural network analysis, which is what I think you're asking for, suggesting a multivariate analysis of exactly, well, not this data because the details of this are still proprietary, but we had a reasonably well conditioned set of data from other sources that did have all of the information about chemistry and processing, metallography and things that we wanted to be able to pump into this neural network analysis.

That analysis will be published I will say in a couple of months, the kind of time frame it takes to turn around a NUREG.

So this sort of work is being done. I'm not sure what, if anything, the industry might be doing along this line. Perhaps something. I just don't know.

MR. POWERS: Well, the question is: when does it creep into our discussions of what the research --

MR. CULLEN: Well, it needs to mature, and I think we're a long ways from maturation.

MR. POWERS: Somehow a regression analysis is not a triumph --

MR. CULLEN: Of modern day technology. I realize it, yeah. It was not exactly yesterday that somebody discovered least squares regression, but the application of that to this sort of database where, you know, everything has variations is something that I think is much more modern day and still at this point less mature and less reliable than, you know, fitting data to something else.

MR. WALLIS: Well, where does this come from? Is this just from this steel, some other situation, or is it for steel under reactor conditions, the environment that you have there or what is it?

MR. CULLEN: Again, to try to be brief because this was described by John Hickling and his colleagues to the ACRS -- oh, I don't know. Tell me when. September, October, some -- June of last year. Okay.

This data was very, very carefully vetted by this Alloy 600 task group. I sat in those meetings and listened to their discussions. Yes, it is data generated for materials that are reactor typical in environments that are reactor typical, and believe me, in the totality of the data that was considered, there are a far greater number of data points that were discarded as being not valid for inclusion in this database.

MR. WALLIS: Well, if you had more data, you'd just get better coverage of the paper.

(Laughter.)

MR. CULLEN: You're absolutely correct, and that is the point. In a way, we want to know what the full extent of the variability is. We're not looking to have all of this data collapsed onto a very thin line and, you know, at some point in time somebody finding out that, you know, the low liers or the outliers were bad data sets for some particular reason. That's not what we're looking for at all.

We're looking for a plot of data that is representative of all of the materials that could possibly be found in the heads of our domestic plants.

MR. WALLIS: What are you going to do with it?

MR. POWERS: I mean, this is like the heavy section steel program. We'll just keep looking until we find another variable that affects things, and then we can go experiment on that for another six months.

CO-CHAIRMAN FORD: Let me try and help.

I don't think it's quite as bad as you're saying.

The end result is to come up in this case using artificial network approaches, to come up with this multivariable algorithm that you're talking about.

MR. POWERS: Peter, I do not need neural networks to do a multivariate analysis.

MR. CULLEN: But it's one technique.

CO-CHAIRMAN FORD: But by getting the multivariate analysis whether you artificial network approaches is going to come up with this multivariable approach, but it needs the data, the good quality data.

Your objection is if you put some more data on there, you come up with a mass of data. If it's unqualified data, I agree with you 100 percent, but this will be qualified data. If that is accomplished, then he has got hope of coming up with this multivariable algorithm.

MR. WALLIS: Isn't scatter here because of these mysterious heats which are all somehow different because of what has happened to them in the past?

MR. POWERS: Well, that might be one way to --

MR. WALLIS: The variable to quantify.

CO-CHAIRMAN SIEBER: That's one factor.

MR. CULLEN: That might be one way of saying it, but it's not getting to the root cause of the scatter, which is differences in the microstructure of the material.

MR. KRESS: Okay, but do you know what those differences are?

MR. CULLEN: We're getting onto that, and that's another point that I want to make, is as time goes on, the experiments that we do get better and better, and the correlative data that we come to understand is necessary gets to be more and more a part of the overall package.

MR. KRESS: On this plot do you know the differences between the Xes and the squares?

MR. CULLEN: I can't stand here and say that I do. I might be able to dig and, you know, maybe guess that these might be very low yield strength materials as a possible example, and if so, then I would say, well, that probably explains why they're sitting down there at pretty low crack growth rates, and you know, this stuff up here might turn out to be highly cold-worked, high yield with rotten grain boundary coverage. See, now we understand why that's high.

I think we're getting onto this. Do we have it for every data point that's on the plot? Well, I doubt that, but I think we're getting on to understanding what it is that produces these valid differences.

MR. WALLIS: What kind of K do you get in these control rod drives?

MR. CULLEN: Up to about the yield strength of the material, which would be up here in about the 60 --

MR. WALLIS: It is not a yield strength. You have to have floor size and things.

MR. CULLEN: Well, yeah. I'm sorry. You were asking the right question. I was just giving the wrong answer, but --

MR. POWERS: Thirty-five.

MR. CULLEN: Yeah.

MR. WALLIS: Oh, the middle.

MR. CULLEN: Yeah, somewhere in here because these things have .625 thickness to them.

MR. WALLIS: And they're highly stretched. So that's where the K comes from.

MR. CULLEN: That's where the K comes from. Now, you have to worry a little bit about constraint.

MR. WALLIS: -- material. Is it applied K? The applied K from the stress condition, do you know the stress condition well enough to know the applied K?

MR. CULLEN: I think we do, yes. I mean, if you believe the finite element plots that I put up a half hour ago, K is being routinely calculated using those stresses, and you know representative crack lengths through the thickness of the housing.

So yeah, and in fact, those sorts of K relationships are being --

MR. WALLIS: Well, what are you going to do when you get scatter like this? Are you just going to keep on correlating until you try and get something with less scatter?

MR. CULLEN: Well, the goal of this --

MR. WALLIS: -- engineering decision with something like that?

MR. CULLEN: The goal of this particular report was to come up with a proposed curve that could be used to disposition flaws, and the MRP is suggesting that this curve reside at the 75th percentile.

MR. POWERS: This will be the most obscure number to pick as a percentile. A 65.3 or something like that.

MR. CULLEN: But, again, you have to keep this in the bigger context of there are other conservatisms in the overall analysis that are part of the overall package.

MR. POWERS: Which is the most catastrophic way to do an uncertainty analysis that I can think of.

MR. CULLEN: Well, yes, I realize, but we're trying to --

MR. POWERS: Put conservatisms here, put conservatisms here, and put conservatisms here, and then tell me what you've got at the end. You have no clue what you've got at the end.

MR. CULLEN: You're talking about the difference --

MR. WALLIS: You're talking about the top point, I mean, the highest points. I mean, you've got a whole population of reactors which maybe have steels which lie all over this map. Some of them are going to be up there growing a few centimeters a year.

MR. CULLEN: That is a possibility.

MR. WALLIS: And therefore, you're making decisions based on that.

MR. CULLEN: You are correct.

MR. WALLIS: You have your inspection intervals accordingly.

MR. CULLEN: Again, correct.

MR. WALLIS: Forget about everything else.

MR. KRESS: Or you use a Bayesian update for each specific reactor. State with that one and Bayesian update each one of them.

MR. WALLIS: As you learn.

MR. KRESS: As you go along and learn.

MR. WALLIS: Yes.

MR. KRESS: I agree.

MR. CULLEN: In a slide or two -- I can't remember -- yeah, two slides, I'm going to talk about the susceptibility model, and I think some of the questions that you're asking now might be addressed a little better when I get to that opportunity.

CO-CHAIRMAN FORD: Okay, guys. If you could look at your root thing because the technician is going to play with the quality of this picture.

CO-CHAIRMAN SIEBER: It might get worse?

