Official Transcript of Proceedings ACRST-3199

NUCLEAR REGULATORY COMMISSION

Title:	Advisory Committee on Reactor Safeguards Materials & Metallurgy and Plant Operations Joint Subcommittee Meeting

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

Docket Number:	(not applicable)
Location:	Rockville, Maryland
Date:	Wednesday, June 5, 2002

ORIGINAL

Work Order No.: NRC-418 Pages 1-496

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

TR04

ACRS Office Copy - Retain
for the Life of the Committee

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

\+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

\+ + + + +

MATERIALS AND METALLURGY

AND

PLANT OPERATIONS SUBCOMMITTEES

\+ + + + +

VESSEL HEAD PENETRATION CRACKING

AND RPV HEAD DEGRADATION

\+ + + + +

WEDNESDAY,

JUNE 5, 2002

\+ + + + +

ROCKVILLE, MARYLAND

\+ + + + +

The Subcommittees met at the Nuclear Regulatory Commission, Room T2B3, Two White Flint North, 11545 Rockville Pike, at 8:30 a.m., F. Peter Ford, Co-chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

F. PETER FORD, Co-chairman
JOHN D. SIEBER, Co-chairman
GEORGE E. APOSTOLAKIS
MARIO V. BONACA
THOMAS S. KRESS
GRAHAM M. LEITCH
VICTOR H. RANSOM
STEPHEN L. ROSEN
WILLIAM J. SHACK
GRAHAM B. WALLIS

ACRS STAFF PRESENT:

MAGGALEAN W. WESTON, Staff Engineer

ALSO PRESENT:

STEVE BLOOM, NRR
KEN CHANG, NRR
STEPHANIE COLLIN, NRR
JAY COLLINS, NRR
ALLEN HISER,NRR
ANDREA LEE, NRR
STEVE LONG, NRR
MICHAEL MARSHAL, NRR
SIMON SHENG, NRR
DWIGHT SNOWBERGER, NRR

ALSO PRESENT (Continued):

KEITH WICHMAN, NRR
NILESH CHOKSHI, RES
BILL CULLEN, RES
EDWIN HACKETT, RES
DEBBIE JACKSON, RES
MARK KIRK, RES
SHAH MALIK, RES
BILL BATEMAN, NRL
JACK GROBE, NRC/R III
GIOVANNA LENGO, OGC
JENNIFER UHLE, DCM/RAM
KURT COZENS, NEI
MICHAEL LEISURE, FENOC
DAVID LOCKWOOD, FENOC
STEVEN LOEHLEIN, FENOC
PATRICK McCLOSKEY, FENOC
MARK McLAUGHLIN, FENOC
JIM POWERS, FENOC
ROBERT SCHRAUDER, FENOC
KEVIN SPENCER, FENOC
STEPHEN FYFITCH, FRA-ANP
JOHN HICKLING, EPRI
CHRISTINE KING, EPRI

ALSO PRESENT (Continued):

STEVE HUNG, Dominion Engineering

GLENN WHITE, Dominion Engineering

NATHANIEL COFIE, Structural Integrity Assn.

PETER C. RICCARDELLA, Structural Integrity Assn.

MICHAEL LASHLEY, South Texas Project

LARRY MATHEWS, SoNuclear

DICK LABOTT, PSEG

CHARLES BRINKMAN, Westinghouse

THOMAS B. HENRY, Toledo Blade

DANIEL KOFF, Cleveland Plain Dealer

JACK ROE, Scientech

ALTHEIA WYCHE, SERCH Licensing/Bechtel

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

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

(8:30 a.m.)

CO-CHAIRMAN FORD: I'd like to get started please.

The meeting will now come to order. This is the 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.

The ACRS members in attendance are everybody apart from Dana Powers. They are George Apostolakis, Mario Bonaca, Thomas Kress, Graham Leitch, Victor Ransom, Stephen Rosen, William 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.

Ms. Maggalan Weston is a cognizant ACRS staff engineer for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting, published in the Federal Register on May 21, 2002.

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

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

We've had no written comments from the members of the public regarding today's meeting.

The last letter that we wrote on this subject was in July 2001 in which we supported the issuance of the Bulletin 2001-01. In that letter and in the subsequent meetings, we raised a number of technical questions.

In his reply to the July letter, the EDO stated the answers would be given to us in early 2002. We requested that data be presented today to support the conclusion relating to three basic questions:

One, what do we know about the degree of degradation of the vessel head assemblies and what is the future predictions?

Second, what are the safety issues?

And, thirdly, what are the mitigation plans?

We shall not be discussing safety culture and impacts on the reactor oversight process as associated with, for instance, Davis-Besse, at this particular meeting.

Jack, do you have any comments?

CO-CHAIRMAN SIEBER: No, I don't.

CO-CHAIRMAN FORD: Before we proceed, Mag, do you have a statement?

MS. WESTON: Yes, one little housekeeping issue. We're going to be using the full committee books today, Tab 2. This is the same material that's for your book tomorrow. That's why you have your books, and I think I have opened them all to Tab 2.

That is all of the information that I have that you have not received in hard copy.

CO-CHAIRMAN FORD: We will now proceed with the meeting, and we will begin with Bill Bateman of the NRR, who will make some opening comments.

MEMBER WALLIS: There is no Tab 2.

MS. WESTON: Yes, Tab 2 is turned.

MEMBER WALLIS: It's not labeled as Tab 2. Oh, excuse me.

CO-CHAIRMAN FORD: Bill.

MR. BATEMAN: Okay. While your looking for your Tab 2s, which --

(Laughter.)

MR. BATEMAN: It's a pleasure to be here today. We have an ambitious schedule, as you can see. We're scheduled to go until six o'clock, and everybody on my staff hopes that we're finished by six o'clock. So that is certainly our goal and we'll do our best to get us all through by then.

And so we are looking for an interactive session. We think we're on the right track. We hope to get some good feedback from you folks today.

I know one of the things that Dr. Ford has commented on a number of times is the lack of data. I think this time we'll have more than enough data for you folks to chew on.

So why don't we get started? And I guess that would be Allen Hiser.

MR. HISER: Good morning. I'm Allen Hiser with Materials and Chemical Engineering Branch at NRR.

What I want to do this morning, very briefly to keep us ahead of schedule, is to provide a status of the review of responses to NRC Bulletin 2001-01, which was entitled "Circumferential Cracking of Vessel Head Penetration Nozzles."

We were here two months ago and provided a more detailed status with putting the inspection results in the overall context so that hopefully you had some understanding of how the data or how the inspection results are falling in line.

At this point, I want to do just one slide to give you a brief overall status. There are no new inspection findings since the April 2002 meeting and presentation.

MEMBER WALLIS: You mean nothing has been done or nothing has been found?

MR. HISER: Nothing has been found. There have been some inspections that have not identified any cracking or leakage.

MEMBER WALLIS: Then there are findings if you found nothing.

MR. HISER: Correct.

The MRP did make a presentation to the staff in late May with a proposed inspection plan. I know that is on the agenda for later this afternoon, hopefully after noon.

The NRC staff is considering a generic communication that would address interim guidance for nozzle and vessel head inspections.

We will talk a little bit this afternoon on some of the concepts and ideas that we have on that. No details at this point, but just some of the concepts that we have at the present time.

In addition, we do have interactions ongoing with the industry that will provide the technical basis for the NRC staff to develop long-term inspection requirements. There are also activities that are ongoing within the appropriate ASME code groups.

So that is basically what I wanted to say about the status.

CO-CHAIRMAN FORD: Is there going to be any more discussion on any of those bulletinized things, Allen?

MR. HISER: I believe two, three, and four will have -- we will have some ideas on later, some presentations this afternoon.

CO-CHAIRMAN FORD: So we will have some heads-up on what the generic communication will entail? For instance inspections?

MR. HISER: A lot of concepts, more at the concept sort of a level.

CO-CHAIRMAN FORD: Will you be discussing the degree of completeness of visual inspections versus 100 percent volumetric inspections?

MR. HISER: We can talk about that this afternoon.

CO-CHAIRMAN FORD: Okay. If you're not

going to cover any more on the first bullet, I do have a question on it which was brought up by Dana Powers at the last meeting.

You've got this famous curve -- I've almost forgotten -- of the time since the CONY (phonetic) versus the vertical axis showing -- and I must admit to myself some degree of conviction that the simple algorithm that we have, prioritization fusion algorithm, seems to be reasonable.

However, Dana Powers brought up at the last meeting in April the statistical relevance of that, given the same number of inspections have not been made at a given time period.

Can you -- and I don't know if you remember that question. It was towards the end of the meeting. Do you have any comments?

MR. HISER: Well, clearly the level of inspections that have been performed throughout that, the plants listed on that chart, are different. The plants that have -- that would seem to provide the greatest support, you know, the plants that have identified cracking and leakage have tended to have the more intensive inspections.

There are very few plants outside of that area that have done under the head, volumetric type of inspections that are capable of detecting cracking. So many of those plants have no results because visual exams have not identified any leakage.

That doesn't mean that there is no degradation ongoing. It just means that thus far, the degradation has not progressed to the point that there are leaks apparent on the head.

We will -- what I will do this afternoon is provide a little more information on which plants have performed which kind of inspection.

CO-CHAIRMAN FORD: Okay. Good.

MR. HISER: Maybe that will put those results in greater context.

CO-CHAIRMAN FORD: Will you also be discussing later on the completeness of that prioritization algorithm or has it served its purpose as of now?

I am referring specifically to the facts that other countries, France specifically, have got much more elongated prediction algorithm, taking into account micro-structure, stress, and position of the nozzle, et cetera.

Are the NRC or the industry planning on developing such a more complete prediction algorithm?

MR. HISER: I think that would be the --

from a technical standpoint, that would be the desire of both the NRC and the industry. I think one of the issues that the industry has run into in trying to put together a more thorough model is the lack of information in some areas.

I know that in the early mid-'90s, some of the initial modeling tried to incorporate some material parameters. And I think the results over the last several years have demonstrated that those modeling efforts were really not as successful as the current model appears to be.

So I'm not sure. Maybe the industry folks can speak to their efforts later during their presentation.

CO-CHAIRMAN FORD: Can we jump -- are you going to, Larry?

MR. MATHEWS: I don't think we were planning on addressing it specifically. Basically the model we've got right now is very simple, like you say. It has tended to sort of mash the data that we're seeing coming in from the field.

To gather -- one of the problems is the welds. Some of the flaws have been in the welds and it is very difficult to quantify the material and all that, properties from a weld material.

I guess our plan was we are going to track data by fabrication and fabricator and things like that as we do inspections. And if we start to see a demarcation, then we can try to take that into account.

But so far, we haven't got enough data on individual heats and individual penetrations to start to try to make that demarcation. So at this point in time, we don't have concrete plans to do more than track the data as we get inspections over time.

CO-CHAIRMAN FORD: Okay.

MR. HISER: And it may be, as well, that one of the biggest parameters would be residual stresses. I think there is the variability from plant to plant and uncertainties in that may tend to --

CO-CHAIRMAN FORD: But there's a generic relationship between fit-up angle and residual stress and, therefore, position that you might expect as a secondary variable.

MEMBER BONACA: I would like to ask a question. I don't need an answer now, but I would like to understand by the end of the day why visual inspections is acceptable as a means of detecting this degradation process for RCS. Why we would not accept leakage in other location of the RCS as a means of detecting cracking?

And so I would not understand why in this case, it is acceptable. Is it because of the difficulties in these inspections? Is it logical, however?

The second point -- so this is an issue I would like to understand -- the second point is I'm concerned about the projection curve, the predicting curve that you are showing. You are throwing on the curve MISDON 2 (phonetic), for example, that perform volumetric inspections. They found cracks, but they didn't have any leakage.

Therefore, you are mixing together visual results with indications from volumetric and that creates confusion, in my judgement, about that predicting curve, and I would like to understand why you are doing that.

MR. HISER: Yeah, I will try to clarify that this afternoon.

Your first question about visual inspections is also addressed in, I believe, the second to last presentation on the use of leak detection as an appropriate management tool.

MEMBER BONACA: If it is appropriate, why wouldn't it be appropriate for cracks in nozzles or, I mean, why don't we wait until we see leakage before doing anything to these plants? Why would we want to attend field inspections?

Thank you.

MR. HISER: If we need to make a distinction, we will do that in that presentation. I'm not sure that will be necessary.

And with that, I will turn it over to Andrea Lee on Bulletin 2002-01.

MS. LEE: I'm Andrea Lee from the Materials and Chemical Engineering Branch, and I'm the lead for Bulletin 2002-01 on RPV head degradation and the rest of the reactor coolant pressure boundary.

With regard to background on Bulletin 2002-01, it was issued March 18 to all PWR plants, and within 15 days, we asked licensees what kind of inspections have you done in the past to identify RPV head degradation. With those inspections, what's the ability of those inspections to determine head degradation?

In addition, after we got information on the actual inspections, we asked: what kind of deposits, descriptors such as was it residue or staining or what types of deposits; did you see what was left on the actual reactor pressure vessel head?

After we asked what was done in the past and what kinds of inspection results were obtained, we asked what kinds of plans do you have for the future to enhance inspections or what kinds of inspections, do you have planned to address this problem.

MEMBER WALLIS: So you asked what they were doing. Was there any kind of instruction as to what they should be doing?

MS. LEE: It was an information request: what kinds of things have you done; what have you seen; what are your future plans?

I will get to, in a little bit later, calls that we have had, conference calls to address the types of things that they've seen; taking experience we've had from talking with each of the licensees; making suggestions on how some of the licensees we've talked to could improve based on what we have heard from other licensees.

MEMBER WALLIS: But it is very much up to them. If you think of Davis-Besse, until they almost accidently found they had a problem, they would have reported everything was fine.

MS. LEE: Un-huh. I think there's been --

MEMBER WALLIS: It just up to them.

MS. LEE: I think there's been a lot of

lessons learned from both on the industry side and on the NRC side with this interaction with the rest of the 68 plants, as well as Davis-Besse. Those types of exchanges have occurred during conference calls.

And each of these conference calls and subsequent supplements have been put on the NRC external Web site so that the public is aware of the kinds of conversations that we've had.

MEMBER WALLIS: Okay.

MS. LEE: After we asked what you've done; what you plan to do in the future, we also ask for the basis of continued operation. How can plants ensure that they met the regulatory requirements with regard to this issue?

There was also 30-day and 60-day responses to this bulletin. The 30-day responses are what are your inspection results in a detailed fashion; what kinds of things have you seen, and we have asked for documentation so that the record is clear.

And then the last of the responses was a 60-day response asking what have you done for the rest of the reactor coolant pressure boundary.

MEMBER APOSTOLAKIS: Do the resident inspectors know all of this?

MS. LEE: No, no, the inspection

results --

MEMBER APOSTOLAKIS: The inspectors, the NRC resident inspectors; can they answer these questions?

MS. LEE: In a lot of cases -- there was a TI written for Bulletin 2002-01 and these are primarily the same inspections. So what we have tried to do in our interactions with the plants is to make sure resident inspectors and regional inspectors are on the actual calls.

In some cases we have gotten information that has helped to guide our interactions with the licensees. We have gotten some good insight from the resident inspectors: where to focus our area and focus the question.

So they are involved and they have been able to provide information.

MEMBER APOSTOLAKIS: I mean, if you ask them instead of the licensee to answer these questions. would they give you good answers or they really don't know?

MS. LEE: Well, one example when we had a pre-qual. with the region to give us information, the same type of questions, there were additional issues that were raised that we were able to talk to the licensee; whereas the licensee addressed it, but we had more of an informed conversation because we were able to dig a little deeper from the inspector's results.

So they have been able to give us information that has helped guide the calls and the interactions.

MR. BATEMAN: This is Bill Bateman from the staff.

In answer to that question, I don't think we were prepared to speak for every resident inspector as to whether or not they could specifically answer these questions if asked.

MEMBER APOSTOLAKIS: Is it up to them? I don't understand that. Your answer implies that it is up to them to decide whether to know or not. Aren't there any rules as to what they're supposed to know?

MEMBER BONACA: Well, the resident inspector can go every morning to the morning meeting and listen to what the results of all the inspections. I mean he has, right, hands-on on everything that takes place in the plant.

