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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

MEETING OF THE SUBCOMMITTEE ON MATERIALS, METALLURGY AND REACTOR FUELS

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TUESDAY,

MARCH 6, 2007

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 1:00 p.m., Dr. William Shack, Acting Chairman, presiding.

MEMBERS PRESENT:

WILLIAM SHACK Acting Chair
MARIO BONACA Member
DANA POWERS Member
TOM KRESS Member
MARIO BONACA Member

NRC STAFF PRESENT:

TED SULLIVAN
ALADAR CSONTOS
SIMON SHENG
MATTHEW MITCHELL

ALSO PRESENT:

DAVID RUDLAND

CRAIG HARRINGTON

JIM REILLY

DANA COVILL

GLEN WHITE

ALEX MARION

A-G-E-N-D-A

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

1:00 p.m.

ACTING CHAIR SHACK: The meeting will now come to order.

This is a meeting of the Materials, Metallurgy nd Reactor Fuels Subcommittee.

I am Bill Shack, Acting Chairman of the Subcommittee. Sam Armijo, the Chairman of the Subcommittee, could not be here today because we sent him off to Japan.

Other ACRS members in attendance are Dana Powers and Tom Kress. Mario Bonaca will be joining us later, we hope if the airplanes fly on schedule.

Gary Hammer of the ACRS staff is the Designated Federal Official for this meeting.

The purpose for this meeting is to discuss the technical basis associated with the regulatory activities for dealing with the dissimilar metal weld issue steaming from the Wolf Creek pressurizer weld flaws as well as industry activities associated with this matter.

We will hear presentations from the NRC's Office of Nuclear Reactor Regulation, the Office of Nuclear Regulatory Research and their contractor, Engineering Mechanics Corporations of Columbus, the Nuclear Energy Institute and the Electric Power Research Institute.

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

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the *Federal Register*.

Portions of this meeting may be closed for the discussion of proprietary information.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

A transcript of the meeting is being kept and will be made available as stated in the *Federal Register* notice. Therefore we request the participants in this meeting use the microphones located throughout the meeting room when addressing the Subcommittee.

Participants should first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We will now proceed with the meeting. And I'll call upon Mr. Ted Sullivan of the Office of Nuclear Reactor Regulation and Mr. Al Csontos of the Office of Nuclear Regulatory Research to begin.

MR. SULLIVAN: Thank you. My name is Ted Sullivan, and I will be making some brief introductory remarks just to get things going and provide a little bit of connection between the last meeting and this meeting. And then Al Csontos is going to continue with a discussion of the analyses performed for NRR with the support of our Office of Research.

On February 2nd we had a fairly short meeting with the ACRS to provide some introductory background on the Wolf Creek inspection results and our assessment of those results. Industry will get a comparably short time to provide some introductory remarks. So, today's meeting is to continue that dialogue and have much more time to discuss it.

But in the February 2nd meeting we talked about our inspection findings. We briefly summarized our fracture mechanics analysis, and we also provided some conclusions. At that time we indicated the following conclusions, and these are still our conclusions:

That we did not consider the Wolf Creek indications to be anomalous;

We indicated that it was our view that inspections and mitigations needed to be accelerated for some plans. And I'll be talking more about that later as to which plans and how that has come into play;

And then we also indicated that we believed that it would be appropriate for enhanced leakage monitoring frequency action levels and actions to be put in place until inspections or mitigations were completed.

The analyses that Al is going to talk about provide the technical basis for the staff's conclusions. And Al is going to provide more detail on the fraction mechanics analyses that were performed by our Office of Research. And subsequent to that I would like to come back and make a couple of sort of conclusionary remarks about what has happened in regulatory space between the analyses and the current time.

And I also wanted to make the statement that I'm sure you're aware of, that the NRC staff is requesting a letter from ACRS on this issue, and we're interested in your views on the staff's approach and conclusions and on our comments on additional industry studies.

Now, I'm bringing it up at this time, it's a little out of context. I think you may be aware of that. But industry/NRC are going to make some comments on it. And I believe that Gary provided to you some late breaking information by means of a copy of a letter that was signed yesterday and just dispatched yesterday or today on this subject. So it'll make more sense as the meeting goes on.

And with that, I would like to turn --

ACTING CHAIR SHACK: Just on that, I sort of read that letter as that you guys had agreed on a course of action.

MR. SULLIVAN: What we have indicated is that -- I'm going to talk about this in a little more detail, but --

ACTING CHAIR SHACK: Maybe we should just wait for that.

MR. SULLIVAN: We have agreed that the analyses that industry is doing may be able to use in regulatory space. And we have made a number of comments on those analyses that we think need to be addressed in order to, at a minimum, assure that those calculations are going in a direction that we may be able to agree on the path and that the results could be useful to us.

It's just some introductory agreements that we're trying to work out with industry before the analyses get too far along so that are thoughts are working together on these analyses.

And we are going to be working, you know, quite real time with industry. We're doing a number of analyses ourselves. We're going to be attending a whole series of meetings where we're going to talk about the project and our views on it's being conducted, as opposed to getting a product some months down the road and saying "Well, we had talked about this, that or the other thing up front."

So we can talk about that more a little bit later.

MR. CSONTOS: I'm Al Csontos. I'm from the Office of Research. And I'll be talking about the NRC flaw evaluation study on the Wolf Creek indications.

I just want to give a little quick chronology before we get into this, which is back in late October '06 NRR came to RES and asked us to support them with this flaw evaluation study. We then contracted out to EMC_2, and Dave Rudland, who is right there, is the principal investigator and also the principal author to the report that you all I believe had access to.

I think it was the middle of November we received site specific information from Wolf Creek itself that we were then able to initiate the calculations. And so this calculation was done over a course of maybe three days. It was a very quick scoping analysis. And under that context that's where all this work is done.

All right. The purpose of the work for this study was to assess the integrity of the pressurizer nozzles as a function of time. And the specific objectives of it were to evaluate or determine the time current size to leakage, the time from leakage to rupture under both the normal operating and the vaulted operations. And all go through all the assumptions that we took into account there.

And the final secondary objective to this was to determine the leak rates from these types of through-wall flaws that were coming through the various nozzles. And we broke out these results by nozzle type.

First, the big assumption here is that we treated the indications as PWSCC flaws. We received site specific information from Wolf Creek itself, and that included the geometry and the dimensions, well dimensions of the indications, and then the nozzle and weld geometries. We also got the operating temperatures for the pressurizer. And then also the normal operating loads. We evaluated three cases, well three loads: the pressure, deadweight, thermal and also the faulted loads that we had in the safe shutdown earthquake that we added to the normal operating ones.

Slide 8.

We took into account the assumptions here that we had elastic K solutions for both the surface optical flaw as well as the through-wall crack flaw. And we had two separate types of assumptions there, elastic K solutions for both. Dave can go into more detail if you want him to. But let's just go through this.

The assumption here was that crack growth rates occur in Alloy 182. I believe the 82 is a slower crack growth rate, but from what our information was is that the 82 was for the route pass and then after that it's filled in with 182. And so we decided to go with 182.

We also went with a 75 percentile for the MRP-115 crack growth rate. And there's several factors that you have to include there. We did not include the microstructure factor where the dendrites are perpendicular to the growth direction. We didn't include any of that. We just went with the equation in there, but we didn't talk about it.

The surface crack was idealized to remain semi-elliptical as it went through the tube through-wall. Once it went through the through-wall it was slightly different. We had an equivalent cracks -- we'll go into that.

Two cracks growth cases were evaluated, K-drive and then constancy override. The constancy override is one where the aspect ratio was fixed throughout the entire growth process. And the K-drive, of course, is just a K-drive where we took the K solutions for the crack growth.

MR. SULLIVAN: Now this is a weighted K solution for the surface crack and so you get the two axis of the ellipse growing?

MR. CSONTOS: Dave?

MR. RUDLAND: It's actually we grew the

crack directly from the struck pins of the active crack and at the dendrite point.

ACTING CHAIR SHACK: Okay.

MR. RUDLAND: It's a weighted average across the crack front. It was just using the Ks at the --

ACTING CHAIR SHACK: At that point?

MR. RUDLAND: -- as well as over it. Yes.

MR. CSONTOS: The crack growth there was for the growing crack. The critical crack size to determine rupture, we calculated for both the surface and the through-wall cases. A surface crack length and also a critical through-wall crack length. That's to determine when rupture would occur or the time between leak and rupture. That was calculated under elastic-plastic fracture conditions. We also did limit load, but elastic-plastic was conservative to the limit load work, so we used that as our condition.

And we looked also at normal operating as well as the faulted condition, which is normal operating plus the safe shutdown earthquake loads.

So we'll go now to the surge line nozzle and its results. This is what was found, UT shared these indications.

There were three flaws that were found. One was the 4" 31 percent through-wall flaw with a nine to one aspect ratio. That's the one that we will be evaluating. We did not evaluate any kind of crack linkage or any kind of a effect between the three. We just worked with the worst case flaw here, which is the 4" flaw.

The weld length is 37" and the diameter of the weld area was 12" and 15 ID and OD respectively.

And let me just say here that this is what we knew at the time. We have some additional information here in terms of the weld repair history. But at that time all we had known about this weld was that it had an extensive repair history. And that's what we went with. And we had to go from that and understand or choose some assumptions that would give us some weld additional stress. And I'll go into that.

Next. The last volumetric examination was done in 1993. That was pre-PDI. So not much can be taken from that.

And now we're on slide 10. These are the assumptions that we took into our analysis. We examined it, we had the loading conditions from the site specific information. I'll go through that first. And we had the deadweight pressure and thermal expansion with no stratification. We evaluated the time to rupture with the normal and faulted operated conditions. And three weld residual stress cases that we evaluated for this was two bounding and then somewhere in between. The least conservative would be the no residual stress case. That, obviously, would be a bounding case. And the other case on the other side, the more conservative side, was a weld residual stress with a repair well residual stress. And weld repair was a 15 percent ID axi-symmetric repair.

And we also looked at our middle case, which is the weld repair. Oh, I'm sorry. Weld residual stress. No weld repair.

The weld residual stresses that we looked at here, the weld residual stress plus the repair weld residual stress were derived from the large break LOCA program with Batelle and EMC_2. And we'll show that, actually right now.

You see here this line right here, the purple line, is the weld residual stress that was calculated from the large break LOCA program.

This light pink or light purple dots are also the calculations that were done for the 15 percent weld repair weld residual stresses. And this was the fit, this darker blue purple line here is the fit to that data. And we used this curve, this purple curve and this lighter blue curve here as our two cases for the weld residual stress and the weld residual stress plus the weld repair residual stress.

ACTING CHAIR SHACK: Dave, have you like at the MRP-106 residual stresses for this case?

MR. RUDLAND: For this particular case, yes, the trends are about the same for this size diameter pipe. We've compared our residual stresses for all the diameters, especially the smaller ones.

ACTING CHAIR SHACK: This is weld center line section?

MR. RUDLAND: Well, you know this really isn't. This is really in -- this is the highest stress through the weld.

ACTING CHAIR SHACK: Okay. So this is a slice actually somewhere through the weld to get the highest?

MR. RUDLAND: Yes, that's right. That's right. That's right.

ACTING CHAIR SHACK: Okay.

MR. RUDLAND: So it's not weld center line. Most of the time weld center line you end up with a little bit more compression issues, especially in the smaller diameter stuff. But, yes, this --

ACTING CHAIR SHACK: We lost you, Dave.

MR. RUDLAND: I'm sorry. Can you hear me now?

MR. CSONTOS: Yes. Can you repeat that last part?

MR. RUDLAND: Yes. For this particular surge nozzle the higher sources were in the butter. So this cut through the butter.

ACTING CHAIR SHACK: I mean when I try to compare it with the MRP-106 stresses, I find their stresses are considerably lower. Now, again, the only slice they give me is through the weld center line.

MR. RUDLAND: Yes. And it's funny because we did a similar analysis on a -- and we found the same thing is that our stresses matched their stresses at the weld center line, but they were much lower in values.

They also did some cases in 106. They

showed the maximum stress in the axial direction. And those stresses are always higher but they're usually tending towards the butter.