(Laughter.)

MR. POWERS: Is he going to add some data to this picture?

MR. WALLIS: You mean after the two previous works on that graph, all of the points will come down?

MR. ROSEN: That's right.

MR. CULLEN: Okay. Let's move ahead just a little bit.

MR. ROSEN: Artificial neural network.

MR. WALLIS: Just tell the guys where to look out.

CO-CHAIRMAN FORD: Thanks, Bob.

PARTICIPANT: That means no more problems here.

(Laughter.)

MR. CULLEN: Okay. Let's forget ahead here a little bit.

The point I'm trying to make on this particular slide is that we have several research programs that relate to the overall CRDM cracking issues other than the ones that I'm mainly involved in, which are stress corrosion cracking. But we have a contract out to look at inspection techniques and probability of detection, issues like that that relate to inspection.

We have the program that I talked about to model residual stresses; another program task aspect that involves developing a probabilistic model, and so on, and --

MR. POWERS: For something called T sub F.

MR. MATHEWS: Time to failure.

MR. CULLEN: Time to failure.

MR. POWERS: You are bright.

MR. CULLEN: And all of these different contract tasks are combined and fed into improved risk analysis models. I want to make again the point here that we are continuing the testing of stress corrosion crack growth rate determination in these relevant alloys and that we are using some materials that we've harvested out of the Davis-Besse head.

MR. WALLIS: Does this probabilistic model have any physics and chemistry in it?

MR. CULLEN: There's a member here of the ACRS who could perhaps comment on that a little bit more.

MR. SHACK: It will have some chemistry and physics in it.

MR. POWERS: All things in life, Graham, are chemistry. So you know that there's some chemistry in it.

MR. SHACK: It will include the mechanistic pictures that we've developed for the residual stresses.

There are things that we know well. I

think we know a lot about residual stresses. We know a lot about K. I think we know a lot about crack growth rate.

MR. WALLIS: About leakage through cracks?

MR. SHACK: We're going up to the place where the leakage starts. We actually know a lot about leakage through cracks, too. You know, it all has to come together.

MR. CULLEN: Let me stress that the probabilistic model that we are developing is to calculate an inspection interval which would be optimized to discover a leak very, very soon obviously after it may emerge after we go through a wall.

So it's not to provide any inspection interval calculations for a plant that already has known leakers in it. What we're trying to do is to come up with intervals for inspection that will help us or assist us to discover leaks as soon as they reasonably can be discovered in a given plant.

MR. KRESS: What do you do when you discover a leak? Go fix it?

MR. CULLEN: I'd rather have the licensee answer that, but I think generally you have the right idea, yeah.

MR. KRESS: Do you fix it the next

shutdown?

MR. CULLEN: Well, of course, they would be shut down at that particular point.

CO-CHAIRMAN SIEBER: NERC does not allow you to operate with a leak except --

MR. KRESS: WE operate with a leak through the steam generator tube. Why is this any different?

CO-CHAIRMAN SIEBER: We didn't operate with a leak. We just didn't operate with leaks. That's the way we interpreted the ASME code.

MR. KRESS: Tech specs allows a certain amount of leakage.

CO-CHAIRMAN SIEBER: Identified leakage, but it can't keep from --

MR. SHACK: If you identify it as a crack in the reactor coolant boundary, it's got to be fixed.

CO-CHAIRMAN SIEBER: There are fair amount of bolted joints or gasketed joints in a plant, some of which may leak. You know, a packing gland (phonetic) on a valve may drip a drop of water on the floor once in a while, and so you're allowed to operate under those circumstances, but you aren't allowed to operate when you have a breach of the physical material of the plant. That's what the code says.

MR. ROSEN: Except for the steam generator tubes.

CO-CHAIRMAN SIEBER: We didn't interpret it that way.

MR. ROSEN: The tech specs interpret it that way.

CO-CHAIRMAN SIEBER: Yeah, I know. There is a tech spec that says you can't have more than a gallon a day or something.

MR. KRESS: So when you detect a crack that's going to be 70 percent through wall by the time of your next shutdown or it's going to -- you're going to repair it at 70 percent through wall or are you going to wait for it to leak?

CO-CHAIRMAN SIEBER: Well --

MR. KRESS: Since you can't have a leak, you've got to decide how far through the wall you're going to let it.

CO-CHAIRMAN SIEBER: When you're operating you aren't going to know.

MR. POWERS: You have flaw evaluation guidelines.

MR. KRESS: Oh, yeah. I haven't read those yet.

CO-CHAIRMAN SIEBER: The only way you're

going to know that you have a leak is when your unidentified number changes, your leak rate number, or you get changes in containment like additional particulate activity or increased humidity. There are indications that you're leaking, but you can't tell where it's coming from. That's why they call it unidentified.

CO-CHAIRMAN FORD: Bill, this construct looks very similar to the NRP construct. Will we have two identical models or two different models or what?

MR. CULLEN: This, I think, falls in the category of confirmatory research.

CO-CHAIRMAN FORD: Well, what happens if it gives a different answer?

MR. CULLEN: We need to resolve an issue like that.

CO-CHAIRMAN FORD: It's bound to give a different answer.

(Laughter.)

CO-CHAIRMAN FORD: I guess I'm wondering what do we do in a case like that. Do you have an argument, a discussion?

MR. CULLEN: I think I don't have an answer to that right now. It's kind of a wait and see once we get there kind of a thing.

CO-CHAIRMAN FORD: Now, the industry are saying that they will have this for Alloy 600 for cracking by the middle of this year. What is your time scale?

MR. CULLEN: Well, this is a work in progress. I think the time scale is roughly the same, but it is definitely a work in progress.

CO-CHAIRMAN FORD: Okay.

MR. SHACK: South Texas may cause some upset to the model.

(Laughter.)

MR. CULLEN: Okay. Let's --

MR. SHACK: Because the model doesn't predict South Texas at the moment.

MR. CULLEN: Let's move on here a little bit. I've mentioned a couple of times now that I've been a couple of months taking a look at this susceptibility plot. As we've heard a few times today, the current model depends only on time at temperature, and the current model, I would have to admit, and it's very easy to see, is doing a very nice job of projecting when the plants will develop obvious leaks.

All of the red squares down here at the bottom are bare metal visual observations of leaking

CRDMs. So the model works. That's indisputable.

There are a couple of orange triangles over here which are NDE cracks, discovered by NDE and repaired. So you know, where these boundaries are maybe something that could be discussed further.

Remember, of course, this is a statistical distribution. So you know, you're going to find some things elsewhere other than right up here at the upper tail.

MR. WALLIS: What does plant ranking mean here?

MR. CULLEN: Oh, we just number from the plant with the highest number of EDYs to the plant with the lowest number.

MR. WALLIS: Then it should be a monotonically increasing curve.

MR. CULLEN: And it is.

MR. WALLIS: It's not. It has got wiggles in it.

MR. CULLEN: I think if you take a look, every data point is a little further to the right. Now, you won't see any back-ups except for something like this which is in there twice.

MR. WALLIS: It should be up as well if it's just a ranking based on EDY.

MR. MATHEWS: The growth mark plant ranking, it was ranking as of a given date and time, and the plots were the inspections for that time of the inspection.

MR. CULLEN: Yeah, that's true.

MR. WALLIS: Ah, that's the only difference.