MR. GROBE: This is Jack Grobe from Region 3.

I think the residents would have a

cognizance of licensee activities in this area. They wouldn't have direct knowledge necessarily of the results of the head inspection because they wouldn't have been involved in those through the past refuel outages necessarily.

So they would assist NRR in focusing activities based on their cognizance from being aware of licensee activities.

MEMBER WALLIS: Are they so far removed? I mean, can't they actually demand to see photographs of what was seen instead of relying on what somebody said they saw?

MS. LEE: Well, they have. We have seen videotapes that were provided. They've seen pictures. There is interaction in that respect, both still pictures and videotapes. And those are primarily how we've gotten some additional information that has helped us focus our calls.

MR. HISER: Yeah, I think part of the confusion may be that plants that have done inspections since last summer,- the residents, the regional inspectors are very familiar with the results, the findings, the condition of the head, things like that, and what sort of inspection was done.

Plants that have not had a refueling since the issuance of the Bulletin 2001-01, the head was not a major focus area. And I think there is much less detailed information available or detailed knowledge by the inspectors for those plants.

That's maybe where the dichotomy is occurring right now at the present time.

MEMBER BONACA: But for the boric acid corrosion prevention program, you don't have to make an inspection of the head alone. You have other symptoms you are looking for.

And one question would have been: in that 60-days, have they performed a lock-down and containment or checked some for deposition, boron deposition upon surfaces? Have they checked filters?

There are elements that can be checked even without a direct inspection of the head.

MS. LEE: One of the things we have covered in the calls for the 15-day responses is information known as 2002-13 which talks about containment error, radiation element fowling (phonetic).

Since that information has come out, licensees have addressed directly on phone calls, in some cases prompted by questions and in some cases on their own, what they're doing to look at filters and things like that in terms of fouling.

MEMBER BONACA: But it seems to be like more -- you know, I mean, some of them are addressed verbally, some in writing. Why can't we be more specific and request specific answers to questions on this?

MS. LEE: Well, we have done that.

MEMBER BONACA: So that you have consistent answers.

MS. LEE: Every time we have calls, we ask for supplements to the actual response.

MEMBER BONACA: Okay.

MS. LEE: Both our written telephone conference summary and their supplement goes on the NRC external Web.

With regard to the 15-day responses, we received all responses except for Davis-Besse. In getting to the punch line first, we haven't identified any plants that have the same conditions of degradation as Davis-Besse.

And the way we came to the conclusion was a priority categorization scheme for contacting plants. This scheme was basically a subjective categorization by the plant to guide us in how we were going to contact licensees, and it was based on needing more information from the actual submittals.

In some cases we didn't feel we had enough clarification or verification with what was provided. And those plants reached a higher level of priority in terms of how -- the order that we were going to contact them.

CO-CHAIRMAN FORD: Surely, the prioritization would be exactly the same as the cracking prioritization out of them because cracking is a precursor to the low alloy steel corrosions; are they not?

MS. LEE: No. It's not exactly the same as the industry prioritizations for a couple of different reasons. One is if we read a response and it wasn't clear. For example, significant deposits were left on the head, and by significant something that would preclude seeing the bare metal, or if there were leaks external to the insulation such as Conoseals or canopy seal leaks, and it wasn't clear that those were repaired within the same outage that they were found.

Those types of considerations that went into this priority scheme. So it's not exactly the same as the industry cracking scheme.

MR. HISER: The other thing that maybe is counter-intuitive is that the plants that have the highest susceptibility to cracking have already done head exams. I think generally, every plant has looked at the head. So they have been able to identify the absence of that sort of degradation.

CO-CHAIRMAN FORD: Now, when you say "look at the head," Allen, do you mean using what technique? Purely visual or --

MR. HISER: Well, uh --

CO-CHAIRMAN FORD: That tells you nothing.

MR. HISER: They have looked visually. So they have been able to generally to see the interface around every nozzle. If there is significant degradation or probably -- I don't want to put a threshold. If there's degradation of a certain level, they would have been able to identify it previously.

So the plants that are the most susceptible to cracking have been, I think, in the best position to address this issue.

What is not readily apparent is the plants that have a lower susceptibility maybe have not done as extensive a visual examination of the head or maybe have not had an outage since over the last year. Those plants, we've had to rely more on photographs and other prior inspection results.

CO-CHAIRMAN SIEBER: I guess the example there, your top priority plant is Beaver Valley 1. In the chart of results from the bulletin that NRR compiled, the result was called "other." When I looked into that, "other" meant did the visual inspection, found what they interpreted to be old Conoseal leakage; the Conoseals had been repaired; that they didn't clean the head, and so there was residual boric acid crystals on the head, which they claimed came from the Conoseals. They didn't clean it because of ALARA considerations.

So that would -- and their response really wasn't all that clear as to, number one, whether they could have seen leakage from the nozzle; whether the leakage that they saw was really Conoseal leakage; and, third, did they return the head to a condition where visual inspection could be done unimpeded by deposits. So maybe that helps.

MS. LEE: And in that specific case with Beaver Valley, there were subsequent interactions with the licensee supplements to the response and future commitment to address those issues.

So that's how that particular issue was resolved.

MR. HISER: And I think Beaver Valley was a case, as well, where we got a lot of input from the resident inspectors and the regional staff who were on site when they were doing the visual exam and could provide a little bit of context.

You know, if somebody says, "There were deposits on the head and we left them there," six months ago that would have been a benign observation. Now, the context is a lot different.

And maybe it really is a thin layer, you know, a crystal thick or something like that. That's the kind of context that we have had to follow up on extensively with a lot of these plants.

CO-CHAIRMAN SIEBER: I would point out that Beaver Valley 1 is on the susceptibility list as a medium point, whereas, on the questioning list was a number one priority.

MS. LEE: Un-huh.

MR. HISER: And partly because they acknowledged leaving deposits on the head and they were moderate susceptibility to cracking. That doesn't mean the cracking is unlikely. I think, to the contrary, it's likely that they may have cracking. It may be unlikely that it's through wall at this point, but there's a certain probability that it could be.

That combination is what we saw at Davis-Besse. And maybe not -- there may not be a scaling necessarily, but the bulletin was really focused on the conditions.Boric acid on the head and some probability of nozzle cracking were the two main parameters.

MS. LEE: And one of the follow-on items with a number of these plants is commitment for future cleaning. Whereas the sensitivity may not have been there at the time, the inspection was done before leaving even, was considered insignificant deposits. The sensitivity is there now. The next time they go in, even those deposits will be cleaned off of the head.

So that's one of the things that has come out of these interactions.

CO-CHAIRMAN FORD: I guess I'm still missing a key point to this rationale here. The main point of this bulletin is, to put it in layman's terms, is to make sure we don't have another Davis-Besse sitting out there.

And your inspection method or an allowable inspection method is just to see whether there's boric acid crystals on the top of the head. That's an allowable measurement.

MS. LEE: No, that's not the --

CO-CHAIRMAN FORD: I can't see how that tells you anything at all about the degree of degradation of the low alloy steel head.

MS. LEE: That's not the only parameter that the bulletin deals with. The first few questions asks about inspection methods and how to ensure that you don't have this particular issue. So those inspection methods go toward the 101 issue of cracking.

CO-CHAIRMAN FORD: When they answer the question to give you a rationale on why they should continue to operate, do you accept the rationale that I haven't seen any boric acid on my head and, therefore, I have no problem?

MS. LEE: No. It's a combination both of what have you done inspection-wise to see -- because axial cracks come into play with this phenomenon. It's not just the 0101 concern of circumferential cracks above the nozzles.

So the first part, it's almost a combination of the two bulletins. The first part asks have you done inspections; what types of inspections have you done of the nozzles to see what you actually have in regard to cracking and degradation.

The second part asks about what have you seen in terms of deposits on the head and things like that. So it is a combination of the two issues and the two concerns.

MR. HISER: But I think, fundamentally though, if I have a head and I'm worried about degradation and I go and look at the head and see no degradation; I can check that plant off.

CO-CHAIRMAN FORD: It didn't at Bouget 3.

MR. HISER: Now it may be that there are conditions that could lead to degradation, but at the present time I do not have degradation ongoing.

CO-CHAIRMAN FORD: But my point is at Bouget 3, for instance, there was no boric acid and yet there was cracking.

MR. HISER: Right.

CO-CHAIRMAN FORD: So that's one. What we need is one more, guys, and we're dead.

MEMBER BONACA: I think, in the context of this question, I agree with that. Even for the plants that already perform inspections, clearly when they did inspections, they did not know that Davis-Besse would occur.

There are tell-tale signs that Davis-Besse was seen. For example, you know, the bottom-up spraying that they have identified and never figured out why they had it, but I'm sure that Oconee didn't look for it whenever they did an inspection.

I think it would still be wise for them to go back to the inspections, review what they did, try to remember if there were signs that Davis-Besse had identified as delta signs.

So I think just the fact of having inspected visually those heads, in the very difficult conditions of the inspections, many of them, I don't think should be just sufficient. I think that they should look back at what they did and try to interpret some other signs that may have seen.

MR. HISER: Well, I think given the information that is in the 2002-13, many of the responses address those kind of indirect indicators directly. They said -- and I think you were at a plant -- they had a used filter from their radiation monitors and a brand-new filter. They were indistinguishable.

Plants are looking at those kinds of indirect indicators as well. If I look at the head and see no degradation, that gives me a good feeling right now that I do not have a Davis-Besse situation at that plant.

Now, that doesn't tell me in five years I may not, and then it becomes incumbent on the NRC and the industry and the licensees to implement effective inspection programs to ensure not that we don't get Davis-Besse, but that we don't get down the road any of the precursors that led to Davis-Besse. That's the thing.

MEMBER WALLIS: You are very reassuring. I mean the crack growth varies by orders of magnitude and the graphs that we look at -- you are going to say that just because someone didn't see some crystals, that there is no crack there which isn't going to grow more rapidly than you thought and is going to lead to some incident?

MR. HISER: I'm saying right now we don't believe that the conditions are there at any plant.

MEMBER WALLIS: I have the concern with this slide. I mean, the statement that was made was a little more reassuring than the first one that the staff has not identified. I think it was a little different. It was ten minutes ago. I'm not particularly remembering it, but I think you wanted to reassure us that there wasn't another Davis-Besse out there.

The fact that the NRC has priority categorization doesn't have any effect on the physics. The fact that the NRC has no concern about 49 plants really surprises me.

There has to be concern about every plant out there.

MS. LEE: Yeah. With regard to the no concern bullet, that doesn't mean we don't have clarifying questions or verification questions. So some of those plants do have questions associated with them. It was prioritized as no concern just based on the order of --

MEMBER WALLIS: Or what you thought you knew before Davis-Besse.

MS. LEE: No, actually this was after, after Davis-Besse.

MEMBER WALLIS: After Davis-Besse?

MS. LEE: Yeah.

MEMBER WALLIS: After Davis-Besse, you had no concern for 49 plants?

MS. LEE: The no-concern categorization really was based on -- and the whole priority scheme is based on -- the order of contacting. And it is caveated to say we may still have clarifying questions or something that wasn't particularly clear.

MEMBER WALLIS: So when something was found at one of these 49 plants, someone is going to remember that the NRC had no concern.

CO-CHAIRMAN SIEBER: I gather the no concern means you didn't have a concern about the response to the original bulletin.

MS. LEE: Yes. There may have --

CO-CHAIRMAN SIEBER: It doesn't mean that you didn't find something.

MS. LEE: It doesn't mean no concern with the actual what would be future occurrences at the plant. It was based on the licensee response was primarily complete, but there may still be a question here or there; to just ensure that we have all the information we need to make the informed decision.

CO-CHAIRMAN SIEBER: I guess one thing that bothers me is the fact that you can have nozzle cracks and you can't find them by visual inspection unless they are through through wall and leaking. To me, that gives me little comfort.

MEMBER BONACA: That is exactly right.

MR. HISER: We'll talk about that later this afternoon, but I think --

CO-CHAIRMAN FORD: It's important line right now.

MR. HISER: The purpose of this bulletin was really short term. Do we have similar conditions at any of the other 68 plants?

The bulletin has served its purpose in that we don't think there are any other plants out there with those conditions. Now that doesn't tell us that in two years something could not develop because clearly it could.

But, for the present time, we don't think that's the case. We are working to implement inspections that will ensure that in two years we can come back and say this problem is being managed and will be for the long term.

That's where we are after. The bulletin is just a short-term instrument to give us a status report on where plants are with this degradation.

CO-CHAIRMAN FORD: You're saying here that you don't have any situations similar to Davis-Besse, based apart from the first ones issued, 100 percent volumetric; based primarily on visual. And that makes me feel really worried.

Because we may hear later today about what the specific criteria or design criteria that will give you the local annulus environment, that could give you one inch per year low alloy steel corrosion rate. We may hear that later on today.

But until we hear something definite, some design feature that would preclude that you've got to assume --

MEMBER BONACA: Yeah, until you rely on the visual, I mean, you know, certainly you know that as soon as a crack develops, it could start the process of erosion and corrosion of the head.

MR. HISER: I think that --

MEMBER BONACA: So we need to hear more about it.

CO-CHAIRMAN FORD: Are we missing something, Andrea? Visual -- you, as professionals, are sure that by looking on the head and not seeing boric acid, therefore, you do not have low alloy steel corrosion.

MR. BATEMAN: This is Bill Bateman from the staff.

I would just like to refresh everybody's memory of the process here. We issued a bulletin requesting information from the licensees with the respect of the condition of their head. We got 68 responses 15 days after we sent the bulletin out.

Those responses were under oath and affirmation. The licensee knows the condition of their heads much better than we do. And so we basically believe what they tell us in their responses.

What we have been doing since then, which is a little over two months ago, is having phone calls with licensees in a priority order here based on the quality of their response and trying to get a comfortable feeling; fill out the details that are missing; et cetera, to come to some kind of conclusion with respect to whether or not we feel they have the potential for the problem.

We have not looked, personally, at any of these heads. Well, maybe I'll take that back. Maybe we've looked at one or two heads. But again, the licensees have sent us their response under oath or affirmation and they basically have made the claim, each and every one of them, that they don't have any evidence of something similar to Davis-Besse.

So that's the process we're in.

I think to take the staff to task for not having seen each and every head and making a visual observation is not fair.

CO-CHAIRMAN FORD: Obviously, you can not go in -- you personally can not go and look at every head. I just -- I'm trying to delve into the rationale.

Right now what you're saying is essentially engineering judgement. You feel comfortable by engineering judgment based on --

MR. BATEMAN: We feel comfortable based on the licensee responses that came in under oath or affirmation, the descriptions that they put into those responses, asking them questions in a priority order of those licensees who didn't give us enough information so that we could come to a clear conclusion. Yes, we feel comfortable based on that.

Their responses and our subsequent questioning of their responses and this kind of a priority order.

MR. HISER: The two things that I guess I would add to that is if you do have corrosion ongoing, you do have water leaking, you do have boric acid, that goes somewhere. The corrosion products have a much lower density than the low alloy steel.

It's going to be obvious somewhere that something is going on. If you look back at the Davis-Besse visual examination results from their head, there were many, many, many signs on the head, containment air coolers, radiation monitors, that something was going on.

These other plants have not identified any of those kinds of indicators that we think are persuasive in indicating that there is no degradation going on in this area.

MS. LEE: And in many cases --

MEMBER LEITCH: What concerns me is that on November 9, we met here and were being briefed on the results, the early inspection results from or the early responses from Bulletin 2001-01, and one of the things that we were told at that time was that Davis-Besse, in trying to justify why they didn't have CRDM cracking at that time, referred to some earlier video tapes they had done of their head.

They did videotapes in 1996, 1998, and 2000. They claimed at that time that they were not specifically looking for CRDM cracking, but they were trying to use those tapes as a justification for why they didn't have CRDM cracking.

But they further claimed that they made those videotapes specifically looking for head degradation as a result of boric acid on the head probably from historic flange leaking and claimed that after reviewing those video tapes, from those three inspections, they were satisfied that there was no head degradation.

And so my question is: aren't we hearing the same thing from these plants?

In other words, when we probed deeper then into the Davis-Besse situation, there were questions about how, well, we couldn't see certain CRDMs very well.