ACTING CHAIR SHACK: Now do you also get the results that they seem to get that the hoop stresses are higher than the axial stresses?

MR. RUDLAND: Yes. Yes.

ACTING CHAIR SHACK: Okay.

MR. RUDLAND: On these weld repairs the ID stresses are always higher.

ACTING CHAIR SHACK: The hoop versus axial, which is --

MR. RUDLAND: Right.

ACTING CHAIR SHACK: The hoop is consistently higher in your analyses also?

MR. RUDLAND: For the cases where there is no weld repair, I would say yes. For the cases of welding repair usually the ID stresses are higher than the hoop stresses.

ACTING CHAIR SHACK: ID, you mean axial?

MR. RUDLAND: The axial stresses, I'm sorry. ID axial stresses.

ACTING CHAIR SHACK: Okay.

MR. CSONTOS: All right. So that was the methodology that we used. And this on slide 12 is--

ACTING CHAIR SHACK: Oh, one other question. How did you handle the moment loads? I don't see any gradient of stress in your analysis for the K --

MR. RUDLAND: This is just weld residual stress. This plot --

ACTING CHAIR SHACK: Yes. But in your K calculation did you have a stress gradient from the moment?

MR. RUDLAND: Yes. The influence functions are set for each of the stress terms. And there are moment-based influence functions also. So those moment-based influence functions were used.

ACTING CHAIR SHACK: But on your long crack tips when you got into the negative part of the bending stress, you never got closure on the track tip?

MR. RUDLAND: Yes. You know, you got to realize these are idealized solutions that were generated by Anderson. So there are some cases I think where a crack closure would probably occur. And that was one of the problems with this particular set of analysis is that some of these cracks when they got too long needed to be extrapolated beyond the fields in which they were generated. And in this little bit of study that we did with the industry at the end of the year they actually ran some cases and showed that in that particular region for the very long cracks on the small diameters, we were slightly high on the K sections. Thus, we had to extrapolate.

ACTING CHAIR SHACK: Okay.

MR. RUDLAND: But overall, the results were very, very close. It's just for the case of the very small diameter very long where there were some extrapolation issues.

MR. CSONTOS: And we were trying to get this done. We did get these calculations done in about two days. And so it was sort of quick scoping analysis. And that was the purpose of it.

We may go back and reevaluate some of this. When Ted talks and we can talk about that. But for this result, for these results we were doing a quick scoping analysis, and that was where -- there's also some other issues but I won't go into those right now.

We're on slide 12 here. And now we'll just go into the results. We've broken these down by nozzle type. And what we're going to show here is the time to leakage and when the leakage was predicted as well as to the time margin between leakage and rupture.

And the color coded sections themselves in these tables here indicate an arbitrary point for us, and which that we knew that we had a of uncertainties in our analysis. For those that showed time margin between leakage and rupture to be six months or less, we color coded in yellow, For those calculations that showed a time margin between leakage and rupture to be greater than six months, we kept it as green. Obviously, just to show that we know there's uncertainly but six months or greater we felt sufficiently okay with our results in that area or those cases.

So the leakage predicted to occur for the surge line between 1 and 2.2 years after discovery in October of '06. All the cases indicated that you see here the time margin between leakage and rupture was at least six months between the onset of leakage and to rupture.

And what you see here is that we have broken it down by the K driven crack growth results and the constant c/a crack growth results for the time margin between leakage and rupture.

We have the normal operating condition

as well as the faulted normal plus the SSE condition. And you can see here what we have broken down here is by the weld residual stress plus the repair residual stresses, the weld residual stress only and the no residual stress case. And only the faulted constant c/a a ratio crack growth analysis showed that we'd have the margin between leek and rupture less than or at basically 6 months.

ACTING CHAIR SHACK: Just --

MR. CSONTOS: Go ahead.

ACTING CHAIR SHACK: -- when I go back and I look at the prediction, you know in this model it means all these cracks initiated about four months before we found them. And they all sort of grew just to the right depth in those four months. That seems like a tremendous coincidence.

MR. CSONTOS: Are you referring the initiation that's in the report?

ACTING CHAIR SHACK: Right. Appendix A, table 2.

MR. CSONTOS: Yes.

MR. SULLIVAN: We decided not to carry through into today's discussion because --

ACTING CHAIR SHACK: No. But it seems to me to indicate something about your assumed crack growth rates. I mean in your whole residual stress model that, you know, it would indicate that if cracks are growing as fast as you think they are, then boy those suckers showed up just a few -- you know, it's a good thing you didn't look six months earlier or you wouldn't have seen anything.

MR. CSONTOS: Well, that's the problem with the initiation. I think you mentioned at the ACRS meeting as well is that to try to predict initiation is --

ACTING CHAIR SHACK: Yes. But I'm not even trying to predict initiation. I'm sort of looking at from my crack growth model at when my initiation occurred and the fact that all these things occurred, three initiated at the same time. You know, I go 20 years without a crack initiating and then somewhere that week, bang, I get three of them. It just, you know, doesn't the sanity check.

MR. CSONTOS: Yes. Well, that's why we didn't add it in here.

ACTING CHAIR SHACK: Well, yes. But then to me it reflects on your crack growth assumption. You know, that if I have to make that initiation assumption in order to get where I am today and I don't like that history, why do I believe your future is my problem.

MR. RUDLAND: There's a couple of things about that. I mean, the sizes of the cracks in the smaller diameter pipes are suggesting that there were multiple initiations that had occurred and in lengths which could explain why the constant depth. That you seem to think about the same depth. But you had several flaws that were growing all about the same rate and they link up and you end up with a long semi-deep flaw. You know, and whether or not you had one initiator on the circumference or whether you had four or five initiator on the circumference if they're growing about the same rate, then you'll end up with several length flaws with all about the same depth.

ACTING CHAIR SHACK: Well, I was going to come up with that issue when, you know, you came up with the conclusion that they're growing faster in the length direction than we're predicting. And that was sort of question: Is how do you know we're not linking up a bunch of little cracks.

MR. RUDLAND: Oh. Well, you don't. I mean that's --

ACTING CHAIR SHACK: Well, but you're making the statement that they're growing faster than we think.

MR. RUDLAND: If you take one crack and base it cracks mechanics --

ACTING CHAIR SHACK: Right.

MR. RUDLAND: -- they seem to be growing faster than that.

MR. CSONTOS: Here is our relief and safety nozzle assumptions. So we will show the relief and safety nozzle results separately. But the assumptions are the same for both analyses.

And what we did here is the loading conditions are the same. Well, the loading are the same except that they're different loads because of different pipes, But the weld residual stress evaluated for this set of analysis was that, again, the no weld residual stress case. And then we had the ASME weld residual stress case based on the 30ksi and 40ksi yield of the weld metal.

The 30ksi, correct me if I'm wrong, Dave, but 30ksi is what is used for the Alloy 600 yield strength data, and we'll show that some of the word that Dave and folks down at Batelle and EMC_2 have showed the weld metal, through experimental results, that the weld metal actually has a little higher yield strength of that at 40ksi.

So we evaluated the 30ksi case where the ASME weld residual stress was normalized to that yield stress. And the 30ksi yield stress and then the 40ksi. And you'll see the three cases here as well.

Slide 14 is derived from the ASME Section X1 and it's the weld residual stress for the 30ksi and then the 40ksi.

Dave, is there anything more you want to say about this?

MR. RUDLAND: The way this was developed was the experimental data was derived from IGSCC cracking in the ASME code and from heat effect zoned cracks. And so the experimental data that was there was fit to a function or a multi-linear type of function that was normalized by the yield strength material at the time. So that's where this 30ksi bit came from.

I knew from some past experimental data that we generated in some of the NRC programs that the actual yield strength of Alloy 182 at operating temperature of a stress was more like about 55/54ksi at operating temperatures. And so since I had a little problem with the stress data a little bit lower than that, I scaled this ASME relationship up to have an ID axial stress of equal to the yield strength of the material since we had no residual stress calculations for this size pipe. So that's where the calculations came from.

So the 40ksi basically is scaled up to the ID axial stress is equal to the yield strength of the way to -- at operating assumptions.

MR. CSONTOS: Okay. And --

ACTING CHAIR SHACK: Just to make one remark about that. You know one thing about that ASME stress is, you know, if you look at the data that it came from if you actually compute the Ks for each of those individual cases rather than sort of eyeballing a fit to that cloud of data, you know you find that this gives you fairly conservative K for crack growth. And that's great for a disposition curve. You know, you're driving the crack through the wall faster, and in many cases that's what you want; a conservative estimate of when this thing is going to leak. It may well not be conservative from a leak before break point of view where you want to retard that through-wall growth a little bit and let that sucker grow around the circumference.

And so you've got a curve that was deliberately set up to be conservative to predict leakage, and it may not be conservative. You know, there's certainly a question in using it when the real question in mind is leak before break.

MR. CSONTOS: It won't effect a relief. You'll see what I mean. The relief will show no time. So we'll go into that.

For relief nozzle, this is the --

ACTING CHAIR SHACK: I'm sort of looking to the most sophisticated analysis coming up.

MR. CSONTOS: Yes. Okay.

As you know --

MR. RUDLAND: Can I make a comment about that, Bill. Your comments are very well taken. And if you go back and actually look at the repair history on this relief nozzle, you know I'm sure that the estimate that we made is very poor for residual stress. Because it was extensively repaired both on the ID after the post weld heat treat as well as on the stainless steel safe end was also -- was built it. So there's a lot of stuff going on there. And so , you know, your point's well taken.

MR. CSONTOS: Yes. And we didn't learn of that until weeks after we did this analysis.

ACTING CHAIR SHACK: And I'm not sure

what you would have done with it if you had known it ahead of time.

MR. CSONTOS: Yes, I was going to say.

So we had one circumferential flaw from the UT indications, and that was 7.7" 26 percent through-wall with a 21 to 1 ratio, c/a ratio.

These are the dimensions. And, again, extensive repair history. This is all we knew at the time when we did the evaluation. And the last volumetric examination was back in 2000.

So here are the results. Same kinds of the green, yellow, red color coded case. Yellow, again, is six months or less between the time to leakage and rupture. And red is where we have no margin.

So what we have here is the results show that the leakage was predicted to occur between 1.9 and 2.6 years. The higher number -- well, I'll just with that. You have some of the results and we can go into that more if you want to. But for this case the 10 out of 12 cases indicate that the leakage and rupture occurred simultaneously. And initially we had said 8 out of 12. I think Ted came in and described 8 out of 12 in the previous meeting. The two other cases that we have that showed that leakage rupture occurred simultaneously is because the surface cracks stability wasn't there.

We did two calculations. One is the through-wall crack stability and the surface crack stability. The surface crack stability indicated two additional cases where before it ever went through-wall, it would have ruptured. That the surface crack would have been critical. And so that's why you have here, we have the 40ksi, 30ksi well residual stress cases and the no weld residual weld cases. And, again, 10 out of 12 showed no time between leakage and rupture.

We knew that the idealized through-wall crack evaluation where we said that the ID -- yes. It's there, yes.

We initially assumed that the idealized through-wall crack with the OD length equal to the ID surface crack length projected radially to the outside surface. And we knew that was a fairly conservative analysis where we took, basically, this line and projected out and said that's our through-wall crack line. We knew that was conservative. We went back and said let's do something a little less conservative to try to do a sensitive analysis to see what results would occur.

We went and did this what we called the equivalent through-wall crack size, which is we took the area here and we reduced the length of the through-wall crack down to what these black lines are. Okay? So that gave a little bit more margin that we thought between leakage and rupture it was more realistic and we thought it would be a better estimate to do these calculations.

We didn't do that for the surge lines because we had plenty of margin for the surge line. But for the relief and safety line, we went ahead and did this analysis. And this was after the initial results that we'd had.

And in this case it still showed that 10 out of 12 cases except for the no low residual stress case and the K driven crack growth models showed that we'd have no time between leakage and rupture. So the results did not change by change of this parameter.

