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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

MEETING OF THE SUBCOMMITTEE ON REGULATORY POLICIES AND PRACTICES

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FRIDAY, NOVEMBER 21, 2003

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Dr. William J. Shack, Chairman, presiding.

MEMBERS PRESENT:

WILLIAM J. SHACK	Chairman
F. PETER FORD	ACRS Member
THOMAS S. KRESS	ACRS Member
GRAHAM M. LEITCH	ACRS Member
VICTOR H. RANSOM	ACRS Member
JOHN D. SIEBER	ACRS Member
GRAHAM B. WALLIS	ACRS Member

ACRS STAFF PRESENT:

SANJOY BANERJEE	ACRS Consultant
MICHAEL R. SNODDERLY	Staff, Designated Federal Official

ALSO PRESENT:

ROBERT L. TREGONING	RES
LEE ABRAMSON	RES
DAVID O. HARRIS	Engineering Mechanics Tech, Inc.
E. MCKENNA	NRR
WAYNE HARRISON	STPNOC, WOG
ART BUSLIK	RES/DRAA/PRAB
STEPHEN DINSMORE	NRR/DSSA
ALLEN HISER	RES/DET/MEB
YURI ORECKWA	NRR/DSSA
RALPH LANDRY	NRR/DSSA
MARK KOWAL	NRR/DSSA
GLENN KELLY	NRR/DSSA/SPSB
ANDRE DROZO	NRR/DSSA/SPSB
ALADAR CSONTOS	RES/DET/MEB
JOHN CLANE	RES/DLAA
RICHARD DUDLEY	NRC/NRR/DRIP

AGENDA

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

8:32 a.m.

CHAIRMAN SHACK: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards -- of the Advisory Committee on Reactor Safeguards, Subcommittee on Regulatory Policies and Practices.

I am William Shack, Chairman of the Subcommittee.

Members in attendance are Peter Ford, Tom Kress, Graham Leitch, Victor Ransom, Jack Sieber, and Graham Wallis.

The purpose of this meeting is to discuss the LOCA.

Banerjee -- Professor Banerjee is joining us today.

The purpose of this meeting is to discuss the LOCA Failure Analysis and Frequency Estimation being developed by the staff in response to the Commission's March 21st, 2003 staff requirements memorandum on recommendations for risk-informed changes to 10 CFR 50.46, acceptance criteria for emergency core cooling system for light water nuclear power reactors.

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

Michael Snodderly is the designated federal official for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on November 10th, 2003.

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

It is requested that speakers first identify themselves and speak with sufficient clarity and volume so they can be readily heard.

We have received no written comments or requests for time to make oral statements from members of the public today regarding today's meeting and again, the focus of today's meeting will be on the expert elicitation in support of -- of 10 CFR 50.46 in defining the large break LOCA frequencies and we'll now proceed with the meeting and Rob Tregoning of the Office of Research will start it out for us.

MR. TREGONING: Okay. Thank you, Professor Shack.

As Professor Shack mentioned, I'm Rob Tregoning from the Office of Research, Division of Engineering Technology in the Materials Engineering Branch.

The morning part of the meeting as Professor Shack had indicated we'll be focusing on details of the expert elicitation. The last time we were in front of you briefing status was July in the main committee and at that time, I think we had a -- we had a relatively short amount of time scheduled, about an hour and a half and at the time, there was -- there was definite consent that we needed to have a longer subcommittee meeting where we could really prob the details of -- of what's happening in the elicitation. What we're doing, what our approach is. So, that's the focus of today.

Many of the slides or some of the slides were presented that I'm giving and some of the topic areas that I've given were provided in a very cursory sense during that main committee meeting in July. Today, we've got sufficient, more in depth technical background information that we can delve more deeply into the subject.

There will be three presenters in the morning meeting, myself and Lee Abramson and David

Harris who is a contractor on this exercise from Engineering Mechanics Technology.

I just wanted to -- the schedule of the morning meeting is -- was in the public agenda, but wanted to revise it a little bit and just tell you how this morning is going to play out. The three of us are going to be essentially giving a tag-team presentation. You have three packets of material there.

The first packet is my slides which I'm starting with now and at certain points, I'm going to break from the slide and move to the next packet. So, when it's Lee Abramson's term to speak, there's a separate package for Lee. When Dave Harris speaks, there's a separate package for Dave. So, hopefully, that won't cause any confusion.

CHAIRMAN SHACK: Rob, have you -- have you done the second probabilistic fracture mechanics analysis?

MR. TREGONING: The second?

CHAIRMAN SHACK: There was -- it's -- there was suppose to be two. One was suppose to be based on PRODIGAL and one was suppose to be done by PRAISE.

MR. TREGONING: Yes. Yes.