I mean, is there anything here about how -- what percentage of the head they can really look at? And how does one interpret what is seen on the videotapes? Is it what is referred to as "popcorn"? Is it what is referred to as "lava"? Is there common understanding when someone says "popcorn" and somebody else says "lava"? Do we really know what we're talking about there? If somebody talks about "white deposits," "red deposits" -- I mean, there is a lot of subjectivity in those kind of words.

MEMBER BONACA: Furthermore, a number of these plants have never inspected their head, I would suspect. I mean some of the 49 plants are not concerned. They may not look at them.

MEMBER LEITCH: So what I'm saying is in the time frame of November 2001, Davis-Besse would have satisfied these criteria, not only could have, but did effectively answer this bulletin before it was written in response to questions at this meeting and answered them in a way that satisfied us all, and we were wrong.

MR. HISER: I would expect if you look at their root cause analysis report, that I think some of the information provided in there is not necessarily consistent with what the ACRS was told and what the staff was told last fall. That would be the main comment that I would make in that area.

The other thing is that, again, from the input we've gotten from the residents and the regional inspectors, from documentation, for plants that are not inspected since prior to Bulletin 2001-01, there tends to be some photographic evidence of the condition either of the head or the insulation that is directly attached to the head, and if that is undisturbed, that, again, is a positive indicator that there is nothing going on.

If you get corrosion, the products are going to go somewhere. For the short term, that provides us with the basis for the first statement on here. For longer term management, I don't know that that is an acceptable approach.

We'll talk about that later this afternoon. Because at the present time we are looking for an outlier condition, you know, gross degradation.

For long term management, that's not the correct standard to use.

We want to ensure that we don't have precursors. We don't want to get -- we don't want to say how far down the path. We don't want to be on the path, overall. We don't want to preclude the industry from being on the path.

MEMBER LEITCH: So I guess what you're saying is the reason that I should have some confidence in these results versus what Davis-Besse told us in November 2001 is that these results are done -- are made with an informed judgment because we now have the history of Davis-Besse.

MS. LEE: Yeah, I think that is one of the most important distinctions to make. When we were in the November time frame, no one could have imagined that we would have discovered this type of degradation on a reactor vessel head.

We're in a different climate now. Because of Davis-Besse, there's heightened sensitivity to these types of issues, and again, the plant that I visited with regard to filter papers, and if you recall, I think it was the April 2000 picture at Davis-Besse with the corrosion pouring out of the mouse holes onto the reactor vessel studs. There were many, many indications of degradation on that head.

I think with the climate that we're in now, people have gone back, looked at their pictures; have gone back, looked at inspection results; and are doing inspections now with a more in-tuned eye and more informed decisions on what they're actually looking for.

That's why I personally think that there's much more scrutiny in terms of per-Davis-Besse and post Davis-Besse.

MEMBER LEITCH: But some of these plants have no new inspection results really since Davis-Besse. In other words, they are just manipulating old data and analyzing old data in light of the Davis-Besse incident.

In other words, a lot of this response represents not new videotapes or new photographs, but going back and looking at videotapes and photographs previously and interpreting them in light of Davis-Besse; is that --

MS. LEE: But they actually do have indicators. The indicators would always be there whether they had done an inspection or not. For example, unidentified leakage. One of the things that a lot of the plants have indicated is they have extremely low unidentified leakage. The tech specs say one gallon per minute. They're at somewhere like .06 gallons per minute.

So the indicators are an important factor with the rest of the plants, even if they haven't done inspections.

MEMBER LEITCH: Well, yeah, but the difference between .1 and .2 gallons per minute could be very significant as far as this is concerned. Your point operators may not react to that kind of change.

What I'm saying is this is small, I think, compared with the normal variability that one sees in unidentified leakage.

MR. HISER: Some of the things just to -- you know, how did some of the plants come on this high priority list is an example of programmatically they did not tell us if they had Conoseal leaks or something like that. Did they immediately clean-up the boric acid spillage?

If they did not say that, we were asking for additional information regarding their practices. There's a variety of practices in areas like that.

So we tried to look at the holistic approach, looking at all of the available information from the programmatic aspects to maybe interpreting old inspection results and any documentation of those inspections, plus the more recent inspections that clearly have been focused on this area as a prime area of concern.

So we tried to gather all that information together to make the determination in this case.

MEMBER LEITCH: Was one of the variables that you considered the ease with which the head could be completely inspected?

MS. LEE: A lot of the questions we've asked licensees very directly is did you get 100 percent inspection of 360 degrees around the circumference of each nozzle, and in some cases the answers were we got 96 with a robotic-type crawler, but we got the rest with a camera on a stick.

So we've gotten very specific in terms of what they could see, what they couldn't see, and what inspection methods they actually used.

CO-CHAIRMAN FORD: Even with conformal insulation?

MS. LEE: Pardon me?

CO-CHAIRMAN FORD: Even with insulation which is conformal to the pressure head?

MS. LEE: In the cases where there is insulation, for example, glued to the head or contoured to the head, we've had discussions about what are your plans.

In some cases, there have been nondestructive examinations performed. So --

CO-CHAIRMAN FORD: So in those cases there was nondestructive --

MS. LEE: Not in every case, but in some cases there were. In the cases where there haven't been inspections done yet, they have plans to do that in the next inspection.

CO-CHAIRMAN FORD: So it's not 100 percent then. In those cases where they were not able to do a visual --

MR. HISER: But the kind of -- I think a typical situation would be, as a part of our normal outage inspections, we look at the insulation. We have seen no disturbances on the insulation. We've seen no staining, no deposits --

CO-CHAIRMAN FORD: Okay.

MR. HISER: -- nothing like that on the insulation. We looked at the flange every outage.

MEMBER WALLIS: But are there indications of what those deposits would look like on the insulation, that they would be visible?

MR. HISER: These insulation packages are pretty much watertight.

MEMBER WALLIS: This stuff is creeping under the insulation and eating away the head and you wouldn't see anything.

PARTICIPANT: Right at the top of the insulation so you can see it.

MR. HISER: Well, they also examine the flange area. If there is anything ongoing under the insulation, we would expect that it would flow out and be visible there.

MEMBER WALLIS: Okay.

CO-CHAIRMAN FORD: Could I try to come to a kind of an agreed upon conclusion as to where we are?

MEMBER ROSEN: Peter, before that, could I --

MS. WESTON: And I have a question too.

MEMBER ROSEN: -- could I make a comment?

CO-CHAIRMAN FORD: Sure, you bet.

MEMBER ROSEN: Allen, you said something I thought was very important, which was that the root cause analysis report, presumably gave the Davis-Besse's report was what you were referring to -- gives you different information than what was provided to the staff and to the ACRS at various times; is that correct?

MR. HISER: That's my understanding. Just reading through some of the observations of their inspections.

MEMBER ROSEN: I'm saying is that what your saying?

MR. HISER: Yes.

MEMBER ROSEN: I assume someone is following that up.

MR. HISER: I believe that's my understanding.

MEMBER BONACA: Was it different or was it additional?

MR. HISER: Probably additional as much as anything. Character deposits, colors, things like that that were not -- information that we were not aware of.

MS. LEE: And also degree of cleaning the head, the level of cleaning.

MEMBER ROSEN: But I'd like to have some assurance that someone is carefully sorting that out.

MR. HISER: Regarding Davis-Besse, I think Davis-Besse has issued press releases to that effect, that there are regulatory activities going on.

MEMBER ROSEN: No, I don't really -- I am interested in what Davis-Besse says, but I would prefer to hear it from the staff, that someone in the staff is carefully sorting out what Davis-Besse told NRC and the ACRS and what they now know and wrote down in their root cause analysis report.

MR. GROBE: This is Jack Grobe from Region III.

There are two activities that are ongoing in that regard. One is follow-up inspection to the AIT inspection evaluating the results of that inspection which included not what the licensee told the ACRS, but certainly what the licensee told the staff. There's also an investigation ongoing by the Office of Investigations into various aspects of what resulted in the head degradation at Davis-Besse.

I'm not sure it is appropriate to discuss the details of exactly what issues the Office of Investigations is focusing on in a public forum.

MEMBER ROSEN: Thank you.

MS. WESTON: I have a question. How much information do you get documentation to independently verify the statements that are made by the licensees? For instance, photographs, videotapes, things like that. Does the staff actually get that information and look at it independently to see?

And I'm thinking basically of the Davis-Besse photo that apparently had been taken some time before it was provided. What do you do to independently verify any of this information?

MS. LEE: In a lot of cases, the licensees have included pictures right with their initial response and also indicate that they have videos. We have followed up with some of the plants and asked for actual videos.

Also the residents are an important factor in that as well. Because a lot of times, they are the first in line that have seen these pictures, seen the videos, were with the licensees when the actual inspections were occurring. So there is the opportunity for independent verification.

And I think in terms of Davis-Besse as Allen said, there were some differences in what was provided back in the November and December time frame and then what was provided after the degradation was discovered.

So again, as Jack said, there is follow-up, investigative follow-up as to sorting out all of that and what was provided and how it differs now.

MS. WESTON: So my question, then, is how do you assure that is not happening again?

MS. LEE: I think in terms of the information that we have gotten and the information that we have followed up on, we try to do integrated types of reviews both -- as Bill said, it's under oath and affirmation. We go with that as the first line.

But we've constructed the questions to dig deeper into what they've provided. In some cases, we have asked for additional pictures, asked for additional video and additional evaluation of that with regard to what the resident saw right directly on conference calls. We try to sort through as much information as we can get at the time.

MR. HISER: In at least one case there were some photos that we were provided of the condition of the insulation, as an example. It appeared, to us, to indicate some sort of degradation of the insulation. It wasn't obvious if it was external, if it was from the head.

In that case, the licensee went in, removed the pieces of insulation, did a bare metal visual exam of the head itself, and confirmed that there wasn't a degradation at that point.

It has been a myriad of approaches to try and to reach conclusion on each plant. But at this point, there are still some outstanding plants that we need to nail down the final details on, but in an overall sense, we have a very good feeling that there is not significant degradation going on.

MEMBER WALLIS: How big are these responses? Are they two pages, a thousand pages, ten thousand?

MS. LEE: No.

(Laughter.)

MS. LEE: Did you say a thousand?

(Laughter.)

MS. LEE: No, it's not a thousand. It varies. Typically they may be like, for example, the 15-day responses, they could be 40 pages; they could be 20 pages.

MEMBER WALLIS: So you've read 68 20-page responses?

MS. LEE: Some --

MEMBER WALLIS: So it come down to what a professor grades in one day?

MS. LEE: -- on average.

MEMBER WALLIS: The kind of thing a professor grades in one day?

MS. LEE: No.

MEMBER WALLIS: You're only 20 percent complete in a month?

MS. LEE: You're talking about the 60-day responses now? You're going down to --

MEMBER WALLIS: Oh, am I going down to the -- am I out of -- okay. I'm sorry.

MS. LEE: Yeah. We were discussing, really -- the original discussion was on the 15-day response.

MEMBER WALLIS: So they have a fat one so that they are much bigger?

MS. LEE: Well, the 60 -- I'll just go on to the end of the slide -- the 60-day responses were due May 18. And we've gotten the last of them in at the end of last month, the end of May.

The staff has begun the review. It's been about 20 percent done.

MEMBER WALLIS: Those are the fat ones?

MS. LEE: The 60-day responses are the rest of the reactor coolant pressure boundary.

MEMBER WALLIS: Oh, the rest of them, okay.

MS. LEE: And again, that varies. There are some that are 40 pages. There are some that are less.

MEMBER WALLIS: So the 15-day responses -- I'm sorry -- have all been reviewed thoroughly?

MS. LEE: Yes.

MEMBER WALLIS: Okay.

MS. LEE: Yes. And just another note about the 60-day responses. Some of them may refer back to past programs on boric acid corrosion programs. So in terms of the length of them, they may be smaller because they are referring back to information that was provided on the docket.

MEMBER WALLIS: Isn't part of the problem in reviewing is that you allow them too much latitude in the way in which they present the evidence?

If you were very firm about that you must have evidence of 360 degree inspection of every nozzle -- we want to see it. We want it at a certain place in the report -- then you could run through them all and see if there was any concern.

MS. LEE: Un-huh.

MEMBER WALLIS: If every report looks different, it is much more difficult to review it, isn't it?

CO-CHAIRMAN FORD: I'd like to bring this one towards a conclusion.

MEMBER BONACA: Could I just make one? We talked about Davis-Besse, and I think Davis-Besse gives us the wrong comfort in my judgment. Because however responsible Davis-Besse will be found to be, we have to recognize we were all surprised by the finding we had at Davis-Besse. We did not -- I did not expect -- that kind of degradation.

Therefore, I don't think we can be comfortable about all the remaining plants out there that are sitting with insulation on their heads expecting that what will happen will be either what we discovered last year, that axial cracks might become circumferential, or we will discover this year that cracks may become degradation of the head. There may be something else that is developing there.

So I think it is important that we don't get too much comfort with the fact that maybe Davis-Besse made some wrong judgments.

MR. HISER: I think short-term comfort is all. For today, I think we have comfort. For the future, we need --

MEMBER WALLIS: Could I have just one quick question for the fact -- you may have said this, but of the seven, four, and eight plants that your contacting, what is the status of that? Have those contacts been made or are they yet future?

MS. LEE: For all of the plants and even the majority of the no-concerns plants, the contacts have been made. The calls have been documented and the supplements are coming in. The majority have come in, have been documented and put on the Web site.

MEMBER WALLIS: I'm not sure I understood your answer. For the high, medium and low priority plants, they have all been contacted?

MS. LEE: Yes. And then some of the no-concerns plants that we may have clarifying questions on, the majority of those have been contacted as well.

MEMBER WALLIS: Thank you.

CO-CHAIRMAN FORD: Let me finish off, unless there's any burning questions, with a -- could you keep that up please, Andrea?

I'd like to suggest that a better wording which would be a compromise wording of the first statement there is that you have not identified any plants with the gross lava flows that you have observed at Davis-Besse.

(Laughter.)

CO-CHAIRMAN SIEBER: However, until we do the 100 percent examination on all plants or until we understand the chemical and geometrical aspects that would give rise to one inch per year corrosion rates, you can't assume that there isn't an incipient Davis-Besse out there.

Is that a fair compromise statement?

MR. HISER: At this point, we are not far down the path. What we need to do now is make sure that nobody is on the path that would lead to Davis-Besse.

CO-CHAIRMAN FORD: Okay.

MR. HISER: I think that's correct.

CO-CHAIRMAN SIEBER: Right.

CO-CHAIRMAN SIEBER: Maybe as another sort of summary of what I thought I heard when we complained about visual might not be being adequate enough to identify cracking, visual was originally chosen because of fracture mechanics arguments that say even if it leaks a little bit, it is not going to separate and go sail on up to the roof of the containment, which I thought was okay at the time.

But that is just the first step. Sooner or later -- and you indicated it yourself -- that you've got to move to a better inspection technique than a visual or the camera on a stick.

MR. HISER: That's correct.

CO-CHAIRMAN SIEBER: Is that the right impression?

MR. HISER: I think that is correct. I think we will talk about that a little bit later this afternoon, but I think Davis-Besse has raised the bar a little bit in terms of the information that we need. How far down the path of leakage and cracking are we comfortable with?

It may be that we need to move back quite a bit, push the bar back.

CO-CHAIRMAN SIEBER: Okay. Mr. Chairman, I now feel comfortable that we can move on.

CO-CHAIRMAN FORD: Okay. Andrea, Allen, thank you very much indeed.

Larry, are you up?

MEMBER WALLIS: That's a new reactor design you've got there?

MR. MATHEWS: Yes, it has plenty of containment.

MEMBER ROSEN: This is some report.

CO-CHAIRMAN FORD: Larry, I understand that Glenn White wants to give a presentation before lunch. Can you arrange, whatever you are both going to do, so we can get Glenn in before lunch?

MS. KING: Yeah, we currently had that planned for the --

CO-CHAIRMAN FORD: Very good. Excellent.

MS. KING: -- for the two and a half hours.