MR. CULLEN: I'm thinking maybe what's confusing things is like that orange triangle also has another data point out here for that same plant. You know, if you eliminated the duplicity where a plant had --

MR. POWERS: The duplicity. Let us eliminate the duplicity at all opportunities.

MR. CULLEN: If you eliminate the double counting of the plant? Okay.

You know, some plants had an observation and disposition at one point in time, and the same plant had another observation and different disposition at a second point in time. Kind of belaboring that in order to straighten it out.

CO-CHAIRMAN FORD: I know we asked the question why the discontinuity in the curve up here and, boom, like that.

MR. CULLEN: Yep.

CO-CHAIRMAN FORD: And I know the answer was given, but I've forgotten what it is.

MR. CULLEN: Well, these are all cold head plants. So they build up EDYs very, very, very slowly. I'm not sure what that plant is. You know, everything has an explanation, but you know, these are basically all of the cold head plants. These are all of the really hot head plants.

CO-CHAIRMAN FORD: But Graham's point is if you have the same algorithm here, it should be a smooth curve.

MR. CULLEN: I wouldn't say a smooth curve.

MR. WALLIS: The different times apparently. They ranked them at different times when they calculated EDY, but it should be essentially a smooth curve. There's no new information involved by plotting plant ranking. It's really on the basis of EDY, the points to the right.

MR. CULLEN: Yeah. The worst plant is the number one plant, the worst in terms of the maximum EDY, and the best plant is up there.

CO-CHAIRMAN FORD: Okay.

MR. CULLEN: It's just a convenience to plot things that way.

Okay, but the point that I want to make here is that, you know, in a statistical basis we can all envision the day perhaps where a plant down in here is going to develop a leak, and we may know about this already, but I'm not going to stand up here and mention names.

So you know, there are other factors that are going to affect this susceptibility ranking one way or another. Some of these low plants are going to develop a crack, and we're going to have to figure out why.

Some of these plants up here in the high ones, maybe that star right there which so far is a good plant, no observations from NDE. You know, this may go on out as a green star for a long, long period of time, and we're going to have to come to some way of understanding why that is.

Again, it's not my role to take a plant position, but I can well imagine that licensee asking for some sort of relaxation from the NRC. You know, why are we driving ourselves nuts just because we're in the high susceptibility category? But, you know, we've got other rationale for why we're staying clean.

So I can see that some of these other factors that I've mentioned, yield strength, grain boundary carbides, actual measurements of stress corrosion crack growth rates in nozzle materials, might be something that we might want to take a look at and have some consideration of going forward.

Okay. I'm going to launch into kind of the last part of this, but I actually thought the last part might generate more questions than the first part. If that's the case, bring in the sleeping bags.

Okay. The Davis-Besse licensee, FENOC (phonetic), has completed the experimental work on the investigation of the cavity dropout from the Davis-Besse plant, and they have provided that information to us at the NRC, and I do have explicit permission from them to show you the pictures that I'm going to show you.

And the reason that I want to show some of these pictures to you, some of the descriptions of what they found metallographically and fractographically is because this information plays directly into the research programs that we're conducting here in the MEB. Basically they looked at the axial and circumferential cracks in the J weld and also in the small section of the nozzle that's still Nozzle No. 3 that remained.

They took a look at the cracks in the

clad, and they took a look at the walls of the cavity, and I'm going to show one example in all four categories: the axial crack in the nozzle, axial crack and circumferential cracks in the J weld, the cracks in the clad. the fourth thing is the walls in the cavity. Because all of those things are important to some of our research programs.

Okay. As an example of what they did -- and all of this work was conducted won in Lynchburg by BWXT -- here's a portion of the cavity. Now, actually they have sliced essentially horizontally through the head and removed what would have been the top part of the head at about two thirds of the way up or at the point where the nose of the cavity was, actually had its greatest extent.

So not to belabor or point out the obvious, but the Nozzle No. 3 was right in here. The zero degrees is always downhill for reference, and you'll need that point of reference as I go through and talk about all of this.

The largest cracks in the nozzle were very near ten degrees, right about there, and that is the one that was spewing water into the cavity and causing this corrosion.

There's another very large crack, actually somewhat larger crack, at 180 degrees which was non-leaking.

MR. WALLIS: Could you tell me again while I'm looking at them? Am I looking down into a hole?

MR. CULLEN: Yes. You're looking from the top down.

MR. WALLIS: It looks as if it's coming out to me. It's actually going away from me.

MR. CULLEN: It's going away from you, yes. That's hogged out or dug out. The illumination is a little bit --

MR. WALLIS: And you're looking at the bright cladding.

MR. CULLEN: Yes. This, of course, is the exposed cladding that has been cleaned up now, and it's shining back at you. This is the low alloy steel. This is the J weld. There's a very nice picture of that coming up in the next slide.

MR. WALLIS: But the boundary is very sharp on the surface of --

MR. CULLEN: No, no. Remember if my hand is describing the thickness of the head, we've sliced through that at approximately two thirds of the way up.

MR. WALLIS: Oh, through the head.

MR. CULLEN: Yeah. So there's another matching piece that would sit on top of this, and if you could see the outside of that, you'd be looking at the original top of the head.

MR. SHACK: Oh. The 180 degree crack was also through wall and metallographically was a larger extent than the ten degree crack?

MR. CULLEN: One, point, two inches versus 1.1.

MR. SHACK: Was it through wall?

MR. CULLEN: Yes.

MR. SHACK: Okay. Why do you label it non-leaking?

MR. CULLEN: Because it didn't leak. There's no corrosion. There's no leak path.

PARTICIPANT: Non-eroding at any rate.

MR. CULLEN: If you look at this wall, it's as pristine as something like that should look.

Okay. Now, this is a picture of a little section of the J weld. Now, remember this surface has never been seen before by man or woman. This is the surface that was exposed by the corrosion of the boric acid.

Here is the low allow steel that I've labeled over here, and this is J weld deposit, and this surface, of course, was in intimate contact with carbon steel once upon a time.

So I'm just showing this as kind of a --

MR. WALLIS: But the J weld was not touched. That's --

MR. CULLEN: The J weld was not attached. That is correct.

MR. WALLIS: Is it similar material to the clad or is --

MR. CULLEN: No. Clad is basically a 308 stainless steel, something that looks vaguely like --

MR. WALLIS: The stuff that you weld stainless to carbon with?

MR. CULLEN: Yeah, this is the Alloy 182 that we've talked about repeatedly this morning.

MR. WALLIS: I didn't know what it is.

MR. CULLEN: Okay.

MR. ROSEN: It doesn't get attacked by boric acid.

MR. CULLEN: That's correct, and the stainless steel clad does not seem to be attacked wither. The reason that this section was made at this point was that this distance here happens to be the very thinnest that the clad got anywhere within the cavity. If memory serves right, this is .208 inches thick right here at this little tucked in corner.

MR. WALLIS: This is a place where the hole is pretty narrow. So it's really in the corner. It goes into a --

MR. ROSEN: Maybe you can go back to the picture before and show us roughly from above where that is.

MR. CULLEN: Okay. You're looking at this piece right here.

MR. WALLIS: It's amazing how narrow that whatever you call it is.

MR. CULLEN: Yeah. Well, you know, it was corroding.

MR. WALLIS: It would carve out in that pattern is really remarkable that you would cut so deep and so narrow.

MR. CULLEN: Well, I mean, the depth of the cavity was almost seven inches.

MR. WALLIS: I know, but isn't this a remarkable pattern?