CHAIRMAN SHACK: And has that been done?

MR. TREGONING: Yes. We -- we have -- and we'll -- we'll see a little bit more of that.

CHAIRMAN SHACK: Will we see a comparison of the two?

MR. TREGONING: We will see a comparison of the two. Yes. Although, we -- we have to be careful because comparisons are difficult because even though and I'm going to get into this in great detail, but even though we attempted to solve similar problems, it's -- it's not -- you know, there's some inconsistency even in the problems that were solved and so, differences are going to be due to those inconsistencies and also due to the different approaches themselves. So, we're going to see some of those later.

The -- the thing which is probably -- that was not done with PRODIGAL is that Dave had some initial work that was done in June. We had a meeting of the experts in June to discuss that work and then there was some follow-on runs made. As a result of that work, Dave revised his numbers for those runs. PRODIGAL runs were never -- have not been revised.

So, while both the runs were done, one set of runs are -- are certainly much more refined. The other set are -- I would consider them more preliminary.

So, when we see those comparison and we look for differences, there are a few things that we'll have to keep in mind to -- to look at those. Okay.

CHAIRMAN SHACK: Yes.

MR. TREGONING: So, I will start off with an overview of the effort and the exercise, what we're trying to do.

Lee will come up and talk about the expert elicitation process. The theory behind it a little bit, but he'll -- he's really trying to tailor this talk to what we're doing in this effort. So, this will be a focused talk on expert elicitation methodology.

Then I'll take back over and we'll go into pretty good detail to give you a sense of how the expert panel and facilitation team developed technological issues and how we structured what we're calling our piping base case development exercises and -- and these piping base cases, those are the things that will run with PRODIGAL and PRAISE essentially.

After this, I will essentially lead up to a presentation by Dave Harris where he was one of the base case development team members. We had a subset of the panel which provided these base case estimates. Dave Harris was one of those members. He's going to provide detail into his calculations only. We'll see a lot of detail about his approach.

At that time once Dave is finished, I'll come back and summarize the base case work of which some of those comparisons we'll be able to make. Then I'll go into more detail about the elicitations question structure and actually go through some of the questions themselves so you can see what we're asking and then I'll finish up with status, where we're at in this effort.

Just wanted to briefly remind the panel of the times that we've been in front of you briefing this effort. We started back in March 2001 which was essentially a background talk, why we thought we needed to pursue this and the last briefing we gave was in July which was in front of the ACRS main committee and at the time, we gave a very brief status and approach of the expert elicitation realizing the schedule was tight that day. So, because of questions and the concerns raised by the committee that wanted to provide more in depth information on this exercise, that's really the reason we're back here today.

Wanted to just highlight some of the program milestones since January 2003. So, really what we've done this year.

We conducted the kickoff meeting of the expert panel in February. Around March, the SRM was issued which gave the -- the staff their formal requirements related to this exercise.

We had what we're calling this base case review meeting in June. That's when the experts got back together, reviewed the preliminary work that the base case team members had done to develop estimates, provided some additional feedback to the experts and -- and we identified some additional sensitivity cases and other runs that we wanted to do. So, this was the meeting we had in June.

We've had several public meetings to discuss the 10 CFR 50.46 effort in general. These June/July meetings here had fairly significant focus on the LOCA work. So, we've had some input from NEI and -- and other members of the public during these meetings.

In June, there was an international CSNI/CNRA sponsored workshop on LB LOCA redefinition. I think we probably had about 12 to 15 countries participating in that. It was held in Zurich, Switzerland. It's a two-day workshop. Part of that was we presented -- the U.S. presented their plans, their rationale for why we're even doing the elicitation, why we're looking at revising 10 CFR 50.46 and the approach that we're following.

Certainly during this meeting, there was certainly a low of interest from the international community. They agreed with us that they think the -- the reevaluation or the revision of 10 CFR 50.46 is technically feasible, but they're interested in -- in -- they're adopting a wait and see attitude for the most part. They want to see what the regulations are going to look like. They want to see more of the results that we're getting out of this exercise.

So, we may -- we essentially made an agreement, an informal agreement, that in about a year's time or so we should have better focus. We'll be back in touch with the international community to get some more explicit feedback from them.

MR. WALLIS: Does that mean that you are the only group that's actively investigating large break LOCA frequency and maybe changing the rules? Is there no other country that's doing it?

MR. TREGONING: The -- the other countries are focusing more on modifications of the rule for new plants.

We are the only country that I'm aware of that is looking at modifying the rules for existing plants.

So, there -- there is a lot of sentiment as -- as to the technical feasibly and there was some interest from the international community on why we were focusing efforts on existing plants. So, that was -- that was quite a expansive topic of discussion during the workshop.