MR. MATHEWS: I'm Larry Mathews, by the way, from Southern Nuclear Operating Company and the Chairman of Alloy 600 Issues Task Group of the EPRI Materials and Liability Program.

This is Christine King, the project manager from EPRI. We'll have other speakers and I will go over that on the agenda here.

I have a few minutes on the status. Then we're going to turn it over to somebody who knows a lot more about this stuff than I do. We have John Hickling from EPRI, who will make a presentation on our Alloy 600 crack growth rate work and the expert panel and where we stand on that.

Then we have Pete Riccardella from Structural Integrity, who will discuss the probablistic fracture mechanics model, and also how he used that or how we used that as the basis for our initial cut at an inspection plan.

I have just a few minutes on collateral damage.

Then Glenn White from Dominion Engineering will come up and make a presentation on the technical assessment that we have ongoing.

Then later this afternoon, we are going to talk about the inspection plan and where we stand on that.

CO-CHAIRMAN FORD: Will you be discussing at all during the day any work on the physics of how you can get one inch per year, low alloy steel corrosion rate?

MR. MATHEWS: That's Glenn's presentation.

CO-CHAIRMAN FORD: Right.

MEMBER WALLIS: I guess it is chemistry, too.

MR. MATHEWS: Yeah.

CO-CHAIRMAN FORD: By "physics," I meant atom by atom.

MR. MATHEWS: Well, it's physics. Chemistry is a subset of physics.

MEMBER BONACA: What's MRP? What's MRP stands for?

MR. MATHEWS: Material Reliability Program.

This is a flow chart -- and I can't see it -- this is a flow chart of basically the strategic plan that we have laid out for addressing the head penetration cracking issue. We have a similar one for the VC summer type issues.

We did not include in here work on Davis-Besse. This was put together before Davis-Besse. In fact, our initial cut at the inspection plan wasn't addressing the Davis-Besse issue. We were saying that it should be relied upon by -- well, we should rely on the 8805 program and improvements that need to be made perhaps to that program. However, based on comments we got, we are going back to take a look at what we really want to say in the inspection plan.

MS. WESTON: Larry, excuse me. Members, there is a larger version of this, page number 17, handwritten 17 in your book.

CO-CHAIRMAN FORD: Thank you, Mag.

MR. MATHEWS: How would you get that?

(Laughter.)

MS. WESTON: Magic.

MEMBER APOSTOLAKIS: Are all of these in the book?

MS. WESTON: I'm not sure. This is from a previous presentation. I will tell you if the page is there in the book. But you have this handout which has them, but I have some of these duplicate slides that are in the book.

MEMBER APOSTOLAKIS: Okay.

MS. WESTON: So handwritten page 17 --

MEMBER APOSTOLAKIS: You're right.

MS. WESTON: -- under Tab 2, has this in

a larger version.

MEMBER WALLIS: Is there some rationale to this figure?

MR. MATHEWS: We ultimately want to arrive at a final reactor pressure vessel head nozzle safety assessment that would be submitted to the staff. And all of these other things are what we're working on to flow into that, including and what we will talk about today are the ones that are highlighted in pink or red.

The susceptibility rankings briefly. We are going to have an extensive presentation on the crack growth rate and the probablistic fracture mechanics in the inspection plan later this afternoon.

MEMBER WALLIS: So it is all cracking?

MR. MATHEWS: It's all cracking on this chart. The MRP is doing work relative to the wastage issue, and Glenn will be discussing what he has been working on at the end.

MEMBER WALLIS: Now, two questions. First of all, this is all Alloy 600 and 182 and 82?

MR. MATHEWS: Right.

MEMBER WALLIS: Anything on 690?

MR. MATHEWS: No, not in here.

MEMBER WALLIS: Is there somewhere?

MR. MATHEWS: It's going to be looked at, yes, but we don't have it now.

MEMBER WALLIS: I ask the question because in all likelihood some of the stations will be going to 690 Alloy 52 replacements where necessary.

MR. MATHEWS: Soon. Yes.

MEMBER WALLIS: And therefore, presumably the staff are going to ask for some quantification of the fact of improvement.

MR. MATHEWS: Yes, and there is some information out there, and it will all be pulled together. Ultimately, the inspection plan should be addressing what's the right thing to do for those materials also.

MEMBER WALLIS: Which comes to my second question: what is the time line?

MR. MATHEWS: We are shooting for this in the third quarter of this year.

MEMBER WALLIS: So a lot -- most of these have been finished?

MR. MATHEWS: Most of them are very far down the road.

MEMBER APOSTOLAKIS: Was this -- this was not started because of Davis-Besse, right?

MR. MATHEWS: No, no. This was started

because of Oconee.

MEMBER APOSTOLAKIS: So coming back to Dr. Wallis' question, where do we enter this?

MR. MATHEWS: Well, it's all parallel really. The susceptibility ranking was the first thing that we put together. It was just the time and temperature ranking to try and figure out what plants were most susceptible and need to be concerned.

So that was put together and I guess it was actually submitted to the staff in response to 2001-01.

MEMBER APOSTOLAKIS: So do the colors mean anything?

MR. MATHEWS: The red means it's just what we're going to be talking about today. This is the final product color, and they're pretty.

(Laughter.)

MR. MATHEWS: The green, I think, was stuff that we were actively working on at that point in time when put these colors. You did the colors?

MS. KING: I did the coloring. Christine King with EPRI.

The green are things that we have interacted with the staff on.

Some issues are red here today. It

doesn't mean we haven't talked to the staff about it. It just means that we're here to talk to you guys about it today.

The yellow are things that we would like to have interactions with NRC staff on. When we get to a risk final, put together a risk assessment, and we would also like to talk to them about the inspection technology demonstrations that we have been ongoing at the EPRI and DE center.

CO-CHAIRMAN FORD: When you say "would like to," Christine, this is one of the other questions I had, is not only the timing, third quarter this year for the blue, but at what points do you have interactions with the staff on a down-and-dirty basis, data-to-data basis?

MR. MATHEWS: We've already had interactions on several of these crack growth rates and the probablistic fracture mechanics. We've had -- I thought it was a pretty down-and-dirty meeting.

(Laughter.)

MR. MATHEWS: A couple of meetings on those issues with the staff and --

CO-CHAIRMAN FORD: Okay.

MS. KING: Yeah. We've spoken to the staff a few times on crack growth rate as well as PFM.

We've been interacting on the PFM model since last September with the staff and incorporating comments and changes.

MEMBER APOSTOLAKIS: Again, is this going to be the traditional scientist's approach and the expert's approach to this? Or is it going to be a realistic risk assessment?

(Laughter.)

MEMBER APOSTOLAKIS: For example, if I look at this and I know what Davis-Besse did, where would I go and say, "Well, gee, this is really where they did things that were surprising"?

Like visual inspection guidelines, are you going to assume that these will be performed in a way that the intended result will be, in fact, achieved? Are you going to assume that the crack growth rates are the scientific rates, when I read here that the B&W owner's group had underestimated those rates in their regional calculations?

I mean, are you going to have issues like that in here? Otherwise the result would be ten to the minus X and we pick X?

(Laughter.)

MEMBER APOSTOLAKIS: Well, I mean, at some point you have to draw the line and say they are not doing it. The program is there, but they are not implementing it correctly.

I know one of our issues addresses safety culture issues, but why else are we doing this?

MR. MATHEWS: The inspection plan is going to be finalized and out to the industry. It is my understanding that already INPO in their visits to the sites are looking into how plants have done boric acid walk-downs, et cetera.

The inspection plan would probably ultimately be audited by the industry itself by INPO. That would probably be the way that it would go.

MEMBER APOSTOLAKIS: Shouldn't there be other boxes with question marks inside feeding into the risk assessment for somebody else to worry about? Or is this the only thing that goes into the risk assessment?

It says probablistic fracture mechanics and there is the arrow to the risk assessment which is of concern to me.

MR. MATHEWS: Everything is feeding into the risk assessment. All of it, ultimately if you look at it, gets into that box.

MEMBER APOSTOLAKIS: But this is the material expert's review, isn't it?

MR. COZENS: This is Kurt Cozens from NEI.

And I might be able to help just a shade on this because I think I understand what you are asking, and if I might just interject for a second.

The MRP process has an executive steering committee, and when we say executives we are talking about the chief nuclear level. These individuals that sit on this executive board have and do review the technical work that has been put out by the ITG, reviewed by its own infrastructure that critiques this.

They look at this, not only from a technical issue, but from what I'll call the policy level issue of what is the right thing to do. And I think that is the essence of what you're looking at.

Not only what do the engineering numbers say, but is that really the right thing to do in managing their plants?

So that is a very big consideration. I believe the staff is looking at that from the same point of view. You know, the numbers may tell us one thing, but when you really look at the real world, what are the things that should be accomplished?

And there is a lot of oversight at a high level within the industry to ask some of those tough questions.

Larry, I defer that back to you. But I think, I believe that's what you were driving to, wasn't it?

MEMBER APOSTOLAKIS: Well, these are policy.

MR. MATHEWS: The risk assessment question or risk assessment that is being done is not just a bare bones. We are putting conservatism in there at various stages, and you'll see some of that in Pete's discussion of the PFM work.

MS. KING: And I guess I would like to point out that this whole thing is fed with the inspection data that we are getting from the field. We continue to evaluate that data, what we're finding in the field, and reviewing our work.

MEMBER APOSTOLAKIS: But if I want to, I mean there is such a thing as Defense in Depth, and the structuralist interpretation is that if I'm wrong or if I don't have good information, I want to make sure that nothing will go wrong.

So in light of Davis-Besse now, if the inspections are inadequate or if the crack growth rates are underestimated, what is it that is protecting me? What Defense in Depth do I have in here that says, yeah, your estimate is ten to the minus six, but it is really .3?

So something needs to be there to protect me and I don't see that.

MEMBER WALLIS: There's a containment.

MEMBER APOSTOLAKIS: Oh, the containment. I think we have to ask those questions because if we don't ask them now, we'll never ask them.

MEMBER BONACA: That's why we're asking questions about the inspections. Because if you went in now --

MEMBER APOSTOLAKIS: If things are implemented the way they are supposed to be implemented, then I will believe this analysis. But unfortunately, sometimes they are not.

So I have to have some measure somewhere that satisfies my Defense in Depth needs. I don't know how we're going to do that.

MEMBER ROSEN: Well, Mario, you have more than the containment. You have your emergency core cooling systems as well.

MEMBER BONACA: Of course.

MEMBER APOSTOLAKIS: Anyway, let's go on.

MR. MATHEWS: I was just going to show what we're going to talk about.

I'm going to turn your ranking around. Okay? What we have done and what we have decided is the right way to look at this thing in the future is not to try and take a reference plant like Oconee 3, which had a large circ. flaw at the time it was discovered, and figure out and back calculate how long each plant had until they got to that point, but rather just look at the degradation that each plant has at a point in time or for degradation time at temperature.

So what we have done is recalculated. This information was in MRP-48; it was just a different column that we had ranked --

MEMBER WALLIS: You mean there are no points where there are no leaks and no cracks? It doesn't seem to be anything, any data for no leaks and no cracks.

MR. MATHEWS: No leaks or cracks detected in all of these.

MEMBER WALLIS: Oh, there are no leaks and no cracks.

MR. MATHEWS: Yeah.

MEMBER WALLIS: Oh, that wasn't clear to me at all.

MR. MATHEWS: Or cracks.

MEMBER WALLIS: I thought it was that there were no leaks, but there were cracks.

MR. MATHEWS: No, no, no. No leaks or cracks.

The X-axis is now what we're calling equivalent effective degradation years, which is the same thing that was presented as effective full power years normalized for 600 degrees Fahrenheit. And I think we even used the term effective degradation years in the original submittal in MRP-48.

But our ranking system was based on taking each plant's number, at that time, and then figuring out how many years they had left to be equivalent to Oconee III.

We said, you know, that's probably not the right way to look at it in the future. So we are just ranking it. Where does each plant are they? Starting at zero at zero and going to the highest plant at the time we had the data was Oconee I, I believe it was.

MEMBER APOSTOLAKIS: So these are the years that are left in the future? No?

MR. MATHEWS: No, no, no. This is accumulated years from time zero to the -- to February 28th. We are going to update all those numbers.

MEMBER BONACA: For understanding, the

blue ones, the diamond, no leaks, cracks detected. Some of them have not been inspected, right?

MR. MATHEWS: No, well, all of the ones that are solid blue have done either a top-of-the-head visual or a volumetric of their plant.

MEMBER APOSTOLAKIS: So pick a point and explain what it means.

MR. MATHEWS: Okay.

MEMBER APOSTOLAKIS: Let's pick the very first one.

MR. MATHEWS: This point right here?

MEMBER APOSTOLAKIS: Yeah. What does it mean?

MR. MATHEWS: That plant is the lowest ranked unit on time at temperature.

MEMBER APOSTOLAKIS: Okay.

MR. MATHEWS: It is a cold head plant. It's a very cold head plant. And even though they have been running for a significant number of years, when you normalize their time at temperature, they are only about one year, effective full-power year at 600 degrees Fahrenheit.

MEMBER ROSEN: Effective degradation year.

MR. MATHEWS: Yeah. One effective degradation year because they have run at such cold head temperatures.

You take another plant here --

MEMBER APOSTOLAKIS: Wait, wait, wait. Why is it 69? What does 69 mean?

MR. MATHEWS: There's 69 units and this is just a rank. This is just a sort that shows the rank.

MEMBER WALLIS: It's not a property. It's just a number assigned to the plant.

MEMBER APOSTOLAKIS: So this is plant number 69?

MR. MATHEWS: It's plant number 69. What it means is that this one has the lowest time at temperature of all 69 PWRs in the country. This one has the next lowest. You come on down and they get higher and higher in their effective degradation years until you get to Oconee I, which had the longest time at temperature run of all the plants at that time.

MEMBER KRESS: How do you normalize the temperature? Is that linear?

MR. MATHEWS: No, it's an arrhenius equation.

PARTICIPANT: It's a arrhenius equation, okay.

MEMBER KRESS: Is that what accounts for the big split right there or --

MR. MATHEWS: Right. These plants are cold head plants. So when you normalize it to 600 degrees, they accumulate effective degradation units at a very low rate in real time. Ones that are over 600, these and Davis-Besse and some of the others that are slightly over 600 accumulate effective degradation units at greater than real time.

So, you know, even though they got 21.7 or whatever the number was, their effective full-power unit was less than that, but they had been running it over 600 degrees. So to normalize it to 600 would --

CO-CHAIRMAN FORD: But the fact that you have a discontinuity and your algorithm only takes in temperature, does that give you --

MR. MATHEWS: In the time that you operate.

CO-CHAIRMAN FORD: But the fact that you have a major discontinuity in that relationship is telling you there is something missing from that algorithm.

PARTICIPANTS: No.

MR. MATHEWS: There will be some plants running cold head temperatures and some plants run hot head.

CO-CHAIRMAN FORD: But using an arrhenius plot, they should all meld into the same plot.

MR. MATHEWS: No, no, no. then the other variable is how long that they've been running.

MEMBER APOSTOLAKIS: But the vertical axis is still not clear to me.

MS. KING: What we did was when we made this calculation for EDY, we just sorted it from top to bottom and assigned a number one through 69.

MEMBER APOSTOLAKIS: Oh, afterwards you assigned a number? Okay.

MR. MATHEWS: Yeah, we assigned a number after we sorted, ranked on EDY. This is just the rank of the unit based on EDY.

MEMBER ROSEN: This is too simple for you to understand.

(Laughter.)

MEMBER ROSEN: It's to simple for you to understand. You can't get your guns down that low.

Now let me go back to my question. The break in the data that I was referring to was not the one down all the way out in the EDY curve. It's the one up at five EDY. Do you want to point to that and tell me what that one's about?

MR. MATHEWS: These plants right here are all Westinghouse units that are later designed and were designed to run with significantly colder heads, somewhere around T-cold, around 550 to 560 degrees Fahrenheit in the head region. They have got a lot of bypass flow that goes to the head.

Most of the plants in here were designed with some bypass flow, and you can call them warm-heads, if you will. They are 580 to 600 degree range.

MEMBER BONACA: The others are hot-heads.

MR. MATHEWS: And these are the hot-head plants --

(Laughter.)