We went to the safety nozzle now. And for the safety nozzle you know that there is one circumferential flaw. We treated it as a flaw. And it was 2.5" long, 23 percent through-wall with an 8 to 1 aspect ratio. This is the weld dimensions. Again, at that time we did not know anything about the weld repair history. And, again, the volumetric examination was back in 2000, pre PDI.

For this case slide 20 the results show that we have leakage predicted to occur in 2.6 to 8 years after the October discovery. And in this case the same color coded cases, K driven, c/a, normal faulted conditions and the three different weld residual states. We have 8 out of 12 cases that show no time between leakage and rupture.

For the case of the K driven with the 30ksi weld residual stresses, we have a couple of months between leakage and rupture. In the no residual stress case we had plenty of time.

That was for the idealized crack, through-wall crack size. We then went ahead and did the equivalent through-wall crack analysis for this case. And in this case we found that we did have margin. And we had a margin for a couple of months and in the case of the no residual stress case, to five years. So this is where we were on the border there of leakage and rupture, rupture occurring simultaneously. And by changing this parameter we showed that there is some time between leakage and rupture.

The leak rate analyses. We were asked

by NRR to determine how much leakage there would be that would come through these through-wall cracks. And so what we'll be presenting here is the leakage analyses that was for the through-wall crack, the equivalent through-wall crack size. The secondary analyses to the safety and relief line.

We evaluated the equivalent through-wall crack size as it went through. We did not account for the time period between the pinhole to that through-wall crack size. We just said that would be the crack size after some period of time. And that's what our calculation is showing for the through-wall crack leakage.

And we used this NRC validated SQUiRT code. Part of it is in our new PROLOCO code.

And the assumptions are, again, idealize all the way through-wall, but it's an equivalent through-wall crack. And we have a PWSCC crack morphology parameter for the COD for in that SQUiRT code. And it's calculated to GE-EPRI.

And here we evaluated for the super subcooled liquid and the 100 percent steam case, and you'll see where we used that.

And we did not evaluate the restraint of pressure induced bending. We can talk about this later. But we calculated leak size as a function of crack size, the greatest function of crack size.

Slide 23. We broke the leakage results down by the different size of nozzles, the surge, release and safety. And the surge nozzle assumed the subcooled water. We have an 8.1" leakage through-wall crack size, equivalent through-wall crack size and that presented us, we calculated 3.1 gallons per minute. And you can through and evaluate and see the different cases. The residual stress case showed the smallest amount of leakage.

The relief line, the difference between here and the surge line is that the relief line assumed 100 percent steam and in here we have rupture occurring. We don't have any leakage whatsoever except for the no weld residual stress case.

And the safety line we do have leakage and we have quite a bit of leakage with the weld residual stress case, but not in the no residual stress case.

These curves were for this leakage, the leak rates are fairly steep. And so very small changes in crack size give you a large change. So, you know, when you see these cracks grow you do get a lot of leakage occurring, as from this point.

MR. SULLIVAN: What was in the calculation?

MR. CSONTOS: Well, we did not calculate that, no. But we have the graphs, and if you want to look at them, we have them. I don't think we added them . That is a section that we may add to the report. We are thinking about adding that section to the report to show some of these graphs.

ACTING CHAIR SHACK: Of course, now again, in a leak before break analysis I always want a lower bound to leak rate?

MR. CSONTOS: Yes. And that's where--

ACTING CHAIR SHACK: And that gets tricky.

MR. CSONTOS: Yes. Well, actually Dave can fill you in on some of the assumptions that we will need to evaluate. Because in the past this SQUiRT code was used for another LOCA program. And that conservative there was over predicting.

ACTING CHAIR SHACK: Right.

MR. CSONTOS: In this case we need to be careful with under predicting or over predicting the real rates. And so we need to go back and evaluate some of those assumptions that we consider to be--

ACTING CHAIR SHACK: Conservative.

MR. CSONTOS: -- conservative. Now it's not conservative. So, we'll go into that in the next slide.

So, slide 24. The summary of our work. We've broken it down by the nozzle types, again.

Leakage was predicted to occur 1 to 2.2 years after October of '06. And all cases showed six months between leakage and rupture.

In the case for the relief line, well we have 1.9 to 2.6 years; that's between October of '06 to leakage.

Twenty out of 24 cases leakage rupture occurring simultaneously. And in that case the surface cracks were unstable before they went through-wall.

Safety nozzle, 8 out of 24 predicted leak and rupture occurring at the same with the leakage predicted to occur between 2.6 to 8 years, depending upon which residual stress case you evaluated.

Slide 25 is the leak rate summary. And here we broke down, again, the leak rates .2 to 3.1 gpm for the surge nozzle depending on crack size and weld residual stress and the idealized through-wall crack equivalent size.

For the relief line we had 2.3 gpm for the no residual stress case only. The remainder of them, the cases predicted rupture and a break and not leakage.

Safety nozzle showed anywhere between .3 and 10.4 gpm. And this is where if you want to talk about some of those nonconservatisms that we are looking into, there are these three. And the first one is probably the more important one.

It's a pressure induced bending for long cracks. And, Dave, do you want to say anything just quick about it?

MR. RUDLAND: Yes. It's that we did some work in a program a few years back that restraint in the piping system can reduce the COD, and thus the leak rate. And so that probably needs to be taken into account.

The analyses that we do for calculating COD are based on free rotation of the ends. So if the piping system is stiff enough or restrained enough, those CODs will be limited and that reduce the leak rate.

MR. CSONTOS: And it could reduce it significantly. Could.

ACTING CHAIR SHACK: What is this piping system? I mean the surge lines are kind of a long flexible thing. That would seem relatively open. What about the other lines?

MR. RUDLAND: The crack in the nozzle, you know, you're pretty tight on one end, right? Because you're up against the pressurizer.

ACTING CHAIR SHACK: Yes.

MR. RUDLAND: And the other end is relatively free or much more flexible.

Again, I don't know how the hangers were set up in there, so I don't know exactly what the restraint is.

ACTING CHAIR SHACK: Yes.

MR. CSONTOS: So it is an assumption that we need to evaluate in the next case. And the same thing with the weld residual stress and also the nonidealized through-wall crack. Those two are secondary of importance to revaluated than the first one.

I think it's to you, David.

MR. SULLIVAN: Okay. And with that, I would like to just go over a few points and we'll be ready to turn the table over to industry.

What I've tried to do just for talking

purposes is indicate that with respect to this issue of pressurizer nozzle welds, the PWRs fall in four different categories. There are a number of plants, I think that turns out to be about 19, that don't have Alloy 82/182 pressurizer nozzle welds. Four of those 19 are new pressurizers that have been replaced in recent years.

And then there are a number of plants that have already inspected or mitigated up until this point. Because these inspections and mitigations began somewhere in late 2005 time frame and continued in and through 2006.

And then there are plants that planned to inspect or mitigate in 2007 outages. At least one of them is going on right now.

ACTING CHAIR SHACK: I mean, we should get a big burst of data this spring, right?

MR. SULLIVAN: Not really.

ACTING CHAIR SHACK: Not really?

MR. SULLIVAN: No. Because most of the plants really can't do these inspections. They're going straight to the weld overlay mitigations for two reasons. One is it's a good fix. And the other is it makes the new configuration inspectable.

Wolf Creek was the anomaly. I mean

maybe I shouldn't say anomaly because, you know, that might sound like I'm making a joke here. But Wolf Creek was the exception. There aren't that many plants that can actually do the inspections.

And there is a survey that was performed by EPRI that Gary may have sent you, I'm not sure. I think he did. And you can go through that and pretty much where it says they're going to do a premitigation inspection, my understanding is they're the plants that actually can do it. And there aren't very many of them. Really not going to get information.

ACTING CHAIR SHACK: Shoot.

MR. SULLIVAN: Yes. It's too bad, but that's the case.

And then there are plants that are going to inspect in the fall. And then there are also a number of plants remaining with respect to this issue, this issue being pressurizer nozzle welds, that have their outages planned for 2008. Now fortunately they're all in the spring, none of them are in the fall.

ACTING CHAIR SHACK: As I recalled the conversation last time, it was like 9 through April and there was one outlier in June?

MR. SULLIVAN: There were a couple of outliers I think in the fall, but they've been moved for a couple of different reasons. What one plant decided to move their outage because it combined nicely with addressing this issue and their desire to shift the plant from 18 month cycle to two year cycle. Something to do with, you know, using up the fuel.

ACTING CHAIR SHACK: So our current understanding is the last one will be something like June 2008?

MR. SULLIVAN: Something like June 2008. That's my understanding. But I need to flush that out a little bit.

Because of the concerns that we've had on this issue and the conclusions that we talked about at the end of the meeting on February 2nd and I opened with at this meeting, we worked with industry to get agreements to move all these inspections into 2007. And there's kind of a caveat to that. And that caveat is at the bottom of page 27. And it may be spelled out a little bit more fully on the next page on page 28.

And that caveat is that if industry's advances analyses that they're going to talk about a little bit today I think, I don't think they're going to go into real deep discussion; if those analyses provide reasonable assurance to NRC staff that PWSCC in these kinds of welds will remain stable and not lead to rupture without significant time from the onset of detectable leakage, then those plants with the 2008 outages will not have to shutdown in 2007. And these plants, these nine plants, have all made commitments in commitment letters that they shut down in 2007 pending these analyses.

I think that Gary also provided you copies of those commitment letters.

So the next slide, 29, just indicates that we have agreements through commitment letters and we're in the process of issuing confirmatory action letters. And they'll be going out, we believe, starting next week. That's our process for handling this particular issues and those more aggressive industry actions that NRC staff were looking for.

So, at this point I'm done with my presentation. If you have any questions, I'll be glad to answer them. Otherwise, it's back to you, Bill.

ACTING CHAIR SHACK: On your slide 28, you know, as I read this it sounds as though you want them to demonstrate that you're going to have leak before break in these geometries. But what you really want is does six months make a difference? You know, I don't think these are good candidates for leak before break. And whatever their finite element analyses shows in the long term one wouldn't accept these as candidates for a leak before break kind of thing. But what's it really going to take give them six months? Or is that's a discussion you're working on?

MR. SULLIVAN: Yes, we're going to have to work that out. As you may have noticed in the letter that we sent yesterday, we've indicated that we don't expect this type of work to be able to provide the same sort of pedigree that we would expect for licensing actions or rulemaking. We're not looking for absolute assurance. We're trying to get an increased level of assurance commensurate with the time we're talking about. And we're going to have work out what the acceptance criteria are and so forth as we see this go on. It's going to be a very, very complicated project.

Even despite the areas that we've

pointed out in that letter that we want to work on, there's still going to be a number of simplifying assumptions that industry is going to have to use. So, it's kind of a work in progress in that sense.

ACTING CHAIR SHACK: Well, we're a little bit ahead of schedule.

MEMBER POWERS: Well, there's something I don't quite understand. Suppose you inspect these plants in 2007 and find things? What implication does that?

MR. SULLIVAN: Well, there aren't very many that are going to be inspected. But when you say "find things," Dr. Powers, you mean find bad stuff like Wolf Creek

MEMBER POWERS: Yes.

MR. SULLIVAN: We could have to revisit the whole issue.

MEMBER POWERS: Okay. So calculations aside, I mean you say things change depending on these calculations. If you find things and the calculations are out?

MR. SULLIVAN: Well, if we find results that are not as severe as Wolf Creek in those few plants that are going to inspect, I think then we'd say well that's more like the kind of results that we would have expected.

If we find indications that are as bad as Wolf Creek or worse, we may have to revisit this whole issue and consider in the context of the analyses that are being done.

ACTING CHAIR SHACK: Is every inspection associated with a mitigation action? I mean the guy's going to inspect and then he's going to mitigate anyway no matter what he finds?

MR. SULLIVAN: I don't think so. I think there's at least one plant, maybe industry could answer this, that's planning to inspect in either the spring or the fall and that plant is not planning to mitigate. And that's a risk that they're taking because if they find inspections, then they're going to have to get a crew in to address the problem with an overlay.

MR. HARRINGTON:

There are a limited number of the plants.

Craig Harrington with EPRI.