MR. CULLEN: Well, it certainly is interesting. Yeah, "remarkable" is a fine word. Interesting, stupendous.

MR. POWERS: Elicited a lot of comment.z

MR. ROSEN: Earth shattering, curious.

MR. CULLEN: All of these kinds of things. Curious. All right.

MR. WALLIS: One has to really think about how that pattern could be developed.

MR. CULLEN: Are you talking about this pattern right here?

MR. WALLIS: Oh, no, no, no. The pattern of the hole, the --

MR. CULLEN: Oh, the geometry of this --

MR. WALLIS: Yes.

MR. CULLEN: -- overall cavity at that location. Well, in the same sort of line, I think, there is a little bit of a corrosion undercut right here. Originally I actually thought that maybe there would be a substantial undercut. That turns out to be not true.

This is almost the undercut in its entirety. If I had included more of the picture, it kind of goes up very quickly up along here.

This photo is a 180 degree reversal of this because of the difference in the type of camera. This is an ordinary camera. This is a telegraph. So this little undercut is actually that little thing right there that you can see.

MR. ROSEN: And there's a crack extending, right?

MR. CULLEN: No, that is not a crack. That is just simply the boundary between cladding and low alloy steel. It does look sharp. I agree. Visually it looks like a crack, but it is not a crack.

MR. ROSEN: Looks like a crack to me.

MR. CULLEN: No. Take my word for it. It's not.

MR. WALLIS: Is there any pattern on the low alloy steel that indicates convection patterns or anything?

MR. CULLEN: We're going to get that in the second and third slides from the end.

Okay. As I've said two or three or four times now, we're doing actual crack growth rate testing of the Alloy 600 that was in Nozzle No. 3. This is some metallography on that nozzle material.

This is the remnants of the non-leaking crack, the longest one, that was in Nozzle No. 3. Basically what happened, as the licensee was, on March the 8th, boring up to prepare this nozzle for its repair, they got up to a certain point where they had actually gotten rid of three of the four cracks that were in this nozzle when it tipped on them, but there was the tail end of that fourth and longest crack, the uphill crack. The one at 180 degrees was still partly in the nozzle. So that's the one that still remains, and that's what you see. Right there is the tip end of that particular crack.

Looking at the metallography of this, and I also would like to mention, and it comes out later actually, the yield strength of this particular material is known, and I would call it moderate, in the middle of the range of yield strengths that we know for this particular material, and the grain boundary coverage is pretty good.

That darkened line right there is basically carbides all along this particular grain boundary. If you do an analysis of the carbides, you get this huge chrome peak right there. Over here there it is right there. You can see it's nothing like what it is over here.

On the other hand, here's the iron peak and here's the nickel peak, and they are virtually nonexistent over here. So there was essential chrome depletion nearby and chrome carbides right on the grain boundary, very low in iron and nickel, but the matrix has the normal Alloy 600 chemistry.

Basically my message here is that considering the chemistry of this material, the yield strength of this material, the fact that the micro hardness traverse on it is fairly flat, basically this is pretty good Alloy 600.

MR. WALLIS: So downhill on this thing is the furthest extent of the hole, is downhill, isn't it? So the debris from the hole is flowing out of the downhill edge presumably.

MR. CULLEN: At the downhill edge, yeah. That is not this crack that we're talking about here. This is --

MR. WALLIS: Going back to the previous picture, yeah. It's flowing -- no, no, the one before that. This is uphill somewhere. It's flowing out over there. It's coming out on the right.

MR. CULLEN: It is coming out at probably about this angle right here, pretty much, you know, coming out of the ten degree crack, and I would say pretty much coming --

MR. WALLIS: Oh, that's where it's coming out of the crack, from the crack.

MR. CULLEN: Yeah.

MR. WALLIS: Okay. So that's also on the side of the most erosion or corrosion.

MR. CULLEN: Right, but the crack that I'm showing in that slide, two slides ahead, is up back here. That's the only crack that remained after the nozzle tipped over on them. It's the only one that we have to look at. The downhill crack, the ten degree crack, the leaking crack is a goner.

Okay. This is a metallograph of that stress corrosion crack that you saw in a normal photo on the previous slide. I'm showing this simply to reinforce what we talked about this morning, the tortuosity of --

MR. WALLIS: The crack growth rate you mentioned is what, the actual distance with a straight line between the end?

MR. CULLEN: No, it's the linear crack growth rate. It would be what you would see if you looked straight down normal --

MR. WALLIS: When it wanders around like this, doesn't K vary?

MR. CULLEN: On a highly, highly --

MR. WALLIS: -- then it must be changing its K all of the time.

MR. CULLEN: But fracture mechanics don't think of the driving force behind a crack in that regard.

MR. WALLIS: Oh, they don't?

MR. CULLEN: You may be correct on a very,

very local basis, but fracture mechanics is a more global analysis of crack driving forces.

MR. WALLIS: But the K forms sort of an analysis of an ideal crack and the square root law for the stress distribution.

MR. CULLEN: That's correct.

MR. WALLIS: Is that the radius? That's where K comes from.

MR. CULLEN: That's correct.

MR. WALLIS: And this doesn't look anything like the model that K is based upon.

MR. CULLEN: That is --

MR. WALLIS: How can you use a K?

MR. CULLEN: Well, in a highly local way that's true. It doesn't look like, you know, a linear crack with an infinitesimally sharp notice.

MR. WALLIS: The tip, it's still doing the same thing. See?

MR. CULLEN: What we do know is that cracks that look like this still, if you will, observe the laws of fracture mechanics.

MR. WALLIS: Except that you can't correlate the data.

MR. CULLEN: No, let's not go that way.

Okay. If you open this crack up, this is what you see: classic intergranular stress corrosion cracking. You couldn't get a picture that's more textbook perfect than that, and that's the reason that the licensee did this, is to prove, if you will, that a stress corrosion crack in a field typical nozzle really looked like that.

It's not the first time that we've been able to do that, but it's helpful to know that.

MR. POWERS: Maybe you should tell me what I am not seeing here.

MR. CULLEN: Well, I'm going to sidestep that question because I think what we are seeing is what we would expect to see.

MR. POWERS: I mean, what you're saying is because you see lots of dodecahedral kind of structures, you're breaking in between the cracks.

MR. CULLEN: Exactly right. So this is classic textbook IGSCC. You don't need another explanation.

MR. WALLIS: Nothing else looks like that?

MR. CULLEN: Now we're getting into a Pandora's box. Are you looking for an answer to that question?

MR. WALLIS: Well, yeah. You said this was now we know sort of for certain that this is an IGSCC crack.

MR. CULLEN: Yeah.

MR. POWERS: I mean, almost ipso facto because it's obviously intergranular and it's obviously a crack. He doesn't know that stress corrosion caused that crack.

MR. CULLEN: Well, you know, it has been suggested, as an example, that thermal fatigue may drive some of these cracks in the head. We don't see any evidence of that, and I'm happy for that. I mean, that would complicate our lives enormously.

So, I mean, it's those sorts of things that we don't see that gives me some ability to understand better what it is that is driving this thing.

MR. SHACK: You don't see the river patterns that you would get if you saw some sort of hydrogen embrittlement.

MR. WALLIS: That's some tip.

MR. POWERS: The thing that puzzles me about this crack, the speakers that precede you a lot said, "Gee, these cracks are very tight."

And I look at that and say, "Gee, that doesn't look like a tight crack to me."

Is that a tight crack to you?