MR. MATHEWS: -- that run at 600 or higher on their temperature on their head.

MEMBER ROSEN: Now some plants have modified that flow scheme during their life. They have gone from being hot-heads to warm-heads. Some of the warm-heads have gone to cold.

MR. MATHEWS: Right.

MEMBER ROSEN: Did you take that into account in EDY?

MR. MATHEWS: We took each period of operation at each temperature when we calculated the effective degradation years, and then we will use their new head temperature to figure out how fast they move to the right, if you will.

MEMBER KRESS: How did you get the activation years?

MR. MATHEWS: We used -- for this we used 51 kilocalories per mole for crack initiation.

MEMBER KRESS: Oh, so that's for experiments on crack initiation.

MR. MATHEWS: Yeah. Okay?

MEMBER WALLIS: It has a lot of uncertainty associated with it, I would assume.

MR. MATHEWS: It's not a lot, but there is -- well, there may be. I don't know. We did some sensitivity studies on our initial ranking going all the way down to 40 kilocalories per mole to see what impact it had on the stack-up of the industry and plants moved around a little bit because of different times and et cetera, but it wasn't a radical shift, and some plants were in a little different position.

MEMBER ROSEN: Now you acknowledge that this is changing every day, this chart, right?

MS. KING: Right.

MR. MATHEWS: It should be, but we don't change it every day. In fact, the data is all effective over a year ago. We are going to update all that data.

MEMBER ROSEN: I understand you wouldn't

change it every day, but --

MS. KING: It's expected that the plant would calculate their EDY continuously.

MEMBER ROSEN: Have you done a calculation, a prospective calculation, so that you know where the plants will end up six months from now, a year from now, two years from now? Because obviously this picture is changing.

MEMBER KRESS: Other than the temperature problem it just shifts one point.

MR. MATHEWS: Each plant will move to the right at a different speed depending on what its temperature is. But typically, they are kind of ranked like they are here. The hot-head plants are here. The cold-head plants are here. And the warm-head plants are in the middle somewhere.

MEMBER ROSEN: Because each plant moves to the right at a different rate, the order will change.

MR. MATHEWS: I guess my intent -- and this is my chart. I kind of came up with it.

(Laughter.)

MR. MATHEWS: --- would be to maintain that initial ranking --

MEMBER ROSEN: Does that mean we can't comment on it?

MR. MATHEWS: Oh, sure, you can.

(Laughter.)

MR. MATHEWS: But, yeah. If I resorted every time I replotted the thing, then, yeah, the plants would move up and down in the ranking. But probably it would be more instructive to watch them move to the right at the different paces.

MEMBER ROSEN: I suggest that you press the sort button every once in a while.

MR. MATHEWS: That's probably not a bad idea. Press the sort button every once in a while.

MEMBER WALLIS: Well, let's tell us the substance now.

MR. MATHEWS: Okay. Now, all of the plants that are red triangles have been inspected and found leakage.

MEMBER WALLIS: That they've seen deposits?

MR. MATHEWS: Well, yeah. Every one of them has had through wall --

MEMBER WALLIS: They have seen deposits. They have not measured a flow. They have seen deposits.

MR. MATHEWS: Right.

MEMBER WALLIS: There might have been a

leak with no deposit, but the evidence is the deposit. So those have seen deposits; is that right?

MR. MATHEWS: These two -- well, three plants. We have three plants on here that are kind of yellow squares. They were plants that did volumetric inspections, found cracks in some penetrations that were not through walls, but did not have leakage at that point.

MEMBER WALLIS: And they did not see boron?

MR. MATHEWS: Right, there's no leakage yet.

MEMBER WALLIS: Did not see boron. How do you know there's no leakage?

MR. MATHEWS: Well, they quantify as best they can with NDE at that point in time the flaws, and the flaws were not through walls, did not reach a pressure boundary.

There are three of those. This one is the Millstone, and this one was --

MEMBER WALLIS: And there is one that's behind another one.

MEMBER ROSEN: Robinson.

MR. MATHEWS: No, Robinson did a visual and found no leakage.

MEMBER BONACA: A question that I have. For those that were inspected volumetrically and found cracks, did they fix those cracks? Did they replace the nozzles?

MR. MATHEWS: There's one in here that you can barely see. Cook 2 found a flaw in '94 and they repaired the flaw in '96.

MEMBER BONACA: Okay.

MR. MATHEWS: Then they came back in 2002, this spring. They did both a visual and a volumetric on their plant and found no additional flaws anywhere.

Several of these plants, clearly the ones that have yellow have done volumetric and it's hard. You can't tell from this symbol whether they have done volumetric or --

MEMBER WALLIS: Yeah, I think that is why I have asked you about it. You said there are no leaks detected is the main thing. The cracks are somehow inferred from the leaks in the blues, isn't it?

MR. MATHEWS: Right. The reason it says that is because that triangle encompasses both visual and volumetric.

MEMBER WALLIS: It would be nice to break that out into two.

MR. MATHEWS: We have a slide and we'll put it up here if she can get to it.

What I have done is flagged the plants that did volumetric in that blue triangle.

MS. KING: It's a little busy, but --

MEMBER WALLIS: Those guys did volumetric?

MR. MATHEWS: All of these plants that have blue have done volumetric in addition to --

MEMBER WALLIS: So those other blues, say, between 15 and 20, they are just relying on not seeing "popcorn"?

MR. MATHEWS: Right. These plants have done their 2001-01 response of an effective visual examination.

MEMBER WALLIS: But we know nothing about the crack situation in those plants?

MR. MATHEWS: Correct. We know they don't have leaks coming to the top of the head. That's what we know at this time.

CO-CHAIRMAN FORD: But I assume that we are going to discuss that later on when we come to the whole question of inspection. Maybe it will be in the NRR one, but this whole question about the relationship between where you see cracks and where you see "popcorn" or not. That's going to come into --

MR. MATHEWS: I suspect we will get into heavy discussions of that when we talk about the inspection plan.

CO-CHAIRMAN FORD: Good. While she still has got that slide up --

MEMBER ROSEN: Excuse me. In the blue diamonds, again, it says no leaks, slash, but cracks were detected. You don't mean that. You mean no leaks or cracks were detected?

MR. MATHEWS: No leaks or cracks were detected.

MEMBER ROSEN: But if you just pick this piece of paper up, you will get the opposite piece of information.

MS. KING: We will make sure that gets fixed.

CO-CHAIRMAN FORD: And also you didn't actually know anything about cracks if you didn't find leaks. So I think you need two different colors, one which is no leaks detected and another one which has no leaks nor cracks.

MR. MATHEWS: Excel has a limited number of symbols. We are tracking it that way. We just -- it is kind of hard to get it all on one graph, but

I'll try and do better.

CO-CHAIRMAN FORD: As I mentioned in the very beginning, there was a question raised about the statistical veracity of this. You could increase that or waylay that problem by including all the French data, using your algorithm, but on the French inspection data.

Is that a possibility or do you not even want to approach that?

MR. MATHEWS: Well, I'm not sure we got even as good a handle on French head temperatures as we have on our own. The other thing is it is not clear to me that what happened in the French plants is the same thing that is happening here.

CO-CHAIRMAN FORD: Well, could you expand on that? Because this was the answer to my question at the very first meeting in July. The French operations got no bearing at all in the United States operations, and I don't understand that. Why?

MR. MATHEWS: I think there was significant differences in the processing of the material that was used.

CO-CHAIRMAN FORD: But processing doesn't come into your algorithm. The only thing in your algorithm is temperature.

MR. MATHEWS: Time and temperature, you're right. That's right.

MS. KING: But it would affect the inspection results.

CO-CHAIRMAN FORD: Exactly. That's why I am asking why don't you improve the algorithm. But regardless, if temperature is the only thing in your algorithm, you should be able to increase your database by including the French data.

MR. MATHEWS: Hopefully, they may all be here and that --

CO-CHAIRMAN FORD: Then that screws up entirely your algorithm.

CO-CHAIRMAN SIEBER: No, it just says there is a difference between the points.

MR. MATHEWS: It says to me that there's something different then --

CO-CHAIRMAN FORD: Their algorithm is not complete, which we know.

MR. MATHEWS: Right. It's just time and temperature. Okay.

CO-CHAIRMAN SIEBER: Well, we know that the heat is apparently very important.

CO-CHAIRMAN FORD: Not in this algorithm.

CO-CHAIRMAN SIEBER: No, but we know it is important to the physical --

CO-CHAIRMAN FORD: Absolutely.

MR. MATHEWS: And what we -- I guess what I hope and what I believe is that the plants that are out here are the leading edge not only in time at temperature, but in the bad material, too. And so what we may find -- and personally I expect to find -- there will be plants that will reach these same time at temperatures that have no problem.

CO-CHAIRMAN FORD: The reason why I keep hammering on this is that the algorithm that you've got served a very useful purpose back in July of last year when you were coming up with your inspection prioritization.

But I hope that it is not the intention of the industry to keep willy-nilly on this algorithm as if it's the only prediction algorithm in existence because it is obviously incomplete.

MR. MATHEWS: We know there are other parameters, and when we are able, based on what we see in the field --

CO-CHAIRMAN FORD: Well, I would hope that from a research point of view it is not when we are able. I mean, I hope that we have got ongoing work to come up with this prediction algorithm which we are going to need until all the heads are replaced. And even then you're going to need it.

MR. MATHEWS: I guess the main problem I see with trying to do it is that all of the tools that I've seen are based on Alloy 600 base metal, and we've got several of these plants where the through wall leakage came through the weld metal.

CO-CHAIRMAN FORD: Well, put yourself in two years' time when I assume that the staff are going to ask you the question, tell me why my safety posture has changed significantly; tell me quantitatively why my safety posture has changed by going to 690 and Alloy 52. Will you be able to answer that question?

MR. MATHEWS: I certainly hope so, and we will be looking into --

CO-CHAIRMAN FORD: Being a researcher, I'm very susceptible to this question because it takes more than two years to come up with that answer unless you've already got it in your back pocket.

MR. MATHEWS: Well, I don't have it in my back pocket finally, no.

CO-CHAIRMAN FORD: Okay.

MR. MATHEWS: That was what I had as the introduction, and I'd like to move on in and get EPRI to come up here and discuss the crack growth rate for

Alloy 600 and where we stand on that in the material in the report.

MS. KING: We had this planned as a 45 minute presentation. Do you want to go into that now or do you want to take a break?

CO-CHAIRMAN FORD: I see. John, does your talk actually go into two parts, fall into two?

MR. HICKLING: Yes, it does.

CO-CHAIRMAN FORD: Let's take your first part and then we'll break.

MR. HICKLING: Good morning ladies and gentlemen. My name is John Hickling from EPRI, and I'm going to talk in some detail about a small piece of this jigsaw, but it is only a small piece, and there are the questions which this presentation certainly won't answer.

What I'm trying to get to is an agreed crack growth rate for thick section Alloy 600 material exposed to PWR primary water. Everybody knows that Alloy 600 is susceptible to primary water stress corrosion cracking. We've known that for a very long time, every since Coriou back in the '60s first discovered the phenomenon.

It's been studied mainly on steam generated tubing where its impact until recently has definitely been greatest, and the challenge now in terms of head penetrations is to find out what a thick section material -- how that behaves and to agree on what sort of crack growth rate we should be using in deterministic and probablistic analyses.

So the goal here is to establish a generic crack growth rate applicable to this material, and our approach was to gather together some of the experts in this field to advise us, and this was done starting in August last year.

Can we flip forward to the slide of the people names? One more.

And we looked around the world for those people who we thought could offer the best advice on this problem. These are the core team members of the MRP expert panel.

We've had a lot of people at various meetings. We've had about four or five meetings of the expert panel since August last year. I myself came into this field only in December when I joined EPRI, but I have worked on stress corrosion cracking for very many years.

As your Chairman well knows, it's not necessarily a particularly exact science, and these are the people who have been in the core team advising us right through.

Can we go back to the overhead?

CO-CHAIRMAN FORD: If I could, just for the other members, apart from Bill, who don't know these names, these are good people. It's not just a random selection of experts.

MEMBER KRESS: Are you including this one?

CO-CHAIRMAN FORD: Bill Shack?

MEMBER KRESS: Yeah, called Bill Shack.

CO-CHAIRMAN FORD: He's okay.

MEMBER SHACK: No doubt about one of them.

(Laughter.)

MR. HICKLING: Bill is by definition okay.

MEMBER APOSTOLAKIS: But when you say "expert," you're not conducting any expert opinion solicitation here, are you?

MR. HICKLING: No.

MEMBER APOSTOLAKIS: It's just that they're advisors to your program.

MR. HICKLING: Not quite. We, as you'll see when I get into the presentation, we have to look where the data we're using has been generated. So those people who have generated the data qualify straight away to some extent.

We've also included other people whose

expertise is more in analyzing the mechanistic side of primary water stress corrosion cracking. We've included people whose expertise is more in analyzing application of data.

MEMBER APOSTOLAKIS: But their role is what? To advise you on the problem.

MR. HICKLING: Their role is to try and reach a maximum degree of consensus on what the crack growth rates should be that we're using for Alloy 600.

MEMBER APOSTOLAKIS: Okay.

MR. HICKLING: So the work of this expert panel, which started, as I say, in August last year, falls really into two sections, and that's why I would take the presentation perhaps in the two sections here.

The first one was to consider following the Oconee experience. What might be happening in the environment which would exist in the annulus of a crack where a leak had already occurred, i.e., we're talking about external OD cracking in that case.

And I'm going to take that issue first in this presentation and then come back to the rather large body of work which is on the actual crack growth rate under normal PWSCC conditions.

I put in a little bullet here and will

come back to that right at the end of the presentation about Davis-Besse. The expert panel or a subgroup of it met quite recently to consider the implications of the Davis-Besse incident to this argument and has reached the conclusion that the arguments I'm presenting today are basically valid in a non-Davis-Besse situation, i.e., at low leakage rates.

And I have a couple of comments to make about how we think the Davis-Besse environment might affect that growth rate.

Next one, please.

So if we move through the presentation on to how we are trying to use it, I think we'll go straight on to the external OD environment.

Slide. Thank you.

A lot of thinking was put into this, first of all, as to what the most and likely environment would be once you had a through wall crack in a CIDM nozzle, and the conclusion was there were three likely environments, and they depend to some extent on the situation as the leak develops because intragranular stress corrosion cracking, primary water stress corrosion cracking in Alloy 600 leads to extremely tight, highly branched cracks.

So that the first time that a crack

penetrates the material, the OD surface, the leakage rate is likely to be extremely low, and the pressure drop is likely to be taking place purely within the crack.

So the environment at that stage is almost certainly going to be hydrogenated, super heated steam.

MEMBER WALLIS: So where does the boron go? If you've got boron coming in with the water, it can't just turn to steam. The boron has got to go somewhere.

MR. HICKLING: No, the boron will exit also with the steam.

MEMBER WALLIS: Well, it so. So it's steam carrying boron in some form.

MR. HICKLING: Yes, yes.

MEMBER WALLIS: So it's borated, super heated.

MR. HICKLING: Borated, super heated state.

MEMBER KRESS: That depends on the pressure at which you convert it into steam.

MEMBER WALLIS: Just by continuity.

MEMBER KRESS: If the pressure is very high, it will concentrate in the water. If the pressure is very low, it's going to go out with the steam. So I don't know how you --

MEMBER WALLIS: Continuity has got to go out some --

MR. HICKLING: It depends on leakage path and the hydraulics of the situation.

MEMBER KRESS: That's what I'm trying to say, yeah.

MR. HICKLING: Absolutely.

MEMBER ROSEN: Now, the boron in the water will range from, depending on the cycle, from something like 2,000 parts per million down to very low, maybe 100 parts per million.

It will also characterize the boron in the super heated steam, or is there a partition factor?

MR. HICKLING: I think that's not an issue in this case for the super heated steam environment. If you see, looking down the slide, we have the three environments. We have the two extreme cases, at the beginning, when we're dealing almost certainly with only steam in the annulus, and we have the second case where we've already flooded the annulus, much later where we have a very high leak rate.

I'm not saying we've got wastage or corrosion or cavity formation. I'm saying we have flooded the annulus with liquid so that the boiling point is high up in the annulus, well above the J-grove weld.