There are a limited number of plants, and it's a handful, that do plan or have completed inspections and have no near term plans to do mitigation. They may have plans three, four outages from now or something like that. But not any immediate plans to do mitigation. But it's a very small number.

ACTING CHAIR SHACK: Yes, but it's greater than one?

MR. HARRINGTON: Something like two or three.

ACTING CHAIR SHACK: Let's just go on with the industry presentation, if that's okay. Five minutes. Don't run away.

(Whereupon, at 1:54 p.m. a recess until 2:01 p.m.)

MR. REILLY: Good afternoon. My name is Jim Reilly. I wanted to thank everybody for the opportunity to brief you from what industry activities we have going on with respect to this situation and indications at Wolf Creek.

What we'd like to do today is make sure everybody has the same background on how we got here and what activities we're going to be taking on in the time come. So we've broken up our presentation as follows. On the slide you can see.

I want to talk to you a little bit about the materials initiative. Some of you may have heard of this, but it's an important aspect of what we're doing in the industry, have been doing and will continue to do over the short term.

A background on what the MRP is and what they're doing. Some background on the MRP-139, which is a guideline document that was being followed at the time these inspection results came in. We wanted to kind of reenforce the work that went into the development of that guideline.

And then go from there to what was found at Wolf Creek, what the industry's response to the findings at Wolf Creek has been and what we intend to do going forward. And at this point we'll be talking more about an analyses that we're developing. And as Ted indicated, at this point we're at the very front end and we'll be, more or less, outlining where we're going on this. We're not going to be talking results or much detail on the analysis.

So Dana Covill will be leading us through most of the presentation.

Dana, if you want to take this from here.

MR. COVILL: Yes. I'm Dana Covill from Progress Energy. I was the LO-600 ITG chairman and integrated pass group. And leader of the development of MRP-139, just for background.

I'm not presenting anything new when it comes to 139 as far as the staff is concerned. Everything we're going to discussed as a background os what we've been discussing over the past four years. And then I'll get into what the future work that we're doing.

For background, the industry's materials initiative was formed, the commitment of the chief nuclear officer level that we needed more structure as an industry to respond to materials issues. This combined several programs and provide a consistent process as an industry prioritization, funding, et cetera.

IT was approved unanimously by the CNOs back in 2003. One of the most important elements of it contains our guidelines that we can issue as mandatory as a must implement needed categories in the initiative and it should implement; good practices review may implement.

We did include a structure and deviation process to where we need, you know, a plant or a company needs to deviate from the guidance, which is similar in concept to the 50.55a relief requesting it or alternative process.

MR. REILLY: May I add something there?

MR. COVILL: Sure.

MR. REILLY: This is Jim Reilly again.

Just want to make one point on the initiative. I think it's pretty important. You noted in the first bullet that it is a commitment at the CNO level. First of all, it's an internal commitment within the industry, but it's a very important commitment. And basically the documents that arise from the materials initiative or any of our initiatives are expected to be followed by the various licensees. And Dana outlined here this different levels of requirement within these industry documents ranging from mandatory needed and good practice. Anything that appears in one of these guidelines as mandatory or needed has to be followed by all the licenses to which the guideline is applicable. In this case it's the PWRs. Or they have to go through a pretty strict process for justifying deviation from them. As Dana pointed out, there's parallels there with respect to 50.55. But those deviation requests are subject to review by third parties and depending on the level of deviation and approval by the executive officers. Because basically at that point if you're deviating from what has been a CNO commitment, you're basically changing that CNO's commitment. So these are taken very seriously.

MRP-139 was issued as a mandatory document or parts of it, the inspection parts of it under the industry's initiative.

So thank you.

MR. COVILL: The next slide 5, these are the industry programs that are covered by the initiative. And you can see PWR MRP is part of it.

The next slide a little bit going backwards in time. The MRP was formed in 1999 primarily based on the success of the steam generator management program and the PWR vessels internal program.

One of the big kickers was the strong executive oversight and involvement. As an industry on the PWR side we had not really engaged.

We're focusing on the primary coolant system, less steam generators, of course.

Developing the tools to manage aging and degradation.

And some of the items working on: Alloy 600, thermal fatigue, working forward to reactor internals degradation and inspection guidance for that especially covering license renewal terms and reactor pressure vessel integrity, the PTS rulemaking that's working its way through.

The MRP-139, this was issued in August of 2005 and it provides mandatory guidance for inspection of these butt welds.

We developed it using a structured approach. The safety assessment, both deterministic and probabilistic. We assessed margins between the onset of leakage and critical crack size.

MEMBER POWERS: Just a quibble. The safety assessments in 113.

MR. COVILL: I'm sorry?

MEMBER POWERS: The probabilistic and deterministic safety assessment is in 113?

MR. COVILL: Oh, that's the roll up. The individual reports went into that. So we had deterministic reports. You can see that on the next slide. The deterministic reports for both the Areva and Westinghouse, CE units did one. And then we did a probabilistic assessment rolling inputs from all three along with several others. So MRP-113 is the summary safety assessment report for all the work we did before. The safety assessment, is the MRP-113 but it builds on the work that was done previously.

MEMBER POWERS: Just that I started looking in 138 for the deterministic analyses and probabalistic analyses and I didn't find it.

MR. COVILL: Oh. And that would be correct.

And the other thing that we did consider this was the previous industry and regulatory guidance along lines of steam generators and, quite honestly, Generic Letter 88-01 for the BWRs for stainless steel pipe cracking and operating experience.

The review and approval process was extensive and challenging, I have to say. But this went through probably the most rigorous and long review of any inspection values I've been involved with. So there was plenty of challenges, lots of questions from all levels of the organization, including the CNOs.

The bottom line was at the end it was unanimous approval by the MRP Executive Committee.

The next page is 8. This shows all the work we've done. And, again, I'm going to go through all the details of each report. But this spanned probably four or five years and a lot of good work was done, a lot of thorough work. MRP-139 was not developed on the back of an envelope. It shows a lot of thought was put into it.

The deterministic analyses that we did to support MRP-139.

There's a safety significance of flaws in the 82/182. The analyses was developed to determine the critical flaw size rebounding, taking representative nozzles, loads from each fleet. Calculate a time to through-wall leak, time between 1 gpm and 10 gpm and failure. Leak rate is a function of flaw size and margin between leak and failure.

Now, we don't say leak before break here because we wanted to separate regulatory leak before break from this particular. Because, like you said, you know most of these lines just wouldn't qualify for leak before break under general design criteria 4 in the SRP guidance.

The results showed us axial cracks limited to length of the welds, critical length of axial flaws is greater than the length of the weld and the safe end is applicable. So there were several plants like CE and another plants having Alloy 600 safe ends, but they're fairly short. In no case the axial crack, critical crack size -- it was longer than the combined length of the weld and the safe factor.

Even though we expected axial cracks, we did analyze for circumferential because we had seen one in the field, and that was VC Summer.

Large critical arc length for through-wall circumferential flaws, fairly similar to the CRD and nozzle work on the heads.

More than 2 years from 1 gpm leak to critical length for most locations. And we used 1 gpm as our so called detection limit in that that is also our tech spec shutdown limit for PWRs. We see 1 gpm and identified leakage, we're in shutdown mode.

And the last bullet for all but one small diameter location, this was true. And these were the small nozzles on top B&W units. And again, that was primarily as we've discussed before it an established mode. Use a small diameter very thick walled nozzles. No surprise.

Some result sampling for large bore piping. Primary loop nozzle welds, they have as expected, large margins for leakage to rupture.

Pressurize nozzle time was less than 10 year ISI interval. That's ASME Section X1.

Smaller bore piping, and this would count the surge line, the KE drop lines, shutdown cooling lines in the CE units and the B&W units. In some cases it was less than a 10 year interval.

Again, deterministic results were really as expected, and they're primarily based on pipe diameter and thickness.

On that work we started some probabilistic analysis for several limiting locations in all three designs. What we did was we wanted to address a probability a flaw could go through the wall and result in core damage. This was performed by Westinghouse using their risk-informed ISI models and approaches that have been approved for risk-informed ISI implementation.

What we wanted to do was quantify the probability of leakage from circumferential flaws. Also looked at the contribution of axial flaws, and that wasn't significant, again as expected. You know, we got leakage but we did not get rupture.

Wanted to look at the change in core damage frequency and assess various inspection frequencies from a risk perspective. Now frequencies, again, the code requires once every 10 years, 100 percent every years outside of risk-informed ISI. What would we do if we made that once every five years? What would the impact on core damage be? I think we went down to one year, if I remember right. And, again, we utilized Westinghouse's approved methodology for this approach.

These are the key inputs. One of the conservatism we used is we assumed failure at the initiation of a leak. Once it grew through-wall, we assumed a failure of rupture. That's a conservatism, did not account for any circumferential growth of the flaw as it progressed around the pipe.

Probability of leak initiating is higher than the probability for small medium LOCA. And we did perform some benchmarking.

Slide 14. The change of core damage frequencies. We show the number there. And we concluded that from a risk perspective the impact of butt weld stress corrosion damage on core damage is insignificant.

Changes in inspection frequency and detection capability. And here what we did was we assumed 50 percent detection of 25 percent flaw in the initial analysis. We took that down to 50 percent detection of a 10 percent through-wall flaw. Neither of those in going from no inspection at all 10 year ISI, 1 year ISI. And then once a year with the improved detection capability. Again, no insignificant impact on CDF.

So purely from a risk perspective, the 10 year ISI intervals were considered to be adequate. So for the most part we concluded deterministically for the big stuff the code was fine. Most of the smaller diameters the code was fine. The smallest diameters that we analyzed, which were these nozzles on tope of the pressurizer, 10 years was probably too long.

From a risk perspective we concluded no impact. In spite of all that, we concluded we needed to do something more than what the code currently requires.

So from the safety assessment standpoint--

ACTING CHAIR SHACK: Have you gone back and looked at those analyses on the basis of Wolf Creek? That is, would your models predict that you would get circumferential cracks in 7 out of 41 nozzles? Would you predict the 155 degree crack?

MR. COVILL: No.

ACTING CHAIR SHACK: So they're inconsistent with experience?

MR. COVILL: Well, I would say they are consistent with experience on known cracks, yes. Clearly from the limited number of destructive analyses that have been performed, our analyses and conclusions are consistent. However, since we have not pulled many samples in the recent past, what we say is we conservatively treat them as real cracks.

ACTING CHAIR SHACK: But treated as real cracks you still wouldn't predict them?

MR. COVILL: I don't think we would, no.

ACTING CHAIR SHACK: No.

MR. COVILL: I don't see anything in our previous analyses that we should see more circumferential cracks than we see axis, except with the various finite analyses we have done we have shown, as discussed earlier, that in some cases depending upon the type of repair done you will get some local areas where the hoop stress is less than the axial stress or axial stress occurred in hoop stress. And we experienced, we have confirmed physically the one flaw in VC Summer. That was in the butter cladding, so to speak, that terminated once the -- steel nozzle.

Our conclusions were we expect axials, never say never in this business, so we're going to analyze for circumferentials, quite honestly, which is why we spent most of our time looking at circumferential flaws in terms of impact and what happens.

The analyses we performed three years ago 360 degree part-depth circ flaws are unlikely. Through-wall flaws will leak 1 gpm at less than the critical size except for one small diameter nozzle, and not inconsistent with what we expected.

Part of the other work showed that through-wall flaws and repaired welds are limited to about the repair length. Again, based on the analysis that we did.

All these welds greater than 4" are inspected for Section X1. We are also looking at these. We have performed visual inspections for leakage and boric acid corrosion impacts.

One of the mandatory items we issued a few years, mandatory needed, was put on a visual inspection of all Alloy 600 components, including 82/182.

MEMBER POWERS: AT what frequency?

MR. COVILL: This is a one time. As we

were developing all this guidance, we had no guidance at all out there, we issued a letter saying okay within the next two outages at least do a 100 percent visual inspection. And that is due this year, I believe.

So in terms of the code, Bill, right now its visual inspection for leakage in accordance with the code, which is not bare metal and look at the insulation. Now when you're doing NDE on greater than 1" nominal pipe size, you're doing PT, primary penetrant testing, you have to do a visual for that, too, obviously if you're looking at it. And then we do the volumetrics for sizes greater 4" per the code.