MR. LEITCH: Bob, you used the term base case review. I'm not sure in what sense you're using that word. What -- what do you mean by base case?

MR. TREGONING: I'm going to define this later.

MR. LEITCH: Okay.

MR. TREGONING: The base cases are essentially well defined sets of conditions that the expert panels define for piping systems. So, what are well defined sets of conditions? Loading, materials, geometry, and degradation mechanisms.

MR. LEITCH: Okay.

MR. TREGONING: We tried -- we tried to define problems that we thought were solvable using codes and also by looking at service history experience.

So, these are -- these make up a very important yet small part of the whole LOCA frequency efforts.

MR. LEITCH: Okay.

MR. TREGONING: But -- but, we'll -- we'll talk a lot more about this term base case, how it's defined, how some of the calculations are done and Dave Harris is going to go into extreme detail on his approach to tackling the base case calculations.

MR. FORD: If I could just one question to that. Will you also be discussing the fact that for instance in the BWR, the base case was 304 stainless steel piping operating under normal water conditions. Very few plants are currently operating under those conditions.

MR. TREGONING: That's correct.

MR. FORD: Do you take into account that in your analysis?

MR. TREGONING: The -- the analysis -- again, the analysis was well defined in the sense that we defined conditions as a group. Okay.

One of the reasons we picked the original stainless was because that was where we thought we had a wealth of operating experience data.

MR. FORD: Right.

MR. TREGONING: And we also had a wealth of experience modeling that type of degradation. So, that was a natural choice. The panel naturally gravitated toward that choice.

Now, the experts when they come in to comment, they obviously have to realize that it's not directly applicable to most of the current plants.

When we did the base cases, we also did some sensitivity analyses. For instance, we looked at operating experience data from both the old stainless, the new stainless. We did also have a small study on looking at some of the mitigative effects of BWRI IGSCC and what the impact of those had been currently.

MR. FORD: So -- so, we will be discussing those specific changes to the -- that have occurred in the real systems?

MR. TREGONING: The -- the panel -- each panel member was -- we discussed that at the base case review meeting in June.

MR. FORD: Yes.

MR. TREGONING: Each panel member is certainly well aware of that. When they did their elicitations, they had to take into account those changes when they did any referencing to these base case conditions.

MR. FORD: Okay.

CHAIRMAN SHACK: You're destroying our database with all these improvements, Peter.

MR. TREGONING: That's right.

MR. FORD: That's terrible. You keep shouting for data and it's very bad if we destroy the data or the relevancy of the data. Yes.

MR. TREGONING: Well, you always have -- whenever you get into these things, you have a tug between the materials people and the PRA-type of people. The material people always want to move onto bigger and better things. PRA people want data. So, when you move onto the bigger and better things, you destroy the -- destroy all the -- all those accumulated years of work, foul up the data.

The other milestones is we've recently completed and I shouldn't say -- we've completed the -- the interview phase of the elicitation. There's still some follow-on work that -- that each of the experts are doing that we haven't quite finished yet. We'll -- we'll get into where we're at with respect to the schedule later. We have conducted all our initial interviews.

MR. WALLIS: How many of these experts are there?

MR. TREGONING: Twelve.

MR. WALLIS: And they're all doing -- they're all actively engaged in doing -- doing the work rather than reviewing or getting together. They're all actively working with data and predictions?

MR. TREGONING: These are all people that have -- all people that either have experience evaluating the effects of degradation mechanisms, evaluating service history data to try to develop failure frequencies and things --

MR. WALLIS: So, they're all doing independent analysis? They're not -- they're not just sitting around talking.

MR. TREGONING: Well, there's -- there's better.

MR. WALLIS: Yes.

MR. TREGONING: We sit around as a group and we've defined issues, framed the approach and things like that, but then each one goes off individually, comes back with their own answers. These -- these elicitations are individual. So, we don't allow -- can't look over at your neighbor and -- and say, you know, what do you think about that?

We're -- we're -- we -- we actively solicited 12 different opinions. We thought that was important here. Lee's going to get into a little bit why we chose this approach later.

This is an executive summary. These are -- I like to give this in the beginning just because I'm never sure how far we're going to get in these meetings. So, these are the main points that -- that we hope to touch on and if we don't touch on it, I'll have it here and you guys can come back and --

CHAIRMAN SHACK: But, you're not going to give us any numbers today?

MR. TREGONING: No, we're -- we're -- this is really going to be an -- an in depth look at the approach. We don't have numbers to give. If we had numbers to give --

CHAIRMAN SHACK: But, you've got a March deadline. Right?

MR. TREGONING: We have a March deadline. Yes, we do. So, we -- we realize the enormity of the task in front of us believe me.