And remember that the J-grove weld determines where the cracking is going to occur because of the residual stress consideration.

And then the third point, which is what we've attached most attention to, is what would happen if you're getting considerably boiling and partition at the point of exit from the crack, i.e., you're getting a different environment forming exactly at the point where you have your residual stress, and that is what most effort has bene put into.

MEMBER ROSEN: Well, are you implying that the concentration of boric acid to be higher than the concentration in the primary water?

MR. HICKLING: Yes. Oh, yes.

MEMBER ROSEN: The concentrates?

MR. HICKLING: Oh, yeah, and the lithium hydroxide does, too.

MEMBER ROSEN: Ultimately it concentrates, but at the very first instance, I guess it's not that relevant. At the very first instance, there's a little boron. Perhaps what the partition factor between steam and water doesn't really matter as long as a little carryover.

The water that carried over stays there.

MR. HICKLING: Yeah.

MEMBER ROSEN: And then it continues to build and build.

MR. HICKLING: Yeah. The steam environment, because it's a pure super heated steam environment with the exception of the boron and lithium carryover, is basically not a difficult environment to handle because there's been a lot of work done on that. The --

MEMBER WALLIS: I'm wondering about that. I mean it depends on where boron and lithium goes. If it builds up, if it deposits on the walls, then your environment is essentially walls plated with boron in various --

MR. HICKLING: Are you talking about the walls of the crack or the annulus?

MEMBER WALLIS: Of wherever the steam is coming out and impinges upon. The OD annulus environment here.

MR. HICKLING: Yes.

MEMBER WALLIS: And presumably some boron is carried out by the steam, but it's a very low flow rate. It's a big area in that.

MR. HICKLING: Yes.

MEMBER WALLIS: I would think it would fill up with boron crystals or whatever, the popcorn or whatever.

MR. HICKLING: Yes, very good point.

MEMBER WALLIS: So the environment, what the wall sees is whatever the bottom of those crystals' condition is, which presumably is dry or wet or whatever, depending on the various phases of boron, boric acid with temperature and concentration.

MR. HICKLING: Correct.

MEMBER WALLIS: So it could be doing something to the wall because it's concentrated boric acid. It's not steam that the wall sees.

MR. HICKLING: Yes. You'll see it right at the end when I come back to talk about the Davis-Besse situation. There's a little -- we have very, very little data on stress corrosion cracking of Inconel in concentrated boric acid solutions. There is one paper essentially resulting from one French program which has addressed that particular condition.

The main concern behind the consideration of the environment in this case on the OD environment has always been traditionally caustic and caustic formation.

MEMBER WALLIS: That puzzled me. That's what Bill was telling us earlier. I guess he can't tell us anything now.

How does it get to be caustic when there's so much boric acid there?

MR. HICKLING: Because the concentration mechanism that is taking place here, depending upon the interactions and particularly the precipitation, as you correctly pointed out, you are going to get precipitation and plugging, and depending upon the exact way in which that forms, you can postulate different chemical environments which might form.

And you cannot per se rule out the tendency to go caustic, and as was also mentioned, you have to consider the differences in boron concentration between beginning and end of cycle, which will affect potentially the final pH of that concentrated solution, and all of that was taken into account.

MEMBER ROSEN: And the fact that there's a coordinated lithium being used in many plants.

MR. HICKLING: Absolutely.

MEMBER ROSEN: The pH of the rapid coolant during normal operation is typically not above neutral. It is basic, kept in the 7.0 to 7.4 range, I would guess.

MR. HICKLING: Right, yes.

MEMBER ROSEN: Now, that does not characterize the pH in the crack.

MR. HICKLING: The pH in the annulus, if you're having boiling in a concentrated environment.

MEMBER ROSEN: Will drive it acidic?

MR. HICKLING: I'll get to that in two minutes, if I may. Let me take the two simpler environments first because the simpler environment -- well, no, I'm sorry. One more slide, Christine, please.

There's one consideration I'd like to take first of all before considering the three environments because it's a very important one, but it is actually the same arguments apply to all three potential environments, and that is the extent to which you might get an oxygenated condition developing within the annulus low down, just above the J-groove weld where you're expecting a stress corrosion cracking to occur.

And traditionally, of course, oxygen virates' (phonetic) effect on electrochemical potential has a huge potential impact on cracking susceptibility. So the panel spent quite some time looking at the arguments as to whether or not the crevice, right down in the crevice, could be oxygenated.

And there are various ways that that was done. The first was to use some back diffusion models for oxygen. In fact, two independent assessments were made.

Considerations of oxygen consumption along the metal walls --

MEMBER WALLIS: But does it just diffuse? I mean, there's a flow pattern in this annulus.

MR. HICKLING: Yeah.

MEMBER WALLIS: There's a crack at one place producing a jet of some sort. I would think it's not just diffusion that's going on. You have to analyze the fluid flow pattern in that space.

MR. HICKLING: Correct.

MEMBER WALLIS: There's a mechanism for back flow in the place where the jet is not perhaps.

MEMBER ROSEN: In fact, the jet could be pumping the crack, right?

MEMBER WALLIS: But I don't know if it can. We'd have to see an analysis.

MEMBER ROSEN: Like a jet pump in a BWR, just like a jet pump.

MR. HICKLING: You've got to remember that we're talking here about a very, very narrow, deep annulus --

MEMBER ROSEN: Around the grain.

MR. HICKLING: -- at this point.

MEMBER WALLIS: But again, I haven't seen any equations or figures or anything.

MR. HICKLING: Right, yes.

MEMBER WALLIS: So I'd have to look at the model to see whether -- when you say "diffusion," it makes me a little suspicious. If someone assumed it was diffusion, I doubt if that's what was going on.

MR. HICKLING: No, the model, both of the model concerned, in fact, do take that into account. I think probably more important in concluding that oxygen is not present right down at the bottom of this very deep and narrow crack, also some of the other points, the oxygen consumption, the presence of hydrogen itself because, of course, hydrogen is present in the water and by diffusion through the metal of the head and is available to react with any oxygen that might be there.

And finally, the fact that even if you were to postulate very low oxygen levels still being credible at the bottom of the crevice, you do have a coupling effect between the alloy steel and the Alloy 600, a galvanic coupling effect, all of which will keep the potential low.

MEMBER WALLIS: Why does the hydrogen react with the oxygen here when it doesn't in the containment?

MR. HICKLING: This isn't --

MEMBER WALLIS: After putting miters (phonetic) in there?

MR. HICKLING: We're talking about reaction here within an aqueous phase.

MEMBER WALLIS: Oh, okay. So that's much more graphic.

MR. HICKLING: Yes. So the bottom line conclusion of all of these considerations was that it is not necessary to consider an oxygenated crevice condition right down at the bottom. As I said, this analysis does not treat a wastage in cavity formation situation.

MEMBER WALLIS: Is there any real evidence of non-oxidation in this annulus space, observation of no rust?

MR. HICKLING: I think the answer to that has to be that there is no observation of what that crevice looks like right down at the bottom.

MEMBER WALLIS: That would have been destructive examinations of real cracked --

MR. HICKLING: The only one I'm aware of is in Bouget nozzle that first cracked, which was destructively examined, in fact, and there was no real evidence of --

MEMBER WALLIS: Thank you.

So the fact is it was useful.

MR. HICKLING: Oh, yes, yes.

CO-CHAIRMAN SIEBER: If wastage does occur, then these arguments, except for corrosion potential, then fall apart; is that correct?

MR. HICKLING: I'm sorry. I didn't hear the first part of the question.

CO-CHAIRMAN SIEBER: If wastage does occur --

MR. HICKLING: Yes.

CO-CHAIRMAN SIEBER: -- okay, then these arguments about oxygenation fall apart because the geometry is now changed.

MR. HICKLING: If significant --

CO-CHAIRMAN SIEBER: With the exception of corrosion potential; is that correct?

MR. HICKLING: Correct. If significant wastage and cavity formation were to occur, then this is a different situation, which would require separate consideration.

CO-CHAIRMAN SIEBER: Now, aside from the factor of the wastage weakening the basic structure of the head, the added oxygen would increase the crack growth rate significantly, don't you think?

MR. HICKLING: Not necessarily. Primary water stress corrosion cracking of Alloy 600, Alloy 600 has a number of separate modes of stress corrosion cracking, and your conclusion would be correct for some of them, but not to primary water stress corrosion cracking.

Remember the original finding that Alloy 600 cracks in pure water or in PWR primary water is extremely surprising, and the mechanistic reasons for it doing that are very closely linked with the fact that the electrochemical potential --

CO-CHAIRMAN SIEBER: Is there.

MR. HICKLING: -- is established in the region of the nickel/nickel oxide transition.

CO-CHAIRMAN SIEBER: Right.

MR. HICKLING: And that is a low potential phenomenon. So in that case it's not fair to assume automatically that oxygen would be negative. It was just a consideration that needed to be very carefully looked at in terms of the narrow annulus.

Now, I'll come back to make a comment right at the --

MEMBER SHACK: Because it could be cracked by another mechanism, and you would have to address that one.

MR. HICKLING: Absolutely, yes. If you had an oxygenated environment, a highly alkaline environment, then that is not primary water stress corrosion cracking. It's a different mode, I think.

MEMBER WALLIS: Tell me more about the hydrogen. I mean, we were hearing about hydrogen explosions in BWRs where they had essentially a stoichiometric mixture of hydrogen and oxygen resulting from radiolysis (phonetic).

MR. HICKLING: Yes.

MEMBER WALLIS: So there is an oxygen in there, not just all leaking out necessarily by the hydrogen.

MR. HICKLING: In the PWR, primary water environment, that is your main reason for adding large over pressures of hydrogen, to make sure it is all --

MEMBER WALLIS: So these are all hydrogenated plants?

CO-CHAIRMAN SIEBER: Yes.

MR. HICKLING: All PWRs run with high hydrogen levels for that reason.

So that consideration was the elimination of oxygen from the picture for the narrow crevice at the beginning of the situation, the non-wasted situation.

Looking back then at the three environments that were considered, and the first one is hydrogenated steam, and as I mentioned, there is quite a lot of evidence, quite a lot of information available on the way in which Alloy 600 cracks in hydrogenated steam primarily because hydrogenated steam has been used as an accelerated test method for determining crack susceptibility in this and other nickel based alloys.

And the main conclusion of the data that's available is that in terms of pure hydrogenated steam, and not including boron or lithium in this, the impure steam environment which is used to accelerate cracking involves chloride and sulfate as contaminates.

In terms of the hydrogenated steel environment which you would expect at the beginning with a very tight crack, the rates of cracking are going to be virtually the same as they would be in normal primary water at the same temperature.

MEMBER WALLIS: Is cumulative percent with IGS? So that means that after 1,000 hours, 60 percent of them have cracks?

MR. HICKLING: Yeah. This is one diagram picked out of a -- it's very hard to summarize in some cases all of the work that's been done on Alloy 600. This particular issue has been studied for very many years, particularly at the Westinghouse laboratories from about 1987 through '95.

MEMBER WALLIS: My question really was this crack development is so rapid because the temperature is so high. Isn't that why?

MR. HICKLING: Correct.

MEMBER WALLIS: If we looked at this as typical, we'd be really scared.

MR. HICKLING: yes.

MEMBER ROSEN: You see, now that's the danger of coming to ACRS. We start putting things together.

If you just said that these crack rate growth rates are accelerated tremendously in chloride and sulfate environments, chloride and sulfate contamination --

MR. HICKLING: Contamination, yes.

MEMBER ROSEN: -- did that happen at Davis-Besse?

MR. HICKLING: I'm going to deal with what we know about that, and I know nothing whatsoever about the Davis-Besse situation. I have no reason to believe it did, but I'm going to --

MEMBER ROSEN: That's a question we could perhaps ask the staff with the applicant. It's easy to get chloride contamination in the primary from a leak from the secondary side. If your secondary side has a, you know, brackish or that kind of water, you're going to be -- in your cooling water, you're going to have chloride.

So if you get some sort of ingress into the secondary side, you will have chloride contamination in the secondary side. It's possible, although not likely to have an intrusion into the primary system.

CO-CHAIRMAN SIEBER: I'm not sure how that happens since the primary runs at a higher pressure.

MEMBER ROSEN: Yeah. That's why it's difficult, but it can happen during shutdown or --

CO-CHAIRMAN SIEBER: It's like pushing water uphill.

MEMBER ROSEN: Well, yes, but it's not

always true that the primary is higher than the secondary. You can have chloride contamination in the primary or sulfate contamination.

CO-CHAIRMAN SIEBER: I'd have to think about that. It doesn't pop to mind readily.

MEMBER ROSEN: No, I'm talking about in shutdown modes.

CO-CHAIRMAN SIEBER: Oh, all right.

MR. HICKLING: Let me just point out that when I said impure steam as a test environment, I'm talking about very considerable levels of chloride contamination, much larger than you could ever postulate, I think, in terms of an accidental contamination of the primary circuit.

MEMBER WALLIS: Unless it concentrates in some way.

MR. HICKLING: Correct, but this was referring to the hydrogenated steam environment.

MEMBER WALLIS: But it came in as water and is going to go back again. And so did it get carried out with the steam or not?

MR. HICKLING: The second OD annulus environment which we're going to talk about in detail in terms of likely crack growth rates that have to be assumed is then normal primary water, which could definitely be the case once the annulus is flooded and when boiling is not taking place down at the bottom of the annulus where you might be expecting OD cracking.

MEMBER WALLIS: So someone has worked all of that out in terms of heat transfer rate? Because with the hot head you would expect that it would boil or flash pretty quickly, wouldn't it?

MR. HICKLING: Yeah, well, in terms of boiling or flashing, they're all going to flash quickly. The head temperature differences are minor in terms of the phase changes which go on.

MEMBER WALLIS: Right.

MR. HICKLING: Although they do have cracks.

MEMBER WALLIS: Doesn't it take a pretty big leak to get any boiling at all in the annulus?

MR. HICKLING: Well, it will take a significant amount of leakage before that scenario takes place, yeah.

So the environment which attracted most attention in terms of the expert panel is the environment number three of the concentrated PWR primary waters as a result of boiling, and the caveat on this is that these considerations apply to low leak rates, and the panel has adopted a definition of less than one liter per hour to quantify what we're talking about here, which is pretty low leakage, in some cases very much less.

There are various ways in which we can analyze the problem of what environment is formed and particularly whether or not caustic forms and pH. One of them is to use the thermodynamic calculations, which are available, which have been produced largely because of secondary side stress corrosion cracking in steam generators, a phenomenon which has been studied very, very intensely over many years.

And EPRI has a program called MULTEQ, which will calculate the expected pH as you concentrate up an environment of that sort, and the answer that comes out by using that program is that you would expect a high temperature pH of somewhere initially between 4.0 and 9.4. So it's quite a narrow range that, in fact, due to the composition of the liquid which is being concentrates.

In fact, that pH range is probably far too broad as calculated because as was correctly pointed out, you're going to get precipitation of various insoluble compounds. We know that, and that narrows it down because it has a buffering effect.

So the likely pH range is going to be much smaller than that. What experimental evidence do we have for what pHs might be involved? After the Bouget experience, the French -- next slide, please -- did a very interesting experiment. This is CEA, the French atomic laboratory, which simulated leakage in this case by injecting the liquid, which was to be concentrated through a heated block, blocking off the flow of liquid so that when it exited the nozzle, there was a very, very tight leak path exiting, simulating what might be expected from a strained granular stress corrosion crack, and allowing that vapor to impact on a heated plate of low alloy steel material simulating the vessel head.

And the next picture gives some feel for what actually happens. In fact, you do get a huge amount of precipitation occurring in the annulus.

Now, there was one caveat unfortunately on this experiment, which was the -- there was a considerably amount of cooling generated of the low alloy steel, relevant certainly to the Davis-Besse incident, but not relevant perhaps to the conditions initially in an annulus where the leak rates are very low and where you would not expect local cooling of the head.

MEMBER ROSEN: Is that some red rust I see there?

MR. HICKLING: Yes. That is the low alloy plate which is being corroded both by boric acid corrosion and impingement and simply, you know, moist atmosphere. So it is rusting.