PRR, based on comments received on MRP-139 from the NRC, we are evaluating expanding that inspection, volumetric inspection requirement to some pipe sizes less than some component that are less the 4" nominal pipe size. And we should be issuing guidance sometime this year.

Is that safe, Craig?

MR. HARRINGTON: Yes. IF we can ever get past Wolf Creek.

MR. COVILL: Yes. And the NRC gave us several comments that we've worked on over the last year or so that were pretty close to resolving the comments, I believe.

On safety assessments perspective, a very number of leaks are 4, having VC Summer in a hot leg -- 2 in a pressurizer similar to the Wolf Creek on top, Palisades pressurizer but that was Alloy 600 base metal and test reactor also had a leak in the Alloy 600 base metal. That was the only four we were aware of.

Probabilistic analysis shows the impact of butt weld stress corrosion damage on core damage. Frequency is insignificant. And the potential for significant boric acid corrosion is considered low, primarily as a result of the programs that we have initiated after Davis-Besse or strength, let's put it that way.

So when we developed MRP-139, which are the inspection guidelines, we wanted to manage potential degradation well in advance of any structural integrity problem. And we wanted to minimize the potential for leaks.

Unlike the IGSCC in the boilers, PWSCC in the PWRs has been slower to initiate. The disadvantage we have with the boilers, at least in the stainless steel side, is we had a preferential path. The head effect, sensitized heat effect.

The other thing we wanted to do was we wanted accelerate getting that first examination of dissimilar metal butt welds using Section X1 Appendix A qualified processes and techniques. We prioritized it in order of temperature so it would be pressurize hot leg and cold leg. And we established aggressive implementation schedules to get these first exams done using Appendix A procedures.

Implementation delays would be addressed to the Materials Initiative process, deviation process that we discussed earlier and similar 50.55a relief request and alternative in Section X1. These would be documented in the site correction action programs and executive approval for mandatory items requires an independent expert review outside of the utility.

And the deviation sent to the MRP for peer awareness. If I remember right, the CNOs would also review these once a year.

MR. REILLY: Well, up through a reporting process. Yes. All the different IPs review the deviations that come in just from a general adequacy standpoint. It's not an approval.

It's a review from a number of perspective. Does the deviation seem to make sense from the perspective of those that created guidelines? Does the deviation say anything to us in the way of our guideline adequacy? If we get a deviations that appear to indicate that people can't follow these guidelines, maybe the guideline needs change. We need to communicate the results of deviations. And that kind of review of what comes up gets passed back through the executive levels by ways of a report that just help people assess are people following our guidelines, are our guidelines appropriate, do we need to be changing anything. And that's reported annually as I indicated.

MR. COVILL: Slide 18 is the implementation schedule. On the first sub-bullet is the end of '07, inspect all welds associated with the pressurizer and exposed to those temperatures.

And then it progresses through smaller diameter hot leg, larger diameter hot leg and finally all cold leg.

ACTING CHAIR SHACK: We've already decided you're missing that milestone, right?

MR. COVILL: Yes. With deviations consistent with Section X1.

ACTING CHAIR SHACK: So it's June 31, '08?

MR. COVILL: Yes.

ACTING CHAIR SHACK: Or 30, however many days there are in June.

MR. COVILL: I heard that very discussion this morning.

Another key one for us in trying to get ahead of this problem, the last one we expect everybody to know what their butt weld configurations are so they know if they're inspectable or not or if we need more mock-ups for the PDI program. The NDE center is getting all these results and then the steering will get together or has gotten together to see if we need any more mock-ups in order to qualify the UT processes and procedures.

MEMBER POWERS: How does the PDI process mock-up a stress corrosion cracks in one of these geometries?

MR. COVILL: I am not the one to answer that. I don't have the true answer. I know that they grow them and them implant them using -- pressure.

ACTING CHAIR SHACK: By HIP.

MR. COVILL: The challenge there was in

the early days you could see the interface.

ACTING CHAIR SHACK: Could see the HIP, yes.

MR. COVILL: So, you know, they had to revise that process. But fundamentally they're lab grown.

Unlike BWRs where we had plenty of samples to cut out with real cracks in them, plant cracks we don't have that for PWR butt welds. Same thing for steam generator tubes. We got a bezillion samples of those. Unfortunately in the butt weld where we just don't have any.

This is a summary of the Wolf Creek pressurizer weld indications. These were done in the fall of '06. These examinations were being performed for MRP-139 requirements. Part of the process, part of 139 says if you can demonstrate by inspection that you have no PWRCC in your welds before you put the overlay on, then the reinspection requirements are different than if you were putting an overlay on a cracked weld. And as discussed as the staff said earlier, this is one of the handful of plants that has an inspectable configuration. When we say inspectable with code and MRP-139 require a specific volume on the ID, about one-third through-wall, it has to be inspected with the ultrasonic examination. You have to lay it out, do all your angles. Because the configuration of a lot of welds we just can't do that, get that inner one-third coverage. Again, which is why most people just put the overlays on to make them inspectable, because the overlays inspection requirements for the overlay plus the 25 percent of the original pipe wall.

The next two slides are the pictures. I don't know if you can see it on the handout, but the indication on the safety relief nozzle is right here. It looks somewhere between along the interface between the original butter and the butt weld.

Next one. Now the surge nozzle it's to be right in the original butter.

MEMBER POWERS: And this is this question they were raising before, whether you're growing along the dendrites, across dendrites depending on whether you're growing through the weld or though the butter. And everybody just ignores that.

MR. COVILL: I don't think anybody can predict which way the dendrites are in any weld, to be honest with you. Especially a repaired weld, especially repaired weld because then they've gone all over the place. And a lot of that depends on whether you're welding in a deep cavity, narrow cavity. I know in the shop we used to do all sorts of configurations for repaired welds.

This is why we're using the MRP-115 for the subsequent analysis. All the analysis we're doing lately, and that's the latest expert panel crack weld model.

Just a brief couple statements on the performance demonstration initiative, PDI. This was established back in the late '80s to qualify UT procedures and personnel following the requirements of Section XI, Appendix VIII, Supplement 10.

This is required by 50.55a to implement by November 22, 2002.

So really in the PWR side of the business for most if not all of these welds, these inspections will be the we've seen in their lifetime.

The challenge and the unfortunate part about it is it doesn't allow us to compare to preservice inspection results. That would be fabrication related flaws, metallurgical conditions, interface. North Ana had from a PSI ISI standpoint a couple of penetrations we pulled out that the NDE people called circumferential cracking indications. We found parts of all in that area. In fact, one of them I think we saw five welds; it was the original butter, the original partial pin weld, repaired one, cut it out, a third one and a repaired one. And you watch the grain structure change all the way across. But we have nothing to compare to with ISI.

The procedure we used on these wells was qualified for detection and length sizing but not for depth sizing. In other words, they met all the requirements of Appendix VIII.

One thing we're seeing on depth sizing, we're not missing by much, a millimeter or two on the standard deviation, but we cannot call it qualified if we miss it.

This is a table of the indications. I know I can't read it on my copy, but this is the information I believe staff had and used for their analysis.

The indications were assumed to be PWSCC attributable to PWSCC as called by the NDE personnel. And it did indicate some facets in connection to the ID. And Wolf Creek and the industry there were no metallurgical specimens obtained.

These are observations on our part. Multiple circumferential indications, no axial component is inconsistent with the stress date that we calculate, as we discussed earlier again. I will not call Wolf Creek an anomaly. And like I said earlier, you never say never.

It doesn't seem likely that before the five of these rapidly growing cracks would be about the same depth. We discussed that earlier. The key to us was the different sizes and the different environments. And quite honestly, given all these welds worldwide, we would expect a lot more leaks if we had a lot more initiation associated with the crack growth rates that we're using. And these are possible explanations, however we are assuming these are PWSCC. We have no evidence otherwise.

What we've done since then, we prepared a white paper on the implications of the inspection results with key safety assessment assumptions, field experience and a review of those findings. We complete the MRP implementation survey. There were a couple of public meetings with the NRC and staff.

The implementation survey was -- I'll

show you. You'll find that all the numbers match with respect to which plants are doing what and when with respect these welds.

And, I'm sorry, Craig, this slide was accurate in the beginning of January. There have been one or changes since then?

MR. HARRINGTON: That's correct. That was transmitted to the NRC. That was the result of reviewing the survey. I spent some time on the phone with Tim Lupold of NRR trying to sort through and agree on how we bend each special case in the list of nozzles. And as of January 1st that was the status.

The one plant that shows fall of '08 for a baseline inspection and mitigation, they have moved their outage into '07. So there's a few adjustments like that. But basically that's reflective of the status of the plants.

The spring '08 plants it shows ten. That number is now nine. One other plant moved into '07.

But generally that was accurate January 1st.

ACTING CHAIR SHACK: And the June plant is still June?

MR. HARRINGTON: I don't know. I think

the last plant is probably April of '08.

ACTING CHAIR SHACK: April.

MR. HARRINGTON: It's spring '08. I don't think there's anything going in in June. I don't know of anybody in June. No.

MR. COVILL: The conclusions that we reached based on background of MRP-139, the inspections that were being done and the impact of Wolf Creek indications we have concluded the acceleration of the implementation schedule is not necessary.

From a risk viewpoint, there's essentially no difference between now and the spring of '07. We will monitor spring '07 and as Ted said, we find some anomalies, some weird things that happened, deep flaws or leaks, we may revise our schedule.

As Ted had noted earlier we have committed to enhanced leakage monitoring as a compensatory measure until inspection/mitigation is complete.

That takes up to today. Any questions?

Okay. We'll get into what we're doing now or what we started doing, actually. I'm sorry. Is going to the advance finite element analysis for refined crack growth calculations.

Objective. Again, determine the margin between the onset of leakage and rupture.

We want to provide reasonable assurance that there is enough time between the onset of leakage to support existing plans to implement the first round of examinations for pressurizer welds.

When we say "examinations," that means examinations of overlay welds because the existing configuration is not inspectable. So this will be a combination of inspection and/or -- with inspection after the overlay is put on.

So the analysis that we're doing, there's some conservatism with respect to the semi-ellipse crack shape assumption that will remain semi-elliptical as it grows through the field. We refine any of this to a lot of the stress intensity factor at each point along the crack front to guide the development of the crack as it's growing.

We're going to repeat recent evaluations we have performed with Wolf Creek indications. And just with some comparison we did rerun some of the analyses back in late December. And we got, you know, roughly not exactly the same answers as the staff did using those assumptions. Again, no surprise.

We perform sensitivity studies and we're also going to work with peer reviews, industry and regulator.

The calculation we've sent to the NRC and the white paper both consider the effects of changing crack shapes in the crack area at the time of through-wall penetration. They'll be compared to the area that's calculated to result in rupture for normal operating and faulted loads. We think that this will give us a good comparison between more refined analysis and the more conservative approach of constant semi-elliptical shape.

We will investigate a wide range and input assumptions for these items, as shown. It will not calculate the time from through-wall penetration to rupture, rather we will account for the change in shape based on what the analysis shows us at each node on the crack front.

And, again, the analysis will include peer review by several experts in the industry and the regulator.

ACTING CHAIR SHACK: It will be a very interesting calculation. You know the difficulty I see is is that you don't know what the residual stress is. You have a range of residual stresses, but you can't, I don't think, assess the probability of any of those residual stresses.

You have a variety of initial crack shapes and sizes. And again, your probabilistic characterization of those is going to be difficult.

The one thing you can sort of count on is your change in shape under the bending moment. And then, you know, maybe that will be enough to get past all the other uncertainties. But it will be interesting.

The one concern I have is that, you know, again as in all these calculations that what we do to be conservative in one case may not conservative in the other.

MR. COVILL: Absolutely.

ACTING CHAIR SHACK: And the bending moments that we calculate from the code analysis are always conservative from a strength point of view, you know. But in this particular case we would like to know how low the moment can go, not how high it can go. You know, we have bounded that with the ASME analysis. I'm not sure how you're going to convince yourself that the moment is as low as it could go. And that's the one of non-axisymmetry that you can really count on.