MR. CULLEN: No. You're not looking at the crack tip though. You were looking at the crack tip.

MR. WALLIS: There is no crack tip. There are thousands of crack tips.

MR. CULLEN: That's true, and that reinforces the point that was made by another speaker this morning, is that stress corrosion cracks typically branch all over the place and give you lots of NDE signatures to look at.

Now, back in here, you know, this is the original ID, and so, yes, the crack has a large opening at this particular point, but if you come down at the end of it and you take a look at some of these tips, you know, they're pretty tight. Up in here it looks open. I'm not so sure we're really looking at the tip of the crack.

And remember this is just a slice.

MR. POWERS: I understand.

MR. CULLEN: And the tip may be who knows what?

MR. POWERS: In or up in the material that you --

MR. CULLEN: Yeah. So I don't think we should be misled by what appears to be a certain openness in the crack enclave.

MR. POWERS: But it is that, those stringer kind of things that you see out there that are being described as tight.

MR. CULLEN: That's correct.

MR. WALLIS: Now, tell me about stress corrosion. That corrosion part must imply some kind of chemistry going on. There's something going through the crack which is causing this to pop through?

MR. CULLEN: Well, I could launch into a long monologue at this point, but --

MR. WALLIS: No, but there is something in the crack? The environment makes a difference?

MR. CULLEN: The environment absolutely makes a difference, yeah. Now, exactly micro mechanistically, micro chemically what's going on, let's not go there.

MR. WALLIS: The environment has to diffuse an awful long way through those metal cracks to relate what's in there to what's back in the reactor.

MR. CULLEN: Well, but remember this was solid metal.

MR. WALLIS: I know.

MR. CULLEN: So solid metal with water out here, what happens when that metal opens? I mean something has got to get sucked up in there and --

MR. WALLIS: There must be a tremendous gradients in the chemical environment going on in there.

MR. CULLEN: I would tend to agree with you. There probably are, and that's been several thousand theses generated on that issue.

MR. WALLIS: Did they ever resolve it? Do you have a model for it?

MR. ROSEN: Yeah, there are lots.

MR. CULLEN: Lots of models. Very, very difficult to prove. Now you get into how do you sample the environment that's up there in the crack. You may be aware there's some attempts been made to sample the environment in the crevice in steam generator tubing, tube sheets, but all of this sampling business is very, very difficult.

MR. WALLIS: You probably influence it just in trying to sample it.

MR. CULLEN: Yeah.

MR. WALLIS: You change what's there.

MR. CULLEN: You know, when you go sample something, you probably are extracting a volume of material that is totally disruptive to the total volume of the crack.

MR. WALLIS: So what's in the crack? There's a liquid in the crack?

MR. CULLEN: Presumably.

MR. WALLIS: Where did the material go that disappeared from the crack?

MR. CULLEN: I don't think anything has disappeared.

MR. WALLIS: Well, how is it opened up then?

MR. CULLEN: Stress.

MR. WALLIS: It has opened up. It has moved. It has moved apart.

MR. CULLEN: Yeah. There's a displacement.

MR. WALLIS: There's a displacement. Okay.

MR. CULLEN: Okay. I just wanted to show this as examples of the cracks in the J weld, and again, we have got sections of the J weld at Argonne. We're going to be doing our own crack growth rates on this material.

Going now to the clad --

MR. WALLIS: That was wonderful.

MR. CULLEN: I'm sorry?

MR. WALLIS: That's wonderful, I said, wonderful.

MR. CULLEN: I still didn't hear.

MR. WALLIS: It's wonderful, the shapes of these things.

MR. CULLEN: Oh, okay.

MR. WALLIS: Remarkable.

MR. CULLEN: Well, you know, initially the first observation that was made of the exposed clad did not provide any indication that there were actually cracks in the stuff. The black right here was originally low alloy steel. Okay? So this surface here, absent a little bit of wastage that has occurred, was the surface that was in fused contact with the low alloy steel. Okay? The surface that is in contact with the reactor coolant is down here somewhere. I don't know where. This is only a part of the thickness of the clad. So this is the exposed.

So this was after the cavity developed highly concentrated boric acid solution, probably at a temperature approaching the boiling point, the normal ambient pressure boiling point, say, 200 and something degrees Fahrenheit.

And these cracks, if you open them up as we have right here, the crack path is interdendritic in a weld that is the analog to intergranular stress corrosion cracking.

MR. WALLIS: Well, why do you say it was 212? Doesn't the boiling point go up on --

MR. CULLEN: It does. Give me a number.

MR. WALLIS: It goes up quite a lot.

MR. CULLEN: I'd be happy with 215. I don't know. We don't know the concentration of boric acid. That's why, you know, I've got to hesitate on that.

MR. WALLIS: It's got to be pretty concentrated.

MR. CULLEN: Pretty concentrated is definitely the answer, but what the boiling point elevation is I'm not sure, but the message I'm trying to deliver there is not 605 degree temperature water. It was down quite low, and we do know that low temperature, concentrated boric acid solutions will corrode the low alloy steel, and that's why 40 pounds of it disappeared.

MR. ROSEN: I didn't just disappear. It just kind of flowed out. It wasn't magic.

MR. CULLEN: It was not magic. That's true.

The message that I was trying to deliver is that initially we didn't know that these cracks existed in the clad. So the safety analysis, structural integrity assessment that we had originally tried to do used the entire thickness of the clad on an assumption that the clad had its original thickness. Okay?

But now, just a few weeks ago when these photographs were presented to us, we found out that we've got cracks in this stuff. Well, the good news is that the cracks are, quote, only about 40 to 60 mils deep in clad that is between 200 and 300 mils thickness depending on where you are. So they only go a fourth or a fifth of the --

MR. WALLIS: Only produce the stress concentration and all of that kind of stuff?

MR. CULLEN: We're in the process of trying to calculate that right now. It will be two or three more months before we get to the bottom line answer.

MR. WALLIS: Very interesting because the assurance we were given was that this thing was a long way from disaster.

MR. CULLEN: We still believe that to be the correct answer.

MR. WALLIS: Just include these cracks in that.

MR. CULLEN: Even including the cracks, we still believe that that's the correct answer.

MR. ROSEN: Now, this stuff was yielded, right?

MR. CULLEN: There was a bulge. This is a point I have to be kind of careful with right now, and it is going to be part of our ultimate dispositioning of this thing. It is correct that there was a bulge in the clad, a bulge of the licensee tells us approximately an eighth of an inch. We take that to be reasonably accurate. We've got the data. It's reasonably accurate.

However, the interesting thing is that these cracks which are located right on top of the bulge show no evidence of plasticity at all, zero. We don't quite understand that yet. We're working on that, but it is very, very perplexing that these cracks appear to be driven entirely by intergranular stress corrosion cracking, no evidence of ductility, plasticity, void formation, whatever you want to look for that would give you some indication that there was plastic deformation going on in addition to stress corrosion cracking. We see no evidence of that, and it is, very frankly, a dilemma

MR. ROSEN: Because there's a bulge.

MR. CULLEN: Because there's a bulge. Now, that bulge, it was not a case of the cracks growing and then the bulging because we would see rounded crack tips.

MR. WALLIS: This is the bulge which is left. It isn't the plastic deformation alone. The elastic deformation would have made a bigger bulge on top of that.

MR. CULLEN: Well, we wouldn't see the elastic deformation. No, that would have snapped back when the --

MR. WALLIS: I know, but it would have been there. It would have been there on top of.