Okay. We go back to the previous slide.

There's been a second experiment, again, performed in France to look at this particular issue, and the results of that were published only very recently, in fact, a month ago. And this involved a slow concentration of a fixed volume of primary water in an autoclave system, which they considered realistic to simulate what would be happening.

And the interesting factor here, in fact, after a concentration factor of 1,000 was that the pH was acid, slightly acid, 4.5 rather than alkaline.

So the general conclusion from both the theoretical analysis and the experiments we know about is that the caustic formation can almost certainly be ruled out. The pH is going to be very limited. It's certainly not going to move strongly alkaline. If anything, it's probably likely to move slightly acid in that environment.

MEMBER SHACK: In that French test, I mean, that was done in what? Did the autoclave have nickel and a low alloy steel?

MR. HICKLING: Yeah. They, in fact, set up a whole system called EVA, and I've forgotten what EVA stands for, but it was for a simulation of what would be expected to happen as you concentrated a limited volume in contact with low alloy steel and nickel, and it was not a simple autoclave, cook-it-up test at all. It was a leak and bleed and reconcentrate test involving quite a complicated experimental system. It was published in Avignon, the Avignon conference last month, yes.

Then the issue came up earlier in connection with the steam: can we exclude the possibility of contaminants which are known to promote more rapid cracking of Alloy 600, and in particular, chloride and sulfate, which might be involved.

And it's very difficult to make any absolute sweeping, generic conclusions here. Obviously the practice during assembly of the heads was to clean. So the amount of contamination that would have been left after assembly is expected to be relatively low.

And, secondly, we know that there's going to be considerable steam flushing within the annulus, which would help to drive out any initial deposited contamination from assembly of the head.

The expert panel did some calculations of possible concentrations, maximum concentrations that could ever be expected, even making very negative assumptions as to contamination which might have been encountered during fabrication, and they were orders of magnitude below the levels at which you would expect any effects on primary water stress corrosion cracking.

MEMBER ROSEN: But is that the only way they thought about getting chloride and sulfite into that crack? Did they think about it as a contamination event of the primary coolant system and then the chloride and sulfates exiting with the steam?

MR. HICKLING: Not specifically because I think there's some -- as the discussion earlier showed, there's some doubt as to whether that is a significant possibility that you could have a contamination of the primary system by chloride and sulfate in the way that you could get --

MEMBER ROSEN: Well, if someone were to inject chloride, for example, into the primary system?

MR. HICKLING: Well, I think that's something that we would very much hope the water chemistry monitoring and guidelines would prevent.

MEMBER ROSEN: It wouldn't be intentional. Let me say that.

MR. HICKLING: Yes.

MEMBER ROSEN: But it has happened.

MR. HICKLING: The more likely scenario is resin intrusion, and that has been considered.

CO-CHAIRMAN SIEBER: That's the only place I --

MEMBER ROSEN: Resin from the?

CO-CHAIRMAN SIEBER: Let-down system, yes.

MEMBER ROSEN: That's happened, too. So there are several mechanisms I can point to.

MR. HICKLING: Yeah, but you've got a huge volume of water in the primary system to dilute that.

CO-CHAIRMAN SIEBER: And those instances are rare and easily detected.

MR. HICKLING: Yes.

MEMBER ROSEN: But I'm only asking the question, Jack if that happened at Davis-Besse because it has happened elsewhere. Two bulk mechanisms: injection when the chemists were trying to -- through they were injecting something and they were actually injecting something else, and resin releases from the clean-up system.

And I don't know the answer to that

question, whether there is any evidence that happened at Davis-Besse, but I know it has happened elsewhere.

MR. HICKLING: The bottom line of the panel's consideration on the OD annulus environment was that even in concentrated PWR primary water, we're considering a very narrow pH range -- there's a typo which is entirely my fault on this first slide. It should read between 5.0 and 7.5.

And even if we take a pessimistic view and rule out what we k now about precipitation of buffering so that we're looking at a whole range between about five and nine, there is only a very, very slight effect on crack growth rate of changes in pH in this area.

If we just flip forward, please to the next slide, the data in this area was generated mainly at Ohio State University on Alloy 600 specimens from steam generator tubing, but there's no reason to believe that in terms of pH effect that it should be invalid or have any less relevance to what we're considering here.

There three diagrams are showing between a pH of five and nine the effect on intragranular stress corrosion crack growth rate at three different stress intensities, 20, 40 and I believe that's 60 at the bottom.

MEMBER WALLIS: That's a freak point, that first graph?

MR. HICKLING: No. If you look at the Y axis on the first diagram, you'll find it's expanded relative to the other two. You've only got one order of magnitude difference here, whereas these two are showing two orders of magnitude.

There's no doubt there is a turn-up after about 7.5 pH, and this is to be expected because if you go sufficiently caustic, then you will get a very rapid increase in crack growth rate.

MEMBER WALLIS: It only really occurs in that top figure. It's very different.

MEMBER BONACA: No, no, because --

MEMBER WALLIS: Yeah, but then it comes back down again.

MEMBER BONACA: It's like the midpoint in your other figures.

MEMBER WALLIS: It's like the midpoint in the other figures, but then there's a point later on above -- I count above nine there, which comes back down again. So I don't know if it's a real turn-up or not.

MR. HICKLING: Yes. You've got to

remember that it's very difficult in testing at low stress intensity to get a uniform, reproducible crack growth rate anyway. My inclination is much greater reliance on the low occurrence where there are, in fact, far more points.

But the bottom line, if we go back, is still the expert panel considered taking even this extreme pH range you would not expect more than about a factor of 1.5 or 1.6 on crack growth rate over that pH range.

And the recommendation was that within the high temperature range of four to nine, we should apply a factor of two on whatever crack growth we were proposing in normal primary water to cover possible uncertainties in the environment.

MEMBER WALLIS: And that crack growth rate is uncertain by more than factor of two anyway.

MR. HICKLING: That's the second part of the talk, yeah, and we'll get into that. I guess you may want to take --

CO-CHAIRMAN FORD: John, I can follow your argument, and it's fairly clear. However, on this particular rationale, you're honing in on crack growth rate. How about crack initiation, and especially crack initiation density? Because that would have an effect on the safety analysis.

MR. HICKLING: Yes.

CO-CHAIRMAN FORD: You're propagating for a circumferential crack all the way around the tube. Are there any comparable data for the effect of the environment change on crack initiation density?

MR. HICKLING: I'm not immediately aware of data in that pH range on crack initiation. I don't think it's necessarily relevant to what we're trying to achieve here though, Peter, because we're trying to disposition here flaws, and as we'll see in the second part of the discussion, we're trying to disposition flaws which are already of considerable size.

There's a whole lot of issues about initiation in Alloy 600 which we're jumping over in this analysis quite deliberately because we're postulating that we already have relatively deep flaws in order to make the analysis.

CO-CHAIRMAN FORD: From one point, not all the way around, not a 360 degree crack.

MR. HICKLING: Again, when we come onto the way we intend to use what we're proposing, you'll see that we're not proposing to disposition OD flaws. We'll come on to see that we're talking about hypothetical arguments about how quickly they could grow.

CO-CHAIRMAN FORD: Okay.

MR. HICKLING: But we considered the only way to handle the OD crack growth rate is a probablistic one.

CO-CHAIRMAN FORD: Okay.

MR. HICKLING: Interest in developing a consensus crack growth rate in normal primary water is in terms of ID flaws how we get to the first leakage rather than in terms of OD flaws.

CO-CHAIRMAN FORD: Okay. I've got one other question. Sorry.

Apart from the one french data where they measured pH rather than inferred it, that's the only experimental data of what that annulus environment would be in terms of pH. Are there any experiments planned or ongoing to increase the database with specific reference to the effect of leak rate?

MR. HICKLING: Yeah. Firstly, it's not the only experiment. It's the only experiment -- you're quite correct -- where they specifically measured the pH of the environment.

But the experiments, and Glenn White will be talking about this in addressing the wastage issue later, there have been experiments performed in this country as well with two prototypical mock-ups in terms of generating wastage in an annulus, and although the pH was not measured directly as far as I'm aware in either of those experiments, the results in terms of wastage of low alloy steel quite clearly show that, if anything, there's a strong move in the acid direction once leak rates become very high, much higher than what we're considering here.

CO-CHAIRMAN FORD: Okay.

MEMBER WALLIS: You have this multi-calculation.

MR. HICKLING: Ye.

MEMBER WALLIS: OS pH is four. Now, if you had suitable deposits in that annulus which you could postulate, you could achieve a much lower pH, couldn't you?

In other words, is there some limit to the pH achievable with --

MR. HICKLING: I think, again, it's a key question of the amount of leakage and the assumptions you make. I think it's conceivable that you can certainly go lower. The buffering is preventing you getting to a caustic condition, which remember was the original consideration.

MEMBER WALLIS: Yeah, but we don't have

much of a database. We have some theoretical calculations. We don't know much about what's really going on in there, and if you looked at some extreme scenario in which you built up deposits, you could tell us what the pH could be in the worst case.

MR. HICKLING: Well, as you'll see when we go on to discuss in detail the thermal hydraulic analysis of the wastage situation, I think you can postulate certain cases where you might go very acid, yes.

MEMBER WALLIS: I thought so, too, but I haven't seen any figure yet. So I have to imagine what might be going on in there.

MR. HICKLING: Right.

MEMBER WALLIS: And I can conceive of a scenario where you could have a very low pH.

MR. HICKLING: I think that's quite correct, but just jumping ahead, it's a point I was going to make right at the end. Alloy 600, the original design basis for choosing that material was its resistance to cracking in acid solution. And so there's no reason, even if you went very acid, to assume that that would automatically be negative as regards the --

MEMBER WALLIS: So it's a bounding pH

rather than a calculated pH.

MR. HICKLING: Yes.

MEMBER WALLIS: Yeah.

MR. HICKLING: That's the natural break because we now go on to the crack growth rate database.

CO-CHAIRMAN FORD: Thanks a lot, John.

I had a question for you, Larry, which is more of an administrative question. I notice John has got a few more slides, and I suspect there will be some questions. I'm proposing that we stop until five minutes to 11, but I notice that Glenn needs an hour for his presentation. So I leave it up to you and John to work out how you want to do --

MR. MATHEWS: And then we have Pete's presentation also.

CO-CHAIRMAN FORD: Pardon?

MR. MATHEWS: We have Pete Riccardella's presentation also. So we're running quite a bit behind here.

CO-CHAIRMAN FORD: Yeah. The trouble is we want to hear them all.

MR. MATHEWS: We can be here all day.

MS. KING: Why don't we come back with a proposal?

CO-CHAIRMAN FORD: Okay, fine. Let's stop until five minutes to 11. Let's go into recess until then.

(Whereupon, the foregoing matter went off the record at 10:42 a.m. and went back on the record at 10:55 a.m.)

CO-CHAIRMAN FORD: Okay. We're back in session.

Christine.

MS. KING: Okay. What we would propose --

CO-CHAIRMAN FORD: Yes.

MS. KING: -- since we have a lot of interest in Davis-Besse type issues, we would like to propose to bring Glenn White's presentation forward --

CO-CHAIRMAN FORD: Good.

MS. KING: -- to this morning following John.

CO-CHAIRMAN FORD: All right.

MS. KING: And depending upon where we land around lunch, I guess we'll either take lunch or continue into the PFM, and it shouldn't put us too far off schedule because there was 45 minutes set aside in the afternoon for Glenn.

CO-CHAIRMAN FORD: Okay. So I think what we'll do is we'll have John -- finish off John.

(Laughter.)

CO-CHAIRMAN FORD: I didn't mean that literally.

And then we'll have Glenn, and then we'll take just three quarters of an hour lunch, and then we'll catch up time that way.

John.

MS. KING: Okay.

MR. HICKLING: The second part of this presentation deals with the meat of the work of the expert panel over the last six to eight months, which is what would be a representative crack growth rate for Alloy 600 base material, thick spectrum material.

And the initial approach taken was to look at what we've learned in stress corrosion cracking testing over the last five to ten years particularly where the international community has focused very much on issues of data quality because it doesn't matter how sophisticated your statistics or your analysis is later. If your data is bad quality, it doesn't really allow you to get a handle on stress corrosion cracking.

And the first thing the expert panel did was to make a list and discuss in depth some of the key technical issues on crack growth rate testing which need to be addressed and which conform the basis of screening out suitable higher quality data from data which is of lower quality for the purpose we are using it.

Many investigations in this area have been for different purposes, trying to understand the mechanisms, trying to understand effects of off-chemistry, things like that, and we were trying to get to where we could screen out things like that.

And as you see, there's a whole list of factors here which involve chemical environment, loading, the way the material was used, the sort of specimens which were generated, the loading characteristics during the test, the crack growth rate monitoring, and all of this sort of thing.

How did we actually do the screening? Really it involved three iterative steps. The first step was to go back to the laboratories which had generated all the data we were able to collect worldwide on thick section Alloy 600 material and ask the initiating laboratory to reexamine their own data in the light of these criteria we had put up and in the light of discussions which they had been involved in on the expert panel.

And this probably was the most important step because it led to elimination of a lot of data points by the initiating laboratory who declared these points to be unsuitable for this particular purpose for developing a crack growth rate disposition curve.

MEMBER WALLIS: It didn't eliminate anything because they didn't want to believe it.

MR. HICKLING: I would hope not. I think the people concerned, their integrity was such that would not be the case.

The second step was a screening step which EPRI put in place, and it basically covered two main areas. As I say, we involved international laboratories. You'll see the list of laboratories in a second, and in one or two cases we had some difficulty in direct contact with laboratories concerned.

One of them particularly, one European laboratory, had performed tests where they had only ever reported maximum crack growth rates during the test. Since the whole thrust of the analysis is to use average crack growth rates determined in a particular specimen, we could not use that particular data.

So in the end, after trying to obtain , and we put a lot of effort into it, we had to screen out that particular laboratory's data.

The second point was one which I was very concerned about. We've mixed in this database specimens which are actively and passively loaded, i.e., they're all fracture mechanic specimens of one type or another, but some are actually tested in a tensile testing machine under active load, and some were under displacement loading, usually by means of wedges.

And the stress corrosion cracking community has known for a number of years that these are actually or even though you are nominally at the same K value, you can get a difference in response. It's much more difficult to initiate crack growth from a passively loaded displacement controlled specimen uniformly.

And so we went back and reexamined the data from that type of specimen, the wedge open loaded specimens and eliminated all of those specimens where crack growth had been very non-uniform, and the criterion we used was less than 50 percent initiation across the width of the specimen. And what that does is it eliminates lots of artificially low points.

Finally, the third iterative step in the screening was for the whole expert panel to reexamine the borderline cases and what we had done to the database, and that was done at the beginning of March.

We didn't even bother to start to try and consider numerous tests where no stress corrosion crack growth was actually obtained, a zero result, and the reason for that is there are a whole number of reasons why you may get a zero result.

You may have a very non-susceptible heater material, but you may also have done the test in an inappropriate way. So there's no zero crack growth rate data in this database at all.

MEMBER WALLIS: That's a bit strange. I mean, in terms of the probability of a crack occurring, zero cracking would be a good data point, wouldn't it?

MR. HICKLING: In some ways, yes. It does hurt to have to eliminate those points. That's correct. But in terms of trying to get at crack growth rates, unless you can convince yourself that everything else was perfect, and it's very difficult to do, you just have to take that step.

MEMBER WALLIS: You're not interested in initiation.

MR. HICKLING: Correct.

MEMBER WALLIS: You're just interested in growth rate.

MR. HICKLING: Yes, absolutely.

The result of this screening was that we eliminated no less than 203 crack growth rate data points for one or more reasons, and these reasons are documented. The main reason is individually documented in the report the MRP is in the process of issuing on this exercise.

The consolidated database now contains 158 points for average crack growth rate during each test, and this is consistent basically with the ASTM recommended procedures for measuring fatigue crack growth rates, to use the average, and they're plotted at a single representative K value for the data point concerned.

And there, again, there was a certain amount of judgment sometimes involved. The expert panel was involved in that in detail because the K value in some tests will change during the test, and we satisfied ourselves that we had a representative value.

MEMBER LEITCH: Why would you not consider -- several bullets back --

MR. HICKLING: Yes.