MR. COVILL: Glen, do you have anything to offer on that?

MR. WHITE: Sure. This is Glen White Dominion Engineering.

I appreciate your comments. Tomorrow, as you may be aware, we have a day long meeting scheduled and in the afternoon will be public portion of that portion. And these items we'll be talking about in detail. We've prepared a large handout, a 92 page handout to guide us in our discussions for tomorrow.

And welding residual stresses, yes, we have to assume a wide range of different possible patterns. But we are of most of the nine plants at issue here have been able to review their detailed fabrication records, shop travelers, weld repair records. And that information has been compiled and is being made available to us. So there is some information there that we can use to compare to similar information that we compiled for Wolf Creek to help us with developing appropriate welding residual stress information. So we're not completely working in the dark as far as welding residual stress.

Regarding the moments, and yes we're definitely cognizant of your point that what's conservative in terms of one analysis may not be conservative in terms of a through-wall leakage prior to rupture. And so we're collecting dimensional and load data for all 53 welds at issue in the nine plants. So we're not just taking the highest thickest to radius ratio and the highest moment loads and just doing a bounding calculation. We're collecting the full matrix of cases. And we've automated in the software in the first stage of the work so we can look at a large matrix of cases, but we decreased the moments, increased the moments and get all the sensitivities recognizing that you can't up front decide what's the most conservative set of inputs.

So we're very cognizant of that.

ACTING CHAIR SHACK: Crack shapes and sizes?

MR. WHITE: Shapes and sizes, yes. We need to look at a range of initial depth and shape, aspect ratios depths and shapes to start out with.

Multiple crack initiation. That is another issue. The staff has expressed their desire to see that that's an important factor to consider.

And we have several different paths to looking at multiple crack initiation. So we will be in fact looking at FEA models with more than one flaw in them, looking at how they interact. We'll be considering enveloping multiple flaws with a large flaw, the standard ASME method. Looking potentially at 300 --

ACTING CHAIR SHACK: No. Again, whether that's conservative for this particular purpose is another question.

MR. WHITE: Yes. And that's why we'll also be looking at explicitly at the multiple models in the FEA also.

ACTING CHAIR SHACK: In your white paper there, your NRC expert had a sort of a comment on your probabilistic distribution. And I'd go with the expert.

You essentially put your thumb on the scale with all those zero length axial cracks and he wanted you to look at just the circumferential indications. And that seems much more reasonable, just as a comment.

MR. WHITE: Yes. That's a separate work that people at Batelle the structural integral has been leading. And, again, you made the point earlier. I will just while I'm up here comment on the fact that we have multiple indications reported in multiple penetrations that are in different nozzles. And they, having all similar through-wall depths, appears to be inconsistent with all these cracks growing at the crack growth rates that we have been calculating. And we have a task included in our project to do a relatively simple probabalistic analysis to show how likely or unlikely it would be to have that situation.

MEMBER POWERS: Why does a probabalistic analysis work here? The probability of having this situation as one at Wolf Creek. What probability you going to do? I'm a little confused here.

MR. WHITE: What is the probability? It's a hypothesis test we can look at. And the hypothesis is the crack growth rates, at these indications we're growing at crack growth rates of multiple inches per year as we're calculating. How consistent is that with them all being found within a narrow range of depths?

MEMBER POWERS: Doesn't that just tell you what the probability is your model is wrong?

MR. WHITE: It says what the probability is that the real crack rates are lower than we're assuming in our analysis.

MR. REILLY: That's highly driven by the residual strength, right?

MR. WHITE: Yes.

MR. REILLY: It's difficult.

ACTING CHAIR SHACK: Yes, and the crack growth rate here means the crack growth rate combining the material crack growth rate and the residual stress. You can really separate the two.

MR. WHITE: Yes.

ACTING CHAIR SHACK: But you're right. I mean, all they can prove is that their model is wrong. Overly conservative or it's predicting higher growth rates than can occur is what they're attempting to demonstrate. But you're right. I mean the situation is one.

MR. COVILL: Thanks.

MEMBER POWERS: Could I ask one question on this previous slide? Suppose that your analyses with these tailored crack rates where you deviate from the standard semi-elliptical shape showed radically different behavior than when you have an elliptical shape, what do you have to validate those analysis?

MR. COVILL: You're on again.

MR. WHITE: Yes. So the question of validation. That's one of the points that the staff has emphasized and we've been emphasizing that point also.

We'll be discussing this in detail tomorrow and the expert review panel that we've assembled will be assisting us with us. But we're envisioning a two step process.

Number one: To validate the level and residual stress inputs as we've been discussing, since they're a key input. But number two: As best we can based on whatever available data there is, validating the overall model. And that means using PWR past experience to the extent we have. We do have some experience of VC Summer who has been doing destructive examination work. And Ringhals in Sweden, they left two indications in service for a full year and got sizing information at the beginning of the year and the end of the year in some piping butt welds. And then destructive examinations at the end. So that was a unique opportunity where we had data on how the cracks grew during that year of service.

Then there's other PWR experience also. The Tsuruga experience in Japan. There's been a good amount of information that's been published and made available to the industry.

Then we move over to the BWR experience. And there is experience there that's been looked at in detail. And, yes, the materials are different but we will also use that information.

And then we move into a laboratory testing. And there has been some MRP sponsored work recently that's looked at how cracks and weld material grow. So that's another source of looking at how the influence of the stress intensity factor on crack development in a laboratory situation.

And then we're also going to look at the general literature with stress corrosion cracking and weld repairs. And there's some information that we'll also try to use.

MEMBER POWERS: In the end you will have something that shows that I predict the crack deviates from the semi-circular this way and, indeed, that's what happens in either experiments or in real situations?

MR. WHITE: That is the goal. In practical experience what we see is that in weld metal in particular we see that the crack growth tends to have a finger like pattern that extends in the through-wall direction with ligaments of material that trail behind the crack front. So even with a very simple loading a compact tension specimen where nominally the stress intensity factor is uniform across the cross section, when we test this in the laboratory what we consistently see or the usual case is we see that some areas of the crack front extend beyond other areas and there are areas of more resistant material. And Bechtel Bettis on the Navy side of the industry has looked closely at these sort of test results and concluded that there are islands of more resistent weld material due to differences in grain boundary energy in the weld microstructure.

So this more real world situation what we see is that in fact you would have ligaments of material that would tend to add strength against rupture while the fingers of crack growth extend through-wall to give leakage. So we'll be comparing to these sort of experience recognizing we can't model that very detailed microstructural type behavior, but we'll look at to what extent we can credit for that as being more conservative and the real situation being -- or the modeling being more conservative than the real life situation with these fingers of crack growth.

MR. COVILL: So in summary, our materials initiative is effective. This was the first guidance issued from the MRP. It was mandatory.

And aggressive baseline inspection program.

Seventy percent of these welds will be mitigated by the end of this year, that's overlayed or replaced.

Our inspection plan remains valid and consistent with other guidance that's out there.

We are working with the NRC staff to perform more analyses, as we just discussed, showing reasonable assurance of leakage prior to rupture and technical leakage prior to rupture, even considering the indications such as Wolf Creek.

We're going to complete that analysis in late June. And, as you've heard, we have our first meeting with the staff tomorrow on this. And we did receive the letter from Jim Dyer with some of their questions, comments, recommendations and thoughts.

And that concludes MPR's part of the discussion.

ACTING CHAIR SHACK: Any questions from

the members? Then I suggest we take a 15 minute break and staff will come back for some comments on where they think the advance analysis is going.

Thank you.

(Whereupon, at 2:57 p.m. a recess until 3:16 p.m.)

ACTING CHAIR SHACK: Just as Ted walks away, I bring us back into session. Ted, it's all yours.

MR. SULLIVAN: Thank you.

So I indicated in my earlier remarks that we provided a letter to industry, dated March 5th. And this was the letter that we sent to Jay Thayer of NEI. And it was responding to a letter that Jay Thayer send Jim Dyer of NRR, dated February 14, 2007.

And one of the things that we indicated in that letter is that we do very much plan to be actively engaging with the industry as they work their way through this project.

In the attachment to this letter we covered, I think, eight different areas that we would be important areas for us to consider the number of potential nonconservatisms and uncertainties int he original calculations would --

let me start that sentence over again.

There were a number of potential nonconservatisms and uncertainties in the analyses that NRC did and which Al presented today. And we wanted to point out the ones that we thought would be areas that we thought need to be addressed for us to be able to come to some satisfactory resolution on this issue.

So the first one we included in that letter had to do with benchmarking. And we're talking about benchmarking the software that industry is doing. And what we're indicating in the letter and in this viewgraph is that NRC contractor, specifically EMC_2 and Dave Rudland, are modifying our fraction mechanic software or the software that EMC_2 uses to basically parallel the kind of changes that Dana was talking about to specifically remove the constraint of the semi-elliptical flaw front. And what we're basically saying with this second bullet here is that the work that we're doing we consider to be work that industry can use to benchmark their software.

The area of validation I don't really think I need to say anything more. There was a good healthy discussion in the last presentation when

Glen White got up to answer some questions. So if I can, I'll just move on to the next one.

The next area that we pointed out was safety factor. And basically what we point out in the letter is that ASME requires the use of safety factors. We gave an example. And we just indicated that the NRC staff views that industry should consider use of a safety factor to cover uncertainties in the analyses, and also use of a safety factor in their estimation of leakage.

MEMBER POWERS: That somewhat begs the question of what size of a safety factor to use, doesn't it?

MR. SULLIVAN: It does and we unfortunately don't have answers to questions about specifically what our acceptance criteria would be in each of these areas. I think it's going to have to depend on how the analyses unfold, how much uncertainties we think really need to be addressed with safety factors.

MEMBER POWERS: Now on many of the pheonomenological fields are moving to very formalized uncertainly analyses, Monte Carlo, Latin Hypercube Sampling and things like that. Do you have anticipation that you would do such a thing?

MR. SULLIVAN: I haven't thought about it. I don't know whether Al or Dave might have comments.

MR. RUDLAND: I think it's a good possibility that we could do some of those types of analyses. Again, I think our work scope is still in the rough stages, but I think we've expressed to the industry the need to take into account some of the probabilistic aspects. And so of course we'll be doing that as part of our studies. But we have a working code right now for doing some of this type analysis, however this type of nonidealized growth is not incorporated in that analysis at this point.

MR. CSONTOS: And I think the safety factor here will be related to what you talked about, what kind of safety factors go in there will depend upon what other uncertainties that we can deduce. And it will be depend on what other areas that we look at. And we'll go into those other areas here. But that safety factor will be related to what uncertainties we can diminish and be more certain about, but still understanding that even though you may change the methodology here, which is changing the elliptical crack shape to a more just K driven, that the uncertainties at the beginning of analysis to the assumptions even though you change the methodology does not make the answer more certain. It still has that uncertainty. And we'll evaluate that.

MR. SHANG: Yes. I just want add one more comment.

What industry proposed and what the prior analyses that the NRC is going to do is still a deterministic analysis. So they're not probabilistic approach.

What we are hoping for is that if we can use some kind of a combination of safety over reasonable number and then combine with some kind of sensitivity study addressing all the major uncertainties of parameters, then we could bond the problem.

MR. CSONTOS: Just to dovetail on that.

We in Research have a program that's trying to develop probabalistic fracture mechanics model to address some of the uncertainty issues. And through the analysis you were just talking about. That's ongoing now. It will be ready in a few years, not right now.

Parts of that is what Dave was talking about that will may be able to pulled out of that code to be used to address those uncertainty analysis.

So we just have to see what is ready for prime time now versus what we have to work on.

MR. SULLIVAN: Okay. The next area is weld residual stresses. And I think the statement that we put here is what we consider as kind of a summary statement. We believe that industry needs to demonstrate that the results would not be significantly effected by other reasonable residual stress distributions that could be assumed. And I think it's industry's intent to do a number of sensitive studies around weld residual stresses. And we're just going to have to work amongst ourselves and work with industry to see if we are of the same mind as to the cases that are being analyzed.