MR. WALLIS: There are some numbers on some of your slides.

MR. TREGONING: Yes, but they're not LOCA frequencies.

MR. WALLIS: Oh.

MR. TREGONING: I am providing base case numbers, but that's just a little piece.

CHAIRMAN SHACK: That's just -- that's a just a little tiny piece.

MR. TREGONING: That's just a little tiny piece, but the individual elicitations are certainly and -- and making sure the quality and the information that we get from those, that's -- that's the major part of this exercise. The analysis of the elicitation results once we're -- once we're assured of the quality and the integrity of those results, that can be done rather quickly.

Okay. So, the first point is the objective and the approach that we're following are really consistent with the guidance that we got for developing what we're calling near-term LOCA frequencies and what do I mean by near term, over the next ten years or so. That's specific guidance that the SRM gave.

The last time I was here in July, the presentation I gave actually broke down pieces of the SRM and tried to demonstrate how we were meeting that. So, we -- we talked a lot about this in the July meeting. I'm not going to go into so much of -- of this point here today.

The elicitation process that we're using they'll develop LOCA frequencies as a function of flow rate and operating time considering both piping and non-piping contributions. So, this is the main focus of the elicitations.

However, a lot of the experts that we have are also experts in looking at the effects of seismic loading, water hammer loading, some of these rarer loadings. We've grouped them together and -- and called those -- the terminology we use is emergency faulted type of loading. So, this is --

CHAIRMAN SHACK: What's the point of highlighting flow rate in the -- in the second bullet? You know, in all the -- the things that might affect the LOCA frequency, you know, flow rate would be probably reasonably far down in my --

MR. TREGONING: I guess what I mean here is -- is flow rate or it's essentially break size not flow rate.

MR. WALLIS: Oh. Oh. It's a consequence rather than a --

CHAIRMAN SHACK: It's a consequence. Yes.

MR. TREGONING: Yes. Yes, so the bigger the LOCA, the bigger the flow rate. So, we're --

CHAIRMAN SHACK: Oh, that -- that flow rate. Sorry.

MR. WALLIS: And -- and on the list of flow rate --

MR. TREGONING: I had leak -- I had leak rate up here at one time and I got a little bit -- I got chastised a little bit by the panel because they said hey, you're -- 500,000 gpm is not a leak. Break flow. Break --

MR. WALLIS: But, sometimes the leak causes the -- causes the whole though.

CHAIRMAN SHACK: Hum.

MR. WALLIS: Even a small leak can cause a big hole.

MR. TREGONING: Yes.

MR. WALLIS: So --

MR. TREGONING: And that's what we're -- that's what we're investigating in this -- in this exercise.

So, again, we're also looking at developing conditional local probabilities for these larger emergency faulted loadings.

I'll go into a little bit -- time permitting, I'll go into this later, but I think the important point here is we're not developing frequencies of these emergency faulted loadings. We're only developing the conditional failure probabilities on a generic basis.

Lee will go into this, but -- but just a point about the elicitation process. We're combining aspects of group and individual elicitation approaches. So, as Graham said, the group part of this is where we're sitting around the table discussing individual parts is more when the experts have to make their own estimates, have to do their own homework, their own analysis, and come back and give us their opinions.

The approach that we're using is based on developing quantitative base case frequency estimates. These base cases are just a little piece, but they're important because they're the only actual absolute numbers that we develop in this whole exercise. Okay.

All the elicitation responses that we ask for we ask to provide answers provided relative to these base-case estimates. Okay. What do we do that? Because, and again Lee may go into this somewhat, but a lot of elicitation theory shows that relative answers are easier to provide than absolute answers. So, we've tried to structure the elicitation in that way. We only ask for ratios, differences, things like that with respect to their quantitative estimates. Okay.

This final point, again I'm not going to cover this so much today, but we also have additional research plans where we're developing alternative techniques and methodologies to provide estimates of LOCA frequencies and we're also working on developing a framework or a methodology for continuously assessing LOCA challenges.

So, elicitation's important. That's what we're going to talk about today, but research also has plans in place to in the longer term provide additional information which will either -- which will be confirmatory in some sense to these elicitation results.

It's just that these other research plans are going to take much longer than we have to develop. Certainly, they wouldn't be ready by March of '04.

Okay. I just want to remind everyone again of -- of what the scope and the objectives of the elicitation are. I said these before. So, I'm just going to say them again, we're developing piping and non-piping passive system LOCA frequencies as a function of flow-rate or effective break size and operating time and we're asking questions up to the end of the license extension period.

We're estimating. The LOCA's frequencies are for a generic plant operational cycles and histories. So, we're not looking at individual plans per se. We're trying to develop generic averages that would be appropriate for the fleet as a whole. I use fleet because a Navy background. The industry as a whole. Fleet of plants.