MR. CULLEN: Oh, it would have been there on top of that. That's absolutely true, but, you know, to a much --

MR. WALLIS: So it would have opened the crack some more maybe.

MR. CULLEN: Well, that, you know, stress corrosion cracks are driven by the elastic stress field. Generally stress corrosion cracks don't like plastic stress fields, plastic strain. That tends to blunt them and stop them. We don't see any evidence of that.

And it's very, very hard to imagine that the cavity opened, the bulge occurred, and then all of these cracks got started. That's not a very comfortable scenario. I mean, it just doesn't sit well.

CO-CHAIRMAN FORD: So this is relevant to the ultimate safety analysis, this particular incident.

MR. CULLEN: Yes.

CO-CHAIRMAN FORD: What does it tell us about --

MR. CULLEN: Can I defer your question for one or two more slides? Because there's another message coming.

CO-CHAIRMAN FORD: Okay.

MR. CULLEN: There is a message about that.

CO-CHAIRMAN FORD: Okay.

MR. CULLEN: So I mean these other things are just more of the same, but one part of the message -- well, I guess I've belabored that point. There's no tearing even near the bulge.

I'm sorry. I didn't mean to switch quite so fast, but we'll leave it. That's okay.

Another part of the message, the licensee made measurements on the depth of those cracks on the remaining ligament. No matter where the cracks occur in the clad, no matter what the thickness of the clad at that particular location, there's about 200 mils of clad remaining intact, in other words, intact, unflawed thickness of the clad.

Why did those cracks all pop in? I shouldn't use that. Erase the tape.

Why did those cracks all develop, move down, and with 200 mils of clad remaining stop? We don't know.

Could it be they are driven by stress? Possibly, and the stress just ran out of gas.

MR. WALLIS: Shut down the reactor.

MR. ROSEN: That could be.

MR. CULLEN: Well, but remember this cavity probably did not develop overnight, and these cracks are distributed throughout the cavity. So you've got to assume that the ones near the nozzle probably got an early start.

MR. WALLIS: They should be longer.

MR. CULLEN: They should be longer, but they're not. I mean, all of these cracks go down and leave about, you know -- so my guess is that they were probably driven by some sort of residual stress, and we do know that when you apply cladding to low alloy steel you create a tensile stress field as the cladding contracts and solidifies and cools.

So it makes some sense that we do know there is a reasonably thin layer of residual stress in the clad. So maybe the crack got nucleated, got started, grew until it just ran out of stress gas, so to speak.

Another possibility is that it's temperature controlled because remember you've got 605 degree water on the underside and you've got 200 degree Fahrenheit, 218, whatever you want to say concentrated boric acid solution on the top. So you've got a temperature gradient through the clad, and maybe that influences crack growth rate in clad.

We don't know because we've never seen stress corrosion crack growth rates in essentially, I mean, pure water. Agree it has lots of boric acid in it, but no other contaminants.

MR. WALLIS: It would be worse, wouldn't it? I mean if it's colder on top it would tend to open up more.

MR. CULLEN: You would tend to think so, yes. I agree with that, yeah.

Lots more questions than we have answers right now.

Okay. Peter, we're getting a little closer to the answer to the question that you were trying to ask me a few minutes ago.

MR. WALLIS: Well, the big question for me has always been why was the hole the shape it was. Have you got any handle on that at all?

MR. CULLEN: I don't at the present time. I'm not sure where the industry program that we heard about this morning is going to take us, but it might take us in that direction.

We may learn -- I say "we" in the sense of NRC RES -- may learn something from our probable investigation of the cavity around Nozzle 2 and the shape that that had relative to the crack that was in Nozzle 2. We just don't know the answer to your question in a sentence today.

MR. WALLIS: Why did it make a cavity instead of just a river or sort of an erosion pattern under the river?

MR. CULLEN: Don't know.

Okay. What we're looking at here is a normal photograph, J groove weld. The difference in coloration here is probably due just to the etching.

It doesn't mean anything particularly about deposits to the welds or anything like that, and this is the clad. This, of course, is where the cavity was, up in here, and this is where reactor coolant was down here.

Here's a little bit of an expansion. What I'm getting at and you'll see much better in the next slide, is there's a bunch of little stress corrosion cracks right over here in the corner as well. There they are metallographically now. This is the clad, and you can see that there's quite a large number of very fine, relatively short cracks, some of which actually penetrate the boundary. This is J weld down here. This is 308 stainless -- I'm sorry -- yeah, that's right, 308 stainless up here, 182 J weld down here.

This type of cracking only occurs very, very near the J weld. So I'm presuming that it has got something to do with the residual stresses that were set up when the J weld was deposited, and again, they only run down to and just barely into the J weld, and they seem to stop more or less, you know, where that boundary is.

The point that I want to make here, and to some extent in the previous slides at the cracks in the cladding is that we have known; you folks in the

ACRS are well familiar with irradiation assisted stress corrosion cracking in stainless steels, sensitized stainless steels. You're very familiar with boiling water reactor cracking problems in sensitized stainless steels, but we do not generally see stress corrosion cracking in stainless steel weld metal in the weld.

We usually see it at the heat affected zone or in some other sensitized part. We don't generally see stress corrosion cracking in weld metal, and here we have it in abundance.

We also have some IGA in abundance, intergranular attack, and some wastage, some grain dropout. These are things admittedly we've got a very off chemistry situation here with highly concentrated, probably highly oxygenated boric acid solution.

But, again, we've never seen this sort of a thing, and some of the people, some of the researchers, science regulators that I have talked to about this feel like this may become an issue, something that we might have to take a deeper look at going forward from here.

Whether this is the precursor to more stress corrosion cracking issues in a material that we thought was going to be fairly immune to this stuff I don't know, but that's the message that I wanted to deliver here, is that --

MR. WALLIS: You've got this thin stainless steel there. You've got a tremendous heat flux through there presumably --

MR. CULLEN: Yes.

MR. WALLIS: -- compared with what you had originally. So you have to supply a lot more liquid to keep it cool.

MR. CULLEN: That's absolutely correct.

MR. WALLIS: Someone has done all of those calculations and figured out what was going on?

MR. CULLEN: In MRP 75, I think it's Appendix C, you might take a look at that. While I'm not a TH kind of guy, I can read through that enough and see through that. I really believe that they have got the right handle, the right model for why liquid at 200 and something degrees accumulated in that cavity. I think I can understand that even though I don't understand the complexity of the calculation.

And I would recommend that. It's good reading, good background reading.

Okay. We had a question just a few minutes ago about the walls of the cavity and what do we see on the walls of the cavity. So this is the low alloy steel now, and actually I've changed.

If you think back to the very first slide in this series where I showed how a typical hunk of the cavity had been sectioned up every which way from Sunday and I said the thing had been split horizontally, well, now we're looking at the top part that was lifted off, but we're looking at the top part from the cut side.

So this is the opening that was visible to the licensee on March the 8th. Okay? And this is the nose, the deepest penetration of the corrosion, and this is the saw cut, horizontal or nearly horizontal surface.

All right. So three examples. This then would be about at the 180 degree or downhill side. The leak, in other words -- the orientation has changed -- the leak is, you know, back up here and streaming water pretty much straight into the nose of the cavity here.