Multiple flaws and flaw sizes, I think we had some discussion on that earlier in the presentation. We think it's important to bound the types of flaws, bound at Wolf Creek but also account for the possibility of multiple crack initiation and linkage. And that's about all I really wanted to say on that.

Crack growth rates. Different crack

growth rates can result in different crack profiles. And what we indicated to industry is that we believe they need to address the effect of crack growth variability on the crack profile.

The next area is predicting growth by K. There is evidence that in-service growth of stress corrosion cracks does not match fracture mechanics predictions. There's a number of possibilities for these differences that I've listed in the second bullet. And what we're pointing out is that this is an issue that we believe industry needs to work on. And we'll be actively discussing this issue also.

MEMBER POWERS: It seems to me that one of the ancillary side comments that were made industry was talking about some sort of a fractal distribution of resistance to crack propagation in the material. I mean, is this some sort of percolation model of crack propagation emerging from this kind of a discussion?

MR. SULLIVAN: I wasn't part of that sidebar. Do you mean during the break?

MEMBER POWERS: No. During the presentation in response to a question. There was a suggestion --

MR. RUDLAND: I think he's talking about

when Glen was talking about the fingers of crack growth. Is that correct?

MEMBER POWERS: That's correct.

MR. RUDLAND: Yes.

MEMBER POWERS: Does that argue for some sort of a percolation model of crack propagation.

MR. SULLIVAN: I am not sure what that is, a percolation model.

MR. RUDLAND: I think it lends -- you said studies and to how crack growth rate variation along the crack front changed the crack profiles.

MEMBER POWERS: I don't know how a sensitivity study would come up with fingers, other than by a percolation kind of modeling.

MR. RUDLAND: Yes, I'm not sure either. I think this is a good point for our technical discussion tomorrow for sure.

Does Glen have some ideas about that?

MR. WHITE: I would just add that, yes, that's the sort of thing that we expect to discuss tomorrow, what are the limitations of a fracture mechanics-based crack growth rate regime. And what do we need to do to consider those sort of effects.

There is the ability in the software that we're using to use different crack growth rate equations at each point on the crack front. So that's something --

MEMBER POWERS: That I understood.

MR. WHITE: -- that we'll potentially want to look at it. But I don't think that it's not realistic to model the detail microstructure. But we will have those microstructural effects that might lead to these finger growth and percolation crack growth. But we will have to consider these things in our project and put together written discussions about how this effects the results and how we need to -- and other issues involved in the limitations of fracture mechanics there.

MR. CSONTOS: But in terms to be done by June 30th.

MR. WHITE: A large amount of work was done on the crack growth rates, MRP-115 was the work. Bill Shack was involved in that work at the beginning.

MEMBER POWERS: Is that a recommendation for the work or is that what you have to overcome?

MR. WHITE: No recommendation. We had very good expert participation from the national labs and international participation under EPRI's direction. So we thought that was a very good -- a successful project. And a lot of these questions have been looked at that expert panel. So we'll build on that work. We're not recreating that work.

MEMBER POWERS: Never invent when you can steal, that's --

MR. SULLIVAN: Okay. The last of these eight points that we made is probably a pretty obvious point. But what it has to do with is that the crack stability methodology that are traditionally used for plates either assume semi-elliptical or constant depth surface cracks. And we're talking here about having different crack shapes. So we're just pointing with this that for the crack stability part of these analyses that the stability of nonidealized surface cracks and through-wall cracks will have to be included in the analysis for accurate leakage and rupture predictions.

MR. CSONTOS: And that's from the analysis I showed on the slide that showed, that it said 8 out of 10 cases that led from leakage to rupture, the margin, it was actually 10 out of 12 because two of the cases the surface crack stability was not there. And so that's where we're going with this.

MR. SULLIVAN: Okay. So I just wanted to transition here to some summary conclusions. Basically what the analyses indicated and what caused us the certain with this whole issue of Wolf Creek was that we found no margin between leak and break. Very little margin actually for the relief line and even for the safety line there were a number of cases where there was no margin between leak and rupture.

So we reached the conclusions that, as it's stated, inspections or mitigations need to be accelerated for some plants. What that really translated into is that we felt that all the inspections should be completed in 2007.

We also concluded that to address possible leaking flaws that it would be important to have enhanced RCS leak monitoring frequency action levels and actions put in place.

And as I indicated earlier, the effected licensees, which I think turns out to be basically 40 licensees, have agreed to those actions. The reason it's 40 as opposed to some of the other numbers that we may have been throwing around, is that there are some plants that have inspected and that are only going to inspect. And one of the things that I actually didn't get into in here is reinspection frequency.

We also asked licensees to reinspect these welds on a four year frequency. So some of the plants that provided us commitments only needed to address the reinspection frequency.

And then as I've been discussing in the last few minutes, industry is pursuing additional analyses. We're going to follow that work closely. And if we conclude that reasonable assurances provided from that work, the plants with outages in 2008 will be able to avoid the 2007 outages that they've committed to.

That ends my presentation.

Now as per request that we received rom ACRS, Matt Mitchell has agreed to join us and present some information on Duane Arnold. If there aren't any more questions, we'll transition to a short presentation from Matt Mitchell.

ACTING CHAIR SHACK: I think we asked this question, you know, is there any consideration to going back to Wolf Creek and taking a sample.

MR. SULLIVAN: I think industry would have to answer that question.

MR. MARION: This is Alex Marion. NEI.

Could you repeat the question, please?

No, seriously. There has been discussions with Wolf Creek's senior management over that possibility and the discussion are continuing, is all I can say at this particular point in time.

ACTING CHAIR SHACK: Well, I imagine you get the -- reception.

MR. MARION: It gets all kinds of responses, I assume you.

MEMBER POWERS: I guess the essential question that comes up is if you argue that Wolf Creek is an outlier, something unusual, something very different how do you agree that even based on calculations of the norm that plants should be allowed to defer until 2007? I mean, aren't they as likely to be outliers as Wolf Creek?

MR. SULLIVAN: How do we argue that plants should be allowed to go as late as 2007, is that --

MEMBER POWERS: 2008. Suppose you do your calculations that say, you know, things are pretty much like we thought they were and that Wolf Creek is something unusual, then why is reasonable to let those other plants to go to 2008? I mean, they're as likely to be outliers as Wolf Creek, I would presume.

MR. SULLIVAN: I mean the best thing I can say is that there's a lot of uncertainties. And when you have uncertainties, or when the staff has uncertainties we tend to try to err on a more conservative side.

MEMBER POWERS: Then you be forced to then do a 2007 no matter what your calculations showed?

MR. SULLIVAN: Well, that's essentially what the agreements that we've got from the licensee is to inspect in 2007 pending these results.

MEMBER POWERS: I mean I don't see how the results change that decision to inspect in 2007. I don't see the mechanism by which I derive anything out of the results that causes me to change the inspection in 2007.

MR. SULLIVAN: What's caused our concern is the possibility that rupture would occur without prior evidence of leakage and that the point of these calculations is to try to demonstrate that there is margin between leak and rupture.

MR. CSONTOS: Enough to detect leakage and enough leakage to detect in a short enough period of time so that actions can be done. And that's where through these calculations show that there is a finite period of time with uncertainty and sensitivity analysis done to legitimately say and have a basis to say that there will be some period of time when we can detect and ensure action. Then that's where the analysis could help us with that decision. Well, your decision.

ACTING CHAIR SHACK: Yes, I mean I think that you're going to have demonstrate that for what you think are reasonable residual stresses or reasonable range of crack growth rates or reasonable range of loadings and a reasonable range of crack sizes considering what you found at Wolf Creek and the possibility that others or even -- will still give you a reasonable probability that you're going to have this, then you come to that conclusion. Now, just how you're going to get there is a different question.

All those have to be considered, obviously.

MR. CSONTOS: Well, from the difference between what we've done in the past in our analysis to what we know how, we know a lot more about the weld repairs and we know a lot more about some --

ACTING CHAIR SHACK: Not interested just

in Wolf Creek.

MR. CSONTOS: No, that's right.

ACTING CHAIR SHACK: It's the weld repairs that could have taken place anywhere.

MR. CSONTOS: But part of the task that we involved, I believe and tell me if I'm wrong, but there is an effort by industry to go and look at the history of whatever those nine outlier plants are to find out what their weld repair history is. And we can then look at those in our analysis, in our parallel analysis, use some of that work to define what the appropriate range of weld residual stresses and what's the range of weld repair residual stresses that we evaluate specific to those that's past.

ACTING CHAIR SHACK: Unless there's any other questions, we can move on to Duane Arnold, everybody's favorite.

MR. MITCHELL: Yes. An oldie but a goodie.

ACTING CHAIR SHACK: An oldie but a goodie.

MR. MITCHELL: I thank Ted for the introduction. Yes, I'm Matthew Mitchell, Chief of the Vessels and Integrity Branch.

And we were invited to come over. I was invited to come over and give you at least a couple of slides with regard to the situation that has arisen at Duane Arnold since about the middle of February when the cracking that was found during this last outage was reported. So I will proceed what will be a very short presentation, but I anticipate that there may be more time for questions and less time for presentation at this point.

ACTING CHAIR SHACK: Just what the jet pump riser at Duane Arnold? Ten inches in diameter?

MR. MITCHELL: This particular location the ID is 11", wall thickness is about 1.1". For the OD it's about 13.2. That was the most recent information that we'd gotten from the licensee. And in this case we're talking about actually an Inconel 600 safe end welded to the low alloy steel reactor vessel. So there's an Inconel 82/182 weld obviously connecting the two pieces.

ACTING CHAIR SHACK: It's just not a sensitized Alloy 600 safe end, is it?

MR. MITCHELL: I believe based upon their experience in the middle to late 1970s that the safe ends that are in there now are improved, yes. They did away with the original safe ends in about '78 or '79 when they did a safe end replacement project based upon the earlier cracking event at Duane Arnold.

So I'll just proceed down the slide. And I think a lot of this information has been given to the Committee, because I provided Gary with some packages of information that we had been developing for our management. So if this seems redundant, I apologize.

But as we just covered, the general configuration of the location, the cracking that was discovered in two of these safe end-to-reactor vessel weld locations has been characterized as being roughly 6" to 7" long and roughly 55 to 75 percent through-wall. That's the best characterization the licensee has given us based upon their 2007 ultrasonic test data.

The licensee has gone back and looked at data from prior examinations of the two welds in questions. And one of the welds had been inspection in 1999, 2005 and then again in 2007. The other one had been inspected in '99 and now again in 2007.

And based upon relooking at their former UT data, they have reported that they believe that they could see an indications of these flaws in the prior ultrasonic data. The flaws were not called when the data was originally taken in 1999 and 2005. But now that they know that the flaw is there and they know what to look, they feel that they can actually indications of it.

There were reports that if we talk about the N2F nozzle, which was the original one that was discovered to be cracked and the one that was inspected in 1999 and 2005, the licensee identified that there were some complications with those inspections. The '99 inspection was done with the weld crown still in place, which may have impeded their ability to get complete coverage and to find this flaw if it were in existence at that time. The 2005 data in the vicinity of the flaw, which is on essentially dead bottom center of the weld, they reported that there was indication of transducer lift-off. Apparently the automated system sort of pulled away from the pipe from the weld location and was giving them sort of an intermit signal, which may have interfered with their ability to detect this particular flaw.

The staff is very interested in having our own independent experts look at this data. We have already requested all of the ultrasonic data files from the licensee from the '99, 2005 and 2007 examinations. And we're putting the appropriate contracts in place with our friends out at Pacific Northwest National Lab, Steve Doctor and Mike Anderson to do an independent assessment of the licensee's UT data to try to confirm that in fact these flaws were visible from the prior data and that the prior data supports the conclusion that the licensee has come to, which is that in effect the flaws do not show significant amounts of growth between those prior inspections and what was found in 2007.

That is the basis that we're working on at this point of time based upon the work that has been done by the licensee, their UT vendor and EPRI to look at the current and past UT data and to better understand the situation at Duane Arnold.

MEMBER BONACA: They were not characterized or recognized. Isn't that in and of itself a concern? I mean what all the measurements or examinations taken by the other licensees? I mean, you know is the story we hear about VC Summer. The flaws were there, they were not recognized. And when you say that it raises the question about the other plants.