And then the final thing we're doing is we're estimating these conditional LOCA probability distributions for rare emergency-faulted loading conditions. Things like seismic loading or other large unexpected and internal and external loads.

So, what do I mean by unexpected, it means they're not expected over the extended licensing period of the plant. So, something that would have a frequency of less than 1 over 60 years essentially.

MR. WALLIS: When they do these estimations, are they required also to estimate the uncertainties in these distributions?

MR. TREGONING: Yes, not -- uncertainties in the sense and -- and you'll see more about this later. We asked for three-point estimates in each question. We asked for essentially your best guess. So, by that, we've defined that as a 50 percent likelihood that the true answer is either higher or lower than the answer that you're providing. Then --

CHAIRMAN SHACK: Good. You work with medians instead of averages.

MR. TREGONING: We don't call them medians. We try to -- this is plain language. So, we can --

MR. ABRAMSON: Call them mid value.

MR. KRESS: Mid value.

MR. ABRAMSON: That is a median.

MR. TREGONING: Yes, we try not to confuse them with statistical lingo. The other thing we ask for is we ask for an estimate of which they would expect there's only a five percent chance that the true value is less than that and then we ask for an estimate such that there's only a five percent chance that the true value is greater than that.

MR. WALLIS: So, these are three points on a cumulative --

MR. TREGONING: Yes.

MR. FORD: And they're going to -- and these experts, these 12 experts, are going to be asked to give the rationale for the -- quantitative rationale for their answers?

MR. TREGONING: Of course. Qualitative

rationale. In fact, that --

MR. FORD: Quantitative. Quantitative. Quantitative rationale for their answers.

MR. TREGONING: I want to make sure I understand what you mean by you say quantitative rationale.

MR. FORD: Well -- well, I presume all 12 of these people are not experts in environmentally assisted cracking.

MR. TREGONING: That's right.

MR. FORD: And therefore -- and presumably one or two are.

MR. TREGONING: Yes.

MR. FORD: And, therefore, the value of their judgment presumably we're going to weigh differently from say somebody from PRA space.

MR. TREGONING: This is correct.

MR. KRESS: Yes, a lot less.

MR. FORD: True. Is there anyway of weighing the value of those judgments?

MR. TREGONING: We're -- we're not specifically weighing one response versus the other. What we're doing though is we're asking people and one of the things we do when we have the elicitations and we'll talk about this. We go through in pretty rigorous detail each approach. How did you come up with the numbers that you did? And as you might imagine, we've done 12 of these. We have 12 different approaches.

MR. FORD: Sure.

MR. TREGONING: We try not to judge -- prejudge during the elicitation the value of the approach, but what we've asked people to do is self-censor themselves. If there are areas or questions that we are asking that they do not feel that they have sufficient expertise to answer it, they either don't answer the question.

MR. FORD: Okay.

MR. TREGONING: Or answer it and provide very wide uncertainty bonds.

MR. FORD: Okay.

MR. TREGONING: So, that's how we -- that's how we attempt to -- to do self-censoring and -- and that hasn't been -- I don't think it's been an issue. The experts have been very forthcoming in -- in admitting their own limitations. I don't know anything about this. I'm not even going to address it and I think they've been happy about doing that because it's less work for them also in the -- I think in the long run.

MR. FORD: Have --

MR. KRESS: That's not ACRS members.

MR. FORD: Could you give us an idea who the cracking -- environmentally-assisted cracking experts on your panel are?

MR. TREGONING: Yes.

MR. FORD: Just to -- to calibrate me.

MR. TREGONING: Okay. We have -- and by experts, I want to make sure I'm -- I'm -- I don't slight anybody on this, but certainly Karen Gott from Sweden is. Let me run down the panel. I don't think, Dave, you would consider yourself an expert in environmentally-assisted cracking.

She is probably the -- she's probably the most expert in environmentally-assisted cracking.

MR. FORD: The reason why I'm picking this up --

MR. TREGONING: Yes.

MR. FORD: -- is that this is the main failure well, apart from fatigue. The main and FAC. The main degradation nodes that you're considering in this analysis. I'm just interested to know who -- who it is that's going to know something about them physically.

MR. TREGONING: Yes, Karen has the best

physical I understand.

MR. WALLIS: Could you supply us with a list of these experts? Is that not --

MR. TREGONING: Well, I already have.

MR. WALLIS: Well, I haven't -- it doesn't seem to be here and I -- I --

MR. SNODDERLY: Graham, if you look at the -- the July 10th slides.

MR. WALLIS: I don't want to look back on something.

MR. SNODDERLY: Okay.

MR. WALLIS: I just want to look at it now.