MEMBER LEITCH: You mentioned that there

was some data that you discarded, eliminated from consideration because the experiment only considered maximum --

MR. HICKLING: Yes.

MEMBER LEITCH: -- crack growth data. Why would you eliminate that data? Would that not be the conservative thing to include that data?

MR. HICKLING: Only at first glance. The problem there is that we had no detailed -- I'm sorry. Let me back up one stage.

The way these tests are run is to use an air fatigue pre-crack in usually a compact tension specimen, sometimes a DCB specimen, which produces a transgranular fatigue pre-crack. You then have to go through a second stage in the text where you initiate an intragranular stress corrosion crack from that transgranular fatigue pre-crack.

And one of the key things we insisted on was we had to have fractographic information available on each specimen or at least in the form of numbers to assess that this transition stage had gone through smoothly.

If that's not the case, you can get some very odd results. Now, you can report a maximum crack growth rate even if you've initiated cracking only over a tiny portion of that transgranular fatigue pre-crack.

And this particular laboratory concerned, they actually were also using perhaps the least suitable type of specimen, a very narrow DCB specimen of only ten millimeter width.

So the bottom line is that if you only have a number saying, "I detected two millimeters of stress corrosion cracking as maximum," you have no feel whatsoever for how representative that is of the amount of crack growth rate that actually took place during the test.

MEMBER LEITCH: Okay. Thank you.

MR. HICKLING: I mentioned I think earlier that all of these tests are obtained in controlled primary water, and we paid a lot of attention to the fact that we didn't have any off chemistry results in here and under two types of loading.

Just touching on one brief point which I'm going to eliminate, I hope, from consideration straight way as well. We have an issue in that some laboratories prefer to test using periodic slight unloading of the specimen, and what that actually means here is nothing to do with simulating possible transience in plant or anything at all. This is a typical way this is done.

It's a drop-in load to about 70 percent of the nominal value, usually about once an hour during testing, and there are very specific reasons for doing that which are connected with the way the test is conducted, and in particular, with the way the crack growth rate monitoring equipment works.

It's an advantageous method of insuring accuracy of measuring your crack depth on line during the test. However, there is a basic tendency if you start what is ultimately some cyclic loading to accelerate crack growth because you'll get out of a pure stress corrosion situation.

So we did some assessment of whether or not this would affect the results, and the answer is that certainly for susceptible heats of material, it doesn't make very much difference. It's possible that in less susceptible heats of material, the application of this procedure may lead to slightly higher growth rates than would otherwise have been measured. but we prefer to leave those in and accept those because, again, it's a degree of conservatism.

Next one, please.

What have we got in this database with 158 points in terms of materials suppliers? And this impacts directly on Peter Ford's discussion earlier about why we're not considering material characteristics in the way that he would perhaps like, and I think most of us would like to do.

First of all, we've got a number of domestic and overseas material suppliers, and we've got 26 heats of material in the database with at least one screened data point for heat.

The maximum number of heats we've got is 32 for any particular heat, and we'll see a table a little bit later on which gives a little bit more information on that.

What product forms? We've got a whole variety of product forms, thick wall tube, forged bar, rolled bar, forged plate, and rolled plate. This is where the crunch comes. Even for the materials which was used for the laboratory testing, the information on the thermal processing history is extremely limited so that we could not obtain the data we would have liked to characterize the material condition in terms of its thermal processing history.

And of course, extrapolating to the field in terms of the nozzles that are out there, that's an even worse situation. It's virtually impossible to get reliable data on the thermal processing history of what is out there.

And the next slide, please? You're already there. Thank you

Which laboratories are involved? We ended up taking data from five laboratories, one in the U.S. and four abroad who have done extensive testing on thick section Alloy 600 material. They've done it at a whole variety of temperatures ranging from 290 right up to 363 Centigrade, the desire, of course, often being to accelerate the crack growth rate to reduce the testing time.

And since we know and have known for very many years that cracking PWSCC in Alloy 600 is very highly temperature dependent, the first step was to try and put all of this on a common temperature basis.

So we did that by choosing the most common test temperature, which is 325 centigrade, or 617 Fahrenheit, and extrapolating everything back to that temperature using an activation energy of 130 kilojoules per mole or 31 kilocalories per mole.

That is, more or less, the accepted activation energy for cracked growth rate in this material, and even if you consider some of the more varied values that have been obtained, the range for cracked growth data is actually pretty small. It's from about 30 to 35.

So this does not have a huge effect on what we're doing.

MEMBER BONACA: I had a question regarding the previous slide actually. You said that the thermal processing history of material is incomplete. I'm trying to understand how significant. I mean this is Alloy 600. I mean, isn't Alloy 600 a pretty -- is it a common material we have or just specific to reactors?

MR. HICKLING: It's a common material in plants for milk processing and things like that, yes.

MEMBER BONACA: Oh, okay. That's all I --

MEMBER ROSEN: Where it works rather well.

MR. HICKLING: It works extremely well. Alloy 600 was originally developed and chosen because of its resistance to chloride induced transgranular stress corrosion cracking. Its application in the nuclear field in the '60s and '70s originated from that.

MEMBER BONACA: So what you're saying is that the thermal processing history could be very different, I mean, depending on the application.

MR. HICKLING: Yes. Unfortunately we do know about the impact of the microstructure on Alloy

600 cracking. We've known about that for many years. It's contrary to what you would expect intuitively, particularly if you know about BWR stress corrosion cracking because Alloy 600 works best when it has the most carbides on the grain boundary, which is an initially surprising result in terms of -- so it's not chromium depletion phenomena.

So short of taking samples from every heat tested and actually doing a microstructural analysis, it's very, very difficult to tie this one down.

Now, of course, in the lab you can do that. The problem arises if you have material out in the field and you don't have archive material which is usually the case. How do you ever get at what microstructure you're dealing with?

MEMBER BONACA: Thank you.

MR. HICKLING: How did we then go on to derive the curve? We knew, as I've just discussed that the heat variation was likely to be very large in this data. Our initial intention was to take a single heat of material where we had the most data points and try and derive the dependence of crack growth rate on stress intensity, on K from that heat alone.

Unfortunately by the time we'd rescreened all of this data, we simply did not have enough data left to do that even for the heat where we had the most points tested.

So we were forced to go back to an alternative approach, which is to adopt the so-called Scott equation for this material, and the Scott equation was basically developed quite some time ago using a very, very large amount of data on Alloy 600 obtained from steam generator tubing, which was undergoing primary water stress corrosion cracking in the field.

So there's a huge number of heats, a lot of very susceptible heats, and a huge number of data points in that original database, and that equation which was developed originally in '91 basically says that the stress corrosion crack growth rate is proportional to a constant alpha times the stress intensity nominal threshold -- I'll come back to what we mean by that -- I'm sorry -- times the actual stress intensity minus a value of nine, which is the nominal stress intensity threshold to an exponent beta, which describes the basic dependence on stress intensity.

And the Scott exponent from this analysis was 1.16.

The next --

MEMBER KRESS: Where does the erroneous relationship enter into the alpha?

MR. HICKLING: The erroneous relationship has been basically calculated in terms of the alpha, yeah.

How does the data actually look in terms of what we're talking about here? These are two examples from two different laboratories for two very different heats, and in this particular case, at 325 degrees Centigrade, this is the Scott model as defined by that equation developed from the steam generator tubing material.

And as you see, it comes down to very low crack growth rates, insignificant crack growth rates at a nominal K of about nine, and this particular test is producing data which clearly lies above that curve.

On the other hand, for some other material, a different heat tested in a different laboratory at two different temperatures, this gives you some feel, incidentally, for the temperature effect, there is the Scott curve for 290, and here is the Scott curve for 325.

The data is falling below the curve at either temperature.

MEMBER WALLIS: That has nothing to do

with the curve really, does it?

MR. HICKLING: Correct. You would be hard put to --

MEMBER WALLIS: It's a little low, but --

MR. HICKLING: One of the problems is that experimentally it's very difficult to test over a wide range of Ks because you cannot get a big enough specimen from the material available to test at high K values as you would like. So all of the data tends to crowd between about 20 and about 40 megapascals.

MEMBER WALLIS: You can't really prove the nine because the crack worth rates are so low down at that end.

MR. HICKLING: Absolutely, yeah. It's only a nominal threshold.

MEMBER WALLIS: -- a matching number then. If it's independent of temperature, it's even lower. It's not magic.

MR. HICKLING: We actually considered -- at one point the expert panel debated rather intensively whether or not we should try and make it zero or whether we should make it four or six, and we did a sensitivity analysis. It doesn't make a whole lot of difference because we're not using the result in that region. We're not trying to describe initiation at all with this approach.

MEMBER ROSEN: That nine is not like Avogadro's number. It's not an important thing.

MR. HICKLING: It certainly isn't.

(Laughter.)

MR. HICKLING: The true definition of a stress intensity threshold for stress corrosion cracking is actually what you would get if you would decrease stress intensity during a test and can prove unequivocally that the crack has stopped.

And in fact, that's a test which is almost impossible to do. So --

MEMBER BONACA: Why do you infer a curve like that, if I can go to the previous curve?

MR. HICKLING: Yes.

MEMBER BONACA: I don't understand. You had a very specific curve that curves and goes to 320 degrees, 330 to the right.

MR. HICKLING: Yes.

MEMBER BONACA: Or 325. How do you infer that curve from the distributional data? You don't.

MR. HICKLING: Not at all. We can't. That is the point I'm making. We were forced to go back to a curve which had been derived from a completely different database and force fit it, if you liked to our data.

MEMBER BONACA: Right. I understand.

MR. HICKLING: Exactly right. So I've just covered that, but it's only an apparent threshold, and we don't have data, but this is not going to be critical in use because we're actually going to be at K values above, well above, say, 15.

There is another point that you have to mention. The threat exponent from the steam generator tubing of 1.16 does imply a considerable dependence of crack growth rate on stress intensity going right up, of course, to very high K values. There's quite a lot of both field and test data which indicates this may not be valid, that we may, in fact, be going too high at high stress intensities, that there may be a plateau appearing.

But we couldn't convince ourselves that for our material that we had enough data to draw a plateau.

MEMBER WALLIS: When it's high enough the material just breaks?

MR. HICKLING: Oh, yes. Eventually it would. You would eventually turn up where you get the mechanical failure.

MEMBER WALLIS: How high is that?

MR. HICKLING: Much, much higher than anything we're dealing with, yes.

MEMBER APOSTOLAKIS: What are the typical K values you're going to have?

MR. HICKLING: You'll see when we come to the way this curve is being applied we're talking typically about Ks in the range of 25, 30, something like that.

MEMBER APOSTOLAKIS: But if you subtract nine, that should have an effect, right?

MR. HICKLING: In what sense?

MEMBER APOSTOLAKIS: Well, the equation is DADT equals alpha K minus nine.

MR. HICKLING: Yes. The equation is just a fitting. The K minus nine is just fitting.

MEMBER APOSTOLAKIS: Right.

MR. HICKLING: It was part of the original fitting to the steam generator data.

MEMBER APOSTOLAKIS: Are you going to use that equation again?

MR. HICKLING: Yes. That is the basis of --

MEMBER APOSTOLAKIS: So I don't understand why you say not critical for intended use since the equation has a K minus nine factor there.

MR. HICKLING: I did mention that we, in fact, discussed extensively whether it should be nine or six or four or even zero, and we tried out the effect of plotting, replotting using all of those different curves, and in the region of interest it makes virtually no difference at all.

It would make a lot of difference if you were trying to analyze the situation at very low K values, but that's not where we are.

So we actually tried out the effect, and we stayed with the --

MS. KING: I would point out the third bullet here.

MEMBER APOSTOLAKIS: I guess it's because the exponent is just 1.16.

MR. HICKLING: Yes.

MEMBER SHACK: No, if you fit with zero, you'll get a different exponent. So you'll change alpha and beta. So you'll get a different curve, but then if you look at that curve between 25 and 35, they'll look sort of similar to --

MR. HICKLING: They'll more or less lie on top of it.

MEMBER SHACK: Yeah, the curves will move around a lot. You know, your alphas and your betas will change.

MEMBER APOSTOLAKIS: Well, the alpha and beta change.

MEMBER SHACK: Yes, but the result in the range of 25 to 35 is not particularly sensitive.

MR. HICKLING: Let me just repeat. Our original intention, our hope was actually to fit our own data with the new curve, and that was the first approach adopted.

But unfortunately by the time we had screened out the reliable data points, we just could not do it. We didn't have enough data over a wide enough range of K. So the fall back position to this Scott curve is to some extent an artificial one.

On the other hand, the Scott curve has stood the test of time, and it has been used very widely, also for the analysis of --

MEMBER APOSTOLAKIS: Now, why didn't Scott have the same problem? Why didn't he screen out inappropriate data?

MR. HICKLING: The main data base that Scott was working with were field inspections on steam generator tubing of which there are literally thousands and thousands of data points.

So he didn't have the same problems that we had. He had a huge number of heats, far more than we have, and he had a huge number of tubes, which had been eddy current tested. So he could determine differences in crack length and crack growth rates. It's a quite different database he was dealing with.

MEMBER KRESS: The database you have, looking at, is crack growth rate versus K.

MR. HICKLING: Yes, sir.

MEMBER KRESS: How did the various laboratories determine the K?

MR. HICKLING: That's a very good point, and I mentioned that the test methods were different, constant displacement load. The simple answer, of course, would be to use the standard equations, whatever form of pre-crack specimen they were using in fracture mechanics, but the real issues that were involved are crack front straightness, degree into which crack Ks change during the test, particularly, for example on wedge open loaded specimens where the K value decreases.

And in one particular case, actually two French laboratories which produced a lot of the data we're using, they went back without our prompting at the beginning of this year and reevaluated their K values for every single specimen in terms of remeasuring every specimen and recalculating.

MEMBER KRESS: Were these artificially made cracks at the start?

MR. HICKLING: Yes, the starter is always a fatigue pre-crack, which is a transgranular pre-crack in the material. Now, that point in time you've got a pretty good handle on what K is. It's later on as an irregular crack front develops you have to consider that.

But that point was given a lot of attention.

MEMBER BONACA: Once you got the results at the end, did you ever go back and took the 203 points that you threw away and see whether they would fit on that curve?

MR. HICKLING: Well --

MEMBER BONACA: Would it be meaningful or just simply a meaningless exercise?

MR. HICKLING: I'm not sure whether it's particularly meaningful. I think you'll see when we come to actually put up the curve in a second with the data, even 158 don't necessarily fit.

MEMBER WALLIS: We're all waiting for that with great anticipation.

MR. HICKLING: Yes, we'll get there very

quickly.

The other point I mentioned is we have to take into account material heat variability because we know how important it is, and we had a very limited number of options as to how we're going to do that, and what we've, in fact, done is we've tried to look at that in terms of calculating a different value of alpha for each heat of material.

Now, what that means is we've taken every single heat of material, all 26 in the database, and we've calculated the appropriate value of alpha to fit the data for that heat to the Scott equation, and that would be the mathematical formula.

No, go ahead. The formula is less interesting than this.

These are, in fact, the 26 heats of material from the different supplies. They're rates in terms of the most susceptible in testing to the least from top to bottom. You can notice, please, the differences in product form, which is implied here, and notice also the difference in number of data points.

There is a certain tendency for laboratories to want to test a particularly susceptible heat because it's an easier testing job, and in fact, that's why some big numbers are coming up here, although there's quite a bit one down here as well.

And there is also equally a tendency -- those heats where we have very little data, and particularly ones where we only have a single data point are tending more towards the bottom, the less susceptible heats where we have less cracking observed.

And so you end up by doing this, by force fitting the Scott curve per heat, you end up with a set of alpha values, the log mean power law constant, which it varies, as you can see, between the most susceptible material actually we had in the database, from six times ten to the minus 12, right down to two times ten to the minus 13. It's quite a difference.

MEMBER WALLIS: Is it fair to ask what heat is? I don't understand what a heat is in this context. Maybe I should have done my homework or something.

MR. HICKLING: What a heat of material is in this contexts?

MEMBER WALLIS: Yeah.

MR. HICKLING: It would be a single production lot as processed by the material supplier.