MR. MITCHELL: The answer is absolutely. And that is exactly the perspective that the staff is looking at the information from Duane Arnold. We're right now looking at it from a, if you will, a personnel performance issue standpoint. And we have challenged the industry via the BWR Vessels and Internals Project to go back and communicate with the entire BWR fleet and to have them now that we know about the Duane Arnold situation, to go back and look at old UT data files to make sure that they do not have a situation similar to what was experienced at Duane Arnold.

MEMBER BONACA: Okay.

MR. MITCHELL: To understand whether they had any inspections that may have been subject to a lift off concern of the transducer, if they might have had any indications for example that they called a subsurface flaws that were just not able to discriminated as surface connected at the time the inspection was made. They should go back and look at those indications more suspiciously. That it may be indicative that they do actually have a relatively large surface breaking flaw in place.

So that is certainly part of the message that has been carried back to the industry through the BWR VIP. So, yes, that is precisely our perspective on the Duane Arnold experience.

And I'll say part of that perspective comes from, I think, my second sub-bullet under the second main bullet, which is that the cracking observed at Duane Arnold is in effect consistent with what we have from prior BWR experience. I think everyone in the room knows that the BWRs have a very long history of stress corrosion cracking flaws going back to the early 1980s even, in sensitized stainless steel and Inconel materials.

So the difference I would draw between I think the story you heard earlier today about Wolf Creek and the story about Duane Arnold is that Duane Arnold appears to be not greatly different from things that we are already well familiar with. If indeed the current reinspection of the ultrasonic data suggests that this flaw was in fact not growing at an otherwise unexpected crack rate based upon the fact that Duane Arnold has been operating under hydrogen water chemistry since at least 1987, it does not appear to be indicative of certainly a new phenomena, not something that we are not already familiar with. And we do take some comfort from knowing that, although objectively speaking the flaws in question here appear to be significant, and they are. But it does not appear to be a new manifestation or a new degradation mechanism with which we are not already familiar.

And that is essentially the proviso that we are operating under at this point in time as we approach the overall problem and the generic implications of it.

I'll add that with respect to trying to put these flaws into perspective, the licensee has done, although the staff has not reviewed, a margins analysis with respect to the significance of these particular flaws. They reported that they postulated a hypothetical through-wall flaw of 100 degrees in arc length and could demonstrate, although such a flaw would obviously be unacceptable because it's a through-wall flaw, that such a flaw would have code margins under all licensing basis loading conditions. That's just sort of a point of comparison with respect to the sizes that the flaws actually were they were discovered at Duane Arnold.

Next slide. Thanks.

So again, going back to both the Duane Arnold specific questions that could be raised and the questions about general implications of the industry, we really pursuing both questions. One is to continue looking at the Duane Arnold data further to understand what happened in those prior inspections and to whether this is indicative of a performance deficiency on the part of Duane Arnold and/or their vendors who were performing the prior UT exams.

The other question is to go out to the fleet. And the BWR VIP issued a letter, dated I believe it was -- well, I've got the letter with me. If I can find it in this stack. It was dated on a recent Friday. And it went out the 23rd. It went out to all the licensees for urgent action to:

(1) Particularly for those plants in spring '07 outage to reassess their plan for doing inspections if Inconel welds and whether or not the Duane Arnold data should effect their plans in their immediate outage. And for them to provide information to the BWR VIP regarding the inspection history of all the plant's welds, what had been found, what it had been called as, et cetera, so that the BWR VIP could assemble a fleet-wide database for these particular welds and report back to the staff.

From talking to Robin Dyle of the VIP

this morning, the latest information was that they expect to get all the answers back now by either the end of this week or very early next week. There are a few stragglers that will be coming in in just a bit. And the BWR VIP plans to be ready to talk to the staff by the end of the month regarding the overall set of data that they've acquired from the fleet regarding the inspection of these welds.

And the staff will based upon that information and based upon the additional information that we can extract from what we know about Duane Arnold, then consider what generic actions may or may not to be taken in light of the inspection program which is already being implemented either ASME code requirements and/or through the BWR VIP requirements for the inspection of these welds under VIP 75. And that goes back to, of course, Generic Letter 80.01 as well.

So with that, I certainly would be happy to take any additional questions.

MEMBER BONACA: I had a question regarding the previous slide. Bottom, the last bullet, the flaws had substantial margin to failure. Could you expand a little bit? One of them was 6" long, 74 percent through-wall.

MR. MITCHELL: Okay. This goes back to the point I had mentioned where they had done an analysis to show that if you had considered a flaw that was a 100 degrees in arc length and completely through the wall, such a flaw would still have ASME code margins to failure. So there you are talking about if you put it in terms of percent area cracked of the cross section, that flaw that's obviously 100 degrees long -- a 100 degrees in arc length and all through through-wall is about 28 percent roughly of the cross sectional area. The largest flaw that was found, even if you assume the 7" long flaw was 56 percent through-wall over its entire length, that's about 5 percent of the complete cross sectional area. An Alloy 82/182 type location is generally going to fail it a limit load mode. So you can draw a lot of conclusions based upon the remaining cross sectional area that's available to carry load.

So in that regard, at least, there would be substantial margin.

And all of that is also predicated on confirming the fact that the crack is not growing at an exceptional rate. In general, obviously, if you believe in effective hydrogen chemistry at this location and the differences in temperature between certain very warm locations in a PWR versus the BWR temperatures, you'd expect a generally much lower crack growth rate in the PWR environment as well. So you have to kind of keep that in mind when you're starting to compare what the story about PWR cracking potentially in the pressurizer surge line or a hot leg versus cracking in a BWR in a location like this. They're --

ACTING CHAIR SHACK: I mean hydrogen water chemistry doesn't necessarily give you a whole lot of comfort here. Because Alloy 182 certainly can crack in low potential environments. But the temperature is a big help.

MR. MITCHELL: The temperature, yes. Yes. Yes. I don't think anyone would suggest that for this material that even the hydrogen water chemistry is a panacea. It can slow things down, but it --

ACTING CHAIR SHACK: Well, I'm not sure. It might even speed them up. I mean Alloy 182, like all nickel, is wonderful. It cracks at high potential, low potential. I'm not sure where the optimum potential for that would be.

MR. MITCHELL: At least based upon my conversations with our colleagues in Research, and

Dr. Cullen in particular, we take some comfort at that at least. But, you're right. It's not the complete answer to stopping these cracks necessarily. But like you say, the temperature difference is significant.

MEMBER POWERS: Why is cracking being an uranous temperate dependent?

ACTING CHAIR SHACK: Since I don't really understand the mechanism of PWSCC, I have a hard time answering that question, except to say that it seems to do it.

MEMBER POWERS: It's not obvious to me why it sound.

ACTING CHAIR SHACK: No. But the experiments seem to indicate that it does.

MR. MITCHELL: The experiments are modeled with a temperature dependence that's reflective of the data.

ACTING CHAIR SHACK: Is this standard construction for BWRs that they do have the 182 dissimilar metal welds or some of them 182 and some of them are 308?

MR. MITCHELL: I can't say that I know whether it is standard or not. That will be part of the information that we will get from the BWR VIP.

I have no reason to think that Duane Arnold is a substantial outlier in this regard in terms of how it was constructed. I have no reason to think that it was unique in any way, shape, form or fashion in terms of the materials chosen or the processes used in the construction.

ACTING CHAIR SHACK: It's that we have variability in PWRs.

MR. MITCHELL: Of course, you also have variable reactor vendors as well.

ACTING CHAIR SHACK: But even within a single vendor in the PWR world.

MR. MITCHELL: Yes. Yes, that's true.

So we will know more definitively the answer to that question when we get the VIP survey originals back. We have not, to my knowledge, ever accumulated a specific database on that fine point in the past.

ACTING CHAIR SHACK: Thank you very much.

MR. MITCHELL: You're welcome.

ACTING CHAIR SHACK: I guess what we need to consider is -- how much time do we have at tonight's meeting?

MR. HARRINGTON: About an hour and a

half.

ACTING CHAIR SHACK: About an hour and a half.

MR. HARRINGTON: An hour and 45.

ACTING CHAIR SHACK: People have suggestions on what we should have presented at the main Committee.

MR. SULLIVAN: Well, one question is do you want Matt Mitchell to come back.

ACTING CHAIR SHACK: I think on Matt's case, no. I think we're okay on that. You know, we'll let that one just ride for a while. You know, I'll mention it in a Subcommittee report,

But on the essentially Wolf Creek situation?

MR. HARRINGTON: Obviously, we need to cut our presentation down somehow.

ACTING CHAIR SHACK: Yes.

MEMBER POWERS: Well, it seems to me, Bill, that I would orient it more to a factual -- just an information briefing to the full Committee, wouldn't you?

ACTING CHAIR SHACK: Well, we've actually had that. I was going to almost start with just where we're at at sort of almost slide 27. You know, what the regulatory action at the moment and how everybody plans to move forward.

MEMBER POWERS: Yes.

ACTING CHAIR SHACK: And, you know, you could give a brief introduction, Ted. But I think, then let industry talk about their plans to go forward and then you come back with your comments on their plans to go forward. And it might not even take the hour and a half.

You know, we've had the sort of factual briefing, I think. And I think it really is at this point what the actions that have been taken and the actions that are planned that are of the greatest interest.

MR. SULLIVAN: Not to be contrary --

ACTING CHAIR SHACK: No.

MR. SULLIVAN: But on February 2nd there were some questions about leakage, and I don't remember who was asking those questions. But it might have been somebody who wasn't here today.

ACTING CHAIR SHACK: Well, that's a distinct possibility.

MR. SULLIVAN: So we didn't cover leakage in the last presentation, but we did in this one. So an alternative, again not to be contrary, is to start on page 22 instead.

ACTING CHAIR SHACK: That's fine. I just didn't want to go over things that we had gone over, and I want to make sure that we get in. But I don't think there's any trouble in covering that in the time that we have.

MR. SULLIVAN: Yes. It's still only like 14 slides or something.

ACTING CHAIR SHACK: Yes. That should not be a problem.

MR. SULLIVAN: Okay. Thanks for the advice.

MR. MITCHELL: Dr. Shack, I hate to interrupt. Could I offer one correction to what I said earlier in answer to Dr. Bonaca's question. I believe I said that when I made that comparison between the hypothetical through-wall flaw it was 28 percent versus 5 percent. It's actually 28 percent versus 12 percent. The flaws that were found that were about 12 percent of the cross section.

IT was 5 square inches. I misread my own note. That's about 12 percent. It's still a sizeable amount, but I just wanted to make sure I told you the right story.

ACTING CHAIR SHACK: But you're pretty

close to the code 75 percent through-wall?

MR. MITCHELL: Oh, precisely. Completely different criteria there, but yes.

ACTING CHAIR SHACK: Different criteria, right.

MR. MITCHELL: And in fact both of these flaws are being well overlay repaired by the licensee prior to go back to service. So I wanted to make that clear, too. That they are weld overlaying these.

ACTING CHAIR SHACK: Not dispositioning by analysis, huh?

MR. MITCHELL: No. And they have actually gone in. They expanded their inspection scope. I think I did not mention that. To inspect all of the rest of nozzles of similar configuration before going back to service as well.

ACTING CHAIR SHACK: Anybody have any other comments they'd like to make?

PARTICIPANT: (Off microphone)

ACTING CHAIR SHACK: Well, I did make a suggestion. And I guess they can take it or leave it, which was to focus on your plans to go forward. The finite element, yes. If that's acceptable to you, that seems reasonable to me.

PARTICIPANT: It won't take up much time.

ACTING CHAIR SHACK:

We don't need to fill time.

MEMBER KRESS: Dr. Shack, the guy over here doesn't know what's going on. He can't hear it.

ACTING CHAIR SHACK: Okay. The question was what industry should present at the full Committee meeting. They accepted my suggestion that we focus on the advanced finite element analysis is the way forward to address the NRC questions.

I think we can go off the record now.

(Whereupon, at 4:03 the meeting was adjourned.)