MR. SNODDERLY: Yes, we'll -- we'll get it. Okay.

MR. LEITCH: Is terrorism or sabotage specifically excluded or included or do various experts form their own opinion on that topic?

MR. TREGONING: It's specifically excluded at this point in time. Reason -- reason being is we're trying to be consistent with -- the definition of LOCA and the usage of LOCA within current PRAs doesn't consider that phenomena. We're trying to develop distributions which are consistent with historical usage.

That exercise is something -- in fact, the agency obviously you guys know much better than me, but we have a lot of interest and a lot of work ongoing in that area. That would be something now that if -- that would have to be a separate study for this in particular.

I think these -- however, what we're trying to do here for conditional LOCA probability distributions, the rare emergency faulted loadings, that information could potentially apply. What we're trying to do here is we're -- people have looked at pipe failures for non-degraded pipes, okay, and developed information on that. All we're trying to do is say well, how would these distributions change -- how would they change over time assuming that you have degradation that occurs?

So, something like this if you had -- if had some sort of estimate as to the frequency of the event and then the loading severity of the event, you could use this information to get at what you're trying to get at.

MR. LEITCH: Yes, it's very difficult to estimate, but in the type of rare thing that we're talking about here, I --

MR. TREGONING: Yes.

MR. LEITCH: -- kind of feel like sabotage may be a significant contributor.

MR. TREGONING: Right. Again, we haven't a --

MR. LEITCH: I don't -- I wouldn't know how to begin to estimate it, but I -- I think there is that possibility of a contribution from that source.

MR. TREGONING: Okay. Just to go back to Dr. Ford's question, Karen, again she's probably the most expert in the -- in -- in the electra chemical aspects of IGSCC, but we have a greater number of panel participants that are familiar and expert in using an interpreting that data to make these type of predictions.

So, for instance, one of the things that Karen did along with Bill Cullen as part of this bench marking exercise, we went back and reviewed some of the IGSCC information that was within PRAISE.

MR. FORD: Oh, Bill was on the panel, too.

MR. TREGONING: Bill was not on the panel, but he helped us with some of this -- developing some background information.

We've pulled in people as -- as needed --

MR. FORD: Oh, it's inside there.

MR. TREGONING: -- to develop technical

information.

MR. FORD: Who are they? Who are they? Can we say -- can we see who they are and what they do and what their qualifications are?

MR. WALLIS: Can we have a list of who they are and what their qualifications --

MR. TREGONING: So, here's the general approach and after I talk about this, I'm -- I'm -- I'm going to turn it over to Lee.

Again, we have -- these last two bullets I'm not going to talk about today, but this is really the complete research plan for how we're looking at developing these estimates long term.

Points one and two are what we're focusing on today. We obviously have to base these things on correct understanding of -- of what the operating experience is. Not only a correct understanding, but a correct application given the current state of plants and the expected future state of plants.

This operating experience assessment is -- as you've indicated, is not an easy thing to do when you -- when you have plants that are continuing to change throughout their life and your data by its very nature lags those changes.

The exert elicitation is using this

information to try to -- to make that link, to extrapolate that data to make it relevant, as relevant as we can make it and what we're looking at again developing this relationship between LOCA frequencies, break size.

The other thing that we're doing is there's some aspects within this probabilistic code that we're developing longer term that areas that we don't have input within the code or we haven't developed modules, we use some of the results from the expert elicitation to feed into this code. This is our longer term effort to analyze and address this problem is -- is to do a more rigorous combination of operating experience and PFM insights and explicitly consider contributions from piping and non-piping components.

This is an effort that -- I mean, quite frankly, to have this become mature enough to use, I think it's going to take five to ten years at a minimum. So, it's not something that will be available in the short term and I -- I think I have a pretty good bench mark because everyone here is very familiar with the work that was done in code development for the PTS analysis.

The thing I like to point up to my

management is PTS was essentially one material, one failure mechanism, number of transients, but now we're dealing with multiple materials, about ten different possible failure mechanisms. It's an order of magnitude harder problem. There's no doubt about that.

Plus, the other thing, the PTS, we actually have -- we have a lot of bench marking work that had been done to verify the codes. So, this is something that's going to take some time to evolve.

We're really just starting this effort now in that one of the things that we're doing and Mr. Shack's group has been instrumental in this aspect of it, but just trying to identify the most current and up-to-date predictive models for various degradation mechanisms. So, this is something we have -- we've started. We've pulsed the community in his area and we will continue to so that we make sure that this code has the most up-to-date models of -- of degradation within them.

MR. WALLIS: How do you do evolution of new degradation mechanisms? These -- to me, they seem -- indicate there are some mechanisms that you may discover you didn't know about before and that's -- that's almost impossible to make a prediction about.