And we have side walls. Again, if you're standing at the top dead center of the head looking down at Nozzle No. 3, this would be to your right side. This would be to your left side, and you can see that there are slightly different morphologies, more of the sort of pock marking on this left-hand side, more of the striations and sort of linearized texture on the right-hand side, and straight ahead almost nothing but pock marks.

So people will look at this and say, "Oh, my gosh, that is classic flow assisted corrosion." I personally have a problem with that because I don't think .01 gpm squirting through this murky solution of concentrated boric acid and hitting this wall seven inches away is going to have very much flow assistance impact to it, but you know, I've heard that spoken by some people in --

MR. WALLIS: Well, if the water is more like boiling, I would think is going on in this hole.

MR. CULLEN: That is definitely true. I mean, you've got enormous what you just said a few minutes ago: a lot of heat flux coming through that quarter inch thick piece of clad down there. So a lot of the stuff spewing into here.

As it turns out, if you look at Appendix C, 80 percent of the water that's coming out of the crack at 0.1 gpm, about 80 percent of it goes off immediately as steam and only 20 percent of it has a chance of remaining as liquid. But of that 20 percent, a whole lot of that is going to be boiled away.

But there's still enough. I mean, the leak rate is enough, according to the calculation that you still have residual aqueous solution.

Early on the people were fussing with the possibility of molten boric acid, a kind of gooey, gummy concoction. I don't see any chance that that existed in any amount that would make any sense or any difference.

Okay. I put this slide up because in the Argonne program we are doing wastage measurements in both quiescent and slightly flowing environments. So the kind of attack that we get may, indeed, look like some of this stuff. I hope it does because then we'll kind of have a rationale for why these sorts of patterns developed.

So, you know, it's nice to have actual photographs of what happened to this low alloy steel as a way of correlating or validating our laboratory investigations.

The same sort of thing, the last slide in this particular series. Again, this is a cross-section that shows how rough that low alloy steel surface was.

Two enlargements that show you what some of these dimples looked like in cross-section, and again, I'm just showing this and waiting to see what the Argonne results --

MR. WALLIS: Those dimples have nothing to do with the micro structure. They're too big.

MR. CULLEN: Well, you know, my experience in similar environment -- I won't say exactly similar environments -- but concentrated acid, concentrated sulfate environments of low alloy steel is that these sorts of dimples usually develop where you have an inclusion that acts as a local corrosion accelerant.

So, yeah, they are related to the micro structure. The point that the licensee is going to make is that these depressions are related to this layering, this segregation, banding, whatever you'd like to call it. You can see this cutout right here is kind of related to these bands. This here is related to that black band. You have another --

MR. WALLIS: This looks more geological all the time.

MR. CULLEN: Oh, yeah, yeah. But you know, this banding is related to the inclusion content in the alloy and does provide what I think is a reasonable rationale for why you get the highly textured surface, the voiding.

MR. WALLIS: Well, you've almost got the

old man of the mountains up there.

MR. CULLEN: Yeah, yeah. You can let your mind run in a lot of directions on some of those profiles.

Okay. So talking a little bit now about the specific program that we've got in place out at Argonne, I want to stress that although we started this program as a result of finding this massive corrosion at Davis-Besse and as a consequence of the fact that I really couldn't find data that we needed to have to help with the dispositioning and the understanding of that right at the beginning, we developed this program at Argonne.

There is a lot of work on the generic description of corrosion of pressure boundary alloys and concentrated boric acid solutions, low alloy steel, Alloy 600 and 182. I think we've going to try to get some 308 in here as well.

So even though the program was spurred on, if you will, by the findings at Davis-Besse, we've designed this program to be very generic and not at all specific to the particular issue at Davis-Besse.

MR. WALLIS: Are they doing experiments in boiling boric acid?

MR. CULLEN: Yes. The temperature range

is from just what you said, from boiling solutions at various concentrations up to as high a temperature as we can get and whatever solution we can get in the autoclaves that are available, something around 600 and extremely concentrated is the answer.

We've encountered some experimental difficulties in elevated temperatures in more highly concentrated solutions, which is not surprising to me, but most of the work in boiling solutions has been completed.

MR. WALLIS: When the boric dissolves the steel, what form of chemical ferreting stuff comes off or whatever it is?

MR. CULLEN: A question that I can't answer. I'm not the kind of guru that gets into that kind of thing, but I do know from some steam generator related research there are lithium ion borates, the usual list of suspects and culprits that I think you'd expect when you corrode low alloy steel in boric acid solutions.

And some of them are very complex, and we may not have a full set of thermodynamic data for all of the compounds that are going to be formed, but there is some modeling of the environment that's going to go on here that's going to be completed.

I talked a little bit earlier on about the computational model and the inputs into that model, and I've talked quite extensively about the fact that we've harvested some of the alloys and that we're going to do some actual crack growth rate.

MR. WALLIS: When they took off the head and tried to, I think, bore it out and the thing fell over and all of that --

MR. CULLEN: Yeah.

MR. WALLIS: -- the material in the hole was solid?

MR. CULLEN: I've got other pictures. The hole was there. The hole was not full of something.

MR. WALLIS: It was not full?

MR. CULLEN: No, and presumably because whatever was there --

MR. WALLIS: Liquid would have evaporated, but solid would have perhaps stayed in.

MR. CULLEN: Yeah. Now, the cavity was crudded up, and that may be putting it lightly.

MR. WALLIS: Analyzing the crud might be very useful. I'm sure it's being done.

MR. CULLEN: The analysis of -- some of the crud was recovered.

MR. HISER: But before they realized

there was a hole, they cleaned the head, and then they said, "Oops, there's a hole," and yeah, there were some trace deposits that were found. I'm not sure that we've seen the analyses of those, the chem. analyses, but not much.

I mean, unfortunately, things got further away before they realized they had a problem.

MR. WALLIS: It was the first time they cleaned the head, wasn't it?

MR. CULLEN: I'm sorry?

PARTICIPANT: Until then they had never cleaned it?

MR. CULLEN: The licensee is going to deliver a final report to the agency somewhere in a month or so kind of time frame, as far as I know, and presumably all of that information is going to be in that report.

And we're also going to do the electrochemical potential and polarization measurements of these solutions against the materials that are relevant.

A couple of slides here now on the structural integrity assessment. Remember I said a few minutes ago that we needed to know the properties of the clad, the extent of the cracking in the clad in order to revise and redo a structural integrity assessment that was underway.

That information has been provided to our contractor. We expect to get answers to this in a couple of months, but the approach is both analytic and experimental. A finite element model of the head containing the cavity and the exposed cladding.

There are two possible approaches, simple plastic -- well, I say "simple." Easy for me to say -- plastic instability model that's calibrated by some experimental data that already existed, and then also to take a look at whether those cracks would have extended in length by a ductile tearing process.

All of that is going to be a part of this deliverable which will arrive in a couple of --

MR. POWERS: Excuse me. Do I understand that you're doing this to say, "Okay. I got a quarter of an inch of this stainless steel cladding left. How much pressure can it tolerate to fail?"

MR. CULLEN: That is one of the two questions that we're trying to deliver to our colleagues doing the ASP. That's correct.

MR. POWERS: Okay, and could you tell me the second question before I ask my second question?

MR. CULLEN: The second question gets a

little more difficult to articulate, but part of the ASP process is to try to predict where this licensee, where the plant was a year ago. So we have to sort of back-calculate what we think the size of the cavity was.

MR. POWERS: And so you want to say, okay, what's the failure probability with the cladding plus a little bit of material.