MR. TREGONING: Well, one of the things we -- and this -- we rely on the old data. The thing that -- the thing that we go back and look for is over the operating experience, we do have a sense for --

MR. WALLIS: Every ten years is a new mechanism or some sort of rule of some --

MR. TREGONING: Rule of thumb is every seven years.

MR. WALLIS: Seven years. Okay.

MR. TREGONING: We get beat up whenever I say that, but that's sort of the rule of thumb, but yes, you can go back over the history and look at the frequency of things occurring and then also the severity. What were the challenges of those like?

Some of these new things have been more challenging and all. Certainly, IGSCC was a very challenging mechanism. Certainly, flow induced vibration was a challenging mechanism. There have been others that have been less challenging.

So, what we'll do within this code -- when you're talking real events though, that's important. The code itself will -- will do some -- again through simulation will try to make some expressions of how often these things could occur and how severe they might be, but least initially, you're right. You can't assess what you do not know. So, we can only go back and use history to provide a guide there.

CHAIRMAN SHACK: Well, even your changes I mean. You might argue or -- or people have that when you reduce the oxygen in your feedwater to protect your steam generator from denting, you made your flow assisted corrosion problem worse and Peter has -- has added noble metals to solve our BWI, you know, ISCC problem, but, you know, long term, you know, will that create some other degradation mechanism. That's always a concern. No.

MR. TREGONING: Okay. If there are no further questions, I'm going to turn the podium over to Lee who's going to talk about the process. Do you want this?

MR. SIEBER: Yes, I guess so.

MR. TREGONING: You want the -- you want the mike, too?

MR. SIEBER: Yes.

MR. TREGONING: I didn't know if you were going to sit down or stand.

MR. RANSOM: I'm wondering why did they say this? I didn't know whether that meant all of these people or just them.

MR. TREGONING: I'll do your slides.

MR. ABRAMSON: Yes, please. Yes, next one.

MR. TREGONING: Next one.

MR. ABRAMSON: Okay. I titled this formal use of expert judgment to contrast the two informal use of expert judgment which this is our business. We -- this is what we do all the time on a day-to-day, hour-to-hour, minute-to-minute basis. This is a formal use of expert judgment and that's what often call expert elicitation.

MR. LEITCH: Do you have the microphone?

MR. ABRAMSON: Yes, I think so.

MR. TREGONING: Bring it up a little bit. It's on.

MR. ABRAMSON: Is it on?

MR. TREGONING: Yes.

MR. ABRAMSON: It's on. Okay. Sorry.

MR. TREGONING: You're too soft though.

MR. SIEBER: You can talk into your tie.

MR. ABRAMSON: Yes, is that better. Okay. There are a number of applications in general. This is a slide that I used in, you know, before presenting to the panel. So, I'm just going to go through a few of these.

A number of applications. One of them is scenario development which I don't think particularly applies here. An example of that could be for example detailing physical processes as you would have with Yucca Mountain issues.

Model development that is maybe when you're trying to perhaps build a code and you need some inputs into the -- into the codes. So, that will just be -- which I don't -- which we're not doing in this particular instance.

MR. TREGONING: The PRODIGAL code which --

MR. ABRAMSON: The PRODIGAL code. That's right PRODIGAL -- PRODIGAL code is a good example. Expect elicitation was used for that.

MR. TREGONING: Welders and material people that develop --

MR. ABRAMSON: Right.

MR. TREGONING: -- flaw distributions. It's easier than that code.

MR. ABRAMSON: Yes, that's a good one. Distribution estimation, a good example of that would be with the PTS when we needed the distribution of well defect sizes as inputs.

And what we're doing here in this case is parameter estimation. Namely, we're estimating the frequencies of various size LOCAs.

One of the characteristics of -- of the expert judgment process of course a predetermined structure. You start with collection which is the -- whole elicitation process which I'm going to talk about in some detail.

Then there's the processing of information that's combining the results which we have not begun to do yet, but that's going to be the next step where we take all of the quantitative inputs from the experts and combine them to come out with our -- with our final estimates.

And then, of course, this documentation. Extremely important. We're very much concerned about this and then contrasting that to informal use. That's often lacking informal use, but it's an integral part of the formal -- formal approach we're taking.

And what are the indicators for use. Well, I think you're all well aware of these. I'll just review them quickly.

First of all, there's a lack of data. The available data is -- is going to be sparse, highly variable, questionable relevance. So, all of that applies in this particular case.

You would do it when there are very

complex issues and we certainly have a lot of complex issues, many different physical mechanisms and so on and you would also do it when it's a very important issue and particular extensive review expected. This is a -- expect that as a controversial issue and so on.