MR. CULLEN: But in both cases --

MR. POWERS: Suppose that you find out that it's 8,000 psi.

MR. CULLEN: Okay.

MR. POWERS: Are you going to announce, oh, okay; everybody can go ahead and let their vessels corrode?

MR. ROSEN: They've got this really robust layer lying there.

MR. CULLEN: Of clad.

MR. POWERS: I mean suppose you get the answer to this question. What are you going to do with it?

MR. CULLEN: Well, you know, from a number like 8,000 psi, not that people are going to let their heads corrode or let the licensees get away with a lot of leakage or anything like that, but we would, I think derive some better understanding of the overall robustness of the design of these plants.

And you know, it gives you a warm, fuzzy feeling. I don't want to say that we're sinking tens of thousands of dollars into trying to get a warm, fuzzy feeling, but it's a requirement for us to provide this data to this analysis, and we're doing that.

MR. KRESS: Are you going to ask the question how big that hole has to be before it fails?

MR. CULLEN: I'm not sure whether that's going to be part of this or not. I don't think so. It's not a requirement for us to project going forward.

MR. POWERS: Tom, even if I had that answer, I mean, what would I do with it? Say, "Okay. We can make these vessels out of Playdough or something"?

It seems like it's an answer to a question that I don't know how I'd utilize it.

MR. WALLIS: Well, the story would be more complete. It would make a much better story and a drama if you knew the answer to some of these things whether you're going to do anything with it or not.

MR. KRESS: But Dana is right. There's

nothing you would do with it in a regulatory sense.

MR. POWERS: Yeah. Am I going to tell them, okay, you know, go ahead and build them out of tin sheeting or something like that?

CO-CHAIRMAN SIEBER: There may be some public confidence aspect.

MR. POWERS: I'm pretty sure that the public reaction to you saying that the vessel wasn't going to fail is going to be loss of confidence in the NRC.

MR. KRESS: Maybe it's an input into the significance determination process.

MR. POWERS: You know, it seems to me that there's just no choice in this matter. You're going to have to say, "Look. The ASME code says build the damned thing this thick. You're going to build it that thick and keep it intact."

I don't care how thing the stuff gets. Don't let it get thin.

MR. WALLIS: I think when you're up there and some Senator asks you these questions you don't have an answer. Otherwise you might just --

MR. POWERS: No, the answer to these question is this was a bad thing. We don't like this to happen to our reactor heads.

MR. WALLIS: That doesn't sound very technically sophisticated.

MR. POWERS: I don't think I have to be very technically sophisticated to tell him this was a bad thing. He knows it from the face of it.

CO-CHAIRMAN FORD: Let's move on.

MR. POWERS: Okay, all right.

MR. CULLEN: Summarizing now, this structural integrity assessment has both an analytical aspect to it and an experimental aspect to it shown on the next slide. We are constructing a simplified, admittedly, model of the cavity with stainless steel that simulates the unbacked cladding, and I can't remember exactly how many of these models are going to be constructed, but several is definitely the answer.

MR. POWERS: Let me ask you a question. You say it simulates the unbacked cladding. I mean, how in the world do you do that?

MR. CULLEN: Does somebody here know the answer to that? I'm not the PM for that particular program.

PARTICIPANT: (Unintelligible), NRC.

We are using cutout from the vessel cladding, and so the disks have been cut out, and then they will be in this chamber. This is the pressurizer chamber.

MR. POWERS: So it's not simulating the cladding. It is the cladding.

PARTICIPANT: It is the cladding.

MR. ROSEN: Is it from P.D. Ruff (phonetic) or Midland or --

PARTICIPANT: P.D. Ruff.

MR. WALLIS: You're going to boil boric acid in the hole?

MR. CULLEN: No, I don't think that's the point of this particular program.

MR. KRESS: Pressurize it at temperature?

MR. CULLEN: Yeah, just pressurize it and find out when it's going to blow out.

MR. WALLIS: -- experiments where you boil boric acid in holes and see how fast the hole grows?

MR. CULLEN: No.

MR. KRESS: This is to validate your pressure.

MR. CULLEN: Yeah, right. It's the validate the calculational model with these sorts of admittedly simplified experiments, but --

MR. POWERS: You mean there are calculational models on what happens to a -- it amounts to a rupture disk problem here -- are so bad that we have to do a whole suite of calculations?

MR. CULLEN: Well, I mean, you say "rupture disk," and you know, that was my first impression, too, is, my gosh, these guys have been making rupture disks for years. The equations have to exist.

But you know, the similitude is not that perfect. The cladding is more thick in a proportional way than you would get in a rupture disk.

MR. POWERS: That's right.

MR. CULLEN: The disk cladding had flaws in it. That's the point I want to get to.

MR. POWERS: That's right. You're going to find out how many flaws you have in this cladding. If you do any one particular one of these tests you'll get a pressure. Now, repeat exactly that same -- you're going to end up with another one of your plots with data all over the place.

MR. CULLEN: Possibly.

MR. POWERS: I mean it's all going to be because of little flaws that you haven't characterized.

MR. WALLIS: So we need 59 experiments.

MR. POWERS: To create a plot we can't use.

MR. ROSEN: Mr. Chairman.

MR. WALLIS: I think we should move on, yes.

CO-CHAIRMAN FORD: Yes.

MR. CULLEN: But at any rate, we are going to pressurize and measure the bursting pressure on this unbacked cladding that is not flawed, that is flawed, flawed in various geometries so that we kind of get a spectrum of the performance of the simulated cavities that look like that.

Okay. These things are coming in kind of one by one here.

MR. WALLIS: Now you said you were duplicating the EPRI work. Are they doing the same thing?

MR. CULLEN: No, I don't think EPRI is doing anything like this. I was sort of whining about that with respect to the boric acid corrosion program.

Now, this is something that we're doing on our own initiative, and again, principally as input to the ASP.

CO-CHAIRMAN FORD: Okay. Good.

MR. CULLEN: Okay. One last thing here now just to review a little bit and point out again what's happening going forward. The licensee has taken a look at Nozzle No. 3 and you've seen a summary of that sort of work. Very soon the Nozzle Nos. 2 and 46 are going to be removed from the Davis-Besse head and to be sent a couple of different places for different types of examinations.

One last time we're doing crack growth rate testing on the alloys that came out of the Davis-Besse head, and as you heard this morning, the North Anna Unit 2 head is being harvested by the industry and hopefully will have some coordination of the research and the failure analysis that will be done on that thing.

And with that, I finally made it through.

CO-CHAIRMAN FORD: Thank you very much, and you're just in time to get your flight.

MR. CULLEN: Yeah.

CO-CHAIRMAN FORD: Any questions for Bill?

(No response.)

CO-CHAIRMAN FORD: Thank you very much, indeed. I appreciate it.

I was told earlier on that for the full committee meeting that the MRP or industry will not be present because of prior -- am I correct? -- because of prior engagements. Therefore, the presentations will be primarily restricted to the NRC regulators and research.

So when you're thinking about what advice we're going to give, bear in mind they will only be there.

Do I have a motion to retire for the night?

MR. KRESS: You do.

MR. POWERS: You can do it in a high handed, cavalier fashion.

MR. KRESS: You have absolutely power to do this.

CO-CHAIRMAN FORD: We will recess until tomorrow morning at 8:30.

(Whereupon, at 4:50 p.m., the meeting was adjourned, to reconvene at 8:30 a.m., Wednesday, April 23, 2003.)