So, these are all indicators for us. Clearly because this is a time consuming and expensive project, we only do it when there is very, very good reason for -- for going ahead with the -- with this kind of procedure.

MR. FORD: So, earlier -- could you just go back to -- just to calibrate me.

MR. ABRAMSON: Yes.

MR. FORD: On the applications, the model development --

MR. ABRAMSON: Yes.

MR. FORD: -- and the distribution estimation, I'm assuming that for instance the model that you're using for instance for a 28-inch scale 80 pipe for BWR, there will be a viable distribution of failure times for such piping in operating reactors for three or four under normal chemistry condition. That -- that -- and that specific condition is your model. A liable distribution.

MR. ABRAMSON: This is -- this is captured in the various base cases I believe.

MR. FORD: Okay.

MR. ABRAMSON: This information, existing data, and how they fit into the liable distribution, all of this will be captured in the base case development.

MR. FORD: I'm just trying to work out what you mean by model development and distribution estimation.

MR. ABRAMSON: By --

MR. FORD: It's the viable distribution and the beta value in that .

MR. ABRAMSON: That would probably come under distribution estimation. These are not hard and fast. Model development, I'm thinking of a computer model or a mathematical model with physical process.

MR. FORD: Could you give us an idea of what those models are?

MR. ABRAMSON: Not in this case. Because I don't think they were used in this -- in this instance.

MR. TREGONING: Again, I -- I brought up the example of PRODIGAL which is used to develop flaw density and defect distributions for various welding processes and what Lee's giving here I think maybe he's trying to give applications historically where formal use of expect judgments can apply.

MR. FORD: Well, it's not for this particular -- this is just a --

MR. ABRAMSON: Not for this particular part. Only for this particular project we're doing number four which is parameter estimates.

MR. TREGONING: This is the only one we're doing.

MR. WALLIS: You're not developing models because you have models already which you have faith in?

MR. TREGONING: No, if we had models already that we had faith in, we wouldn't do this exercise. Each expert may -- each expert may have their own models that they have faith in.

MR. WALLIS: Right. Right.

MR. TREGONING: And -- and we -- we certainly ask them and expect them to exercise those models and come back and give us their -- their results from the models. Each individual expert has some sort of model that he has developed. It might be more -- some are more ad hoc than others, but --

MR. FORD: And we will be hearing in some detail about some of those. I mean you're -- you're well into this program. Presumably your experts have come along with their models and presented to the group and defended them. Will we be hearing at all any details about that?

MR. TREGONING: Dave Harris today is going to be giving you exacting details about his particular model --

MR. FORD: Good.

MR. TREGONING: -- for -- for developing these. Now, again, his model is probably more mature than any other model that was used within the expert panel. Again, some of -- by models I'm saying models are essentially the approach -- the approaches that the experts use to get the answers to the questions. So, they all developed an approach.

I wouldn't consider what all of them did -- all of them didn't take -- go to the level of detail of developing rigorous models per se that would -- that would consider a particular degradation mechanism, show its evolution over time, and then predict when failures are going to occur. We only had a small subset of the panel that had that kind of expertise.

MR. FORD: The reason -- recognize the

reason why I'm hammering away at this is that this is the basis for his whole evaluation.

MR. TREGONING: Well, when we did the base cases, that's exactly how the people that did the probabilistic fracture analysis, they did exactly that.

MR. FORD: Okay.

MR. TREGONING: That information was provided to the experts and what we asked the experts to do is we -- we said we can't possibly run models for all these different combinations, but what we want you to do as an expert is we want you to take the results and the well-defined conditions that we did solve and then extrapolate those other conditions which may or may not be important.

The first thing we ask the experts to do is list the things which you think are important in various areas and if we had solved those quantitatively, great. If we hadn't, tell us how different what your set of conditions are from the base case. Provide us a relative answer. So, that's essentially how we're proceeding in all --

MR. FORD: Okay.

CHAIRMAN SHACK: I think a lot of your concerns, Peter, are probably more relevant to his --

his number three bullet, the probabilistic LOCA development which is where he's going in the future.

MR. TREGONING: Right.

CHAIRMAN SHACK: And a lot of this will be built into that, but again, he's -- he's really back on his expert elicitation stage.

MR. TREGONING: Right.

CHAIRMAN SHACK: Where because he doesn't really have a comprehensive model, he can't exercise it to give him the answer.

MR. FORD: Right. Yes.

MR. TREGONING: I mean as you know even -- you know, one of the things we realize is we had a lot of work that was done in developing IGSCC models back in the early to mid-'80s. As we've gone back and looked at our codes, we've said, you know, the codes -- we saw that initial problem, but a lot of the codes really haven't followed the evolution of the field and the understanding of the physical parameters involved with current IGSCC.

So, we've -- a lot of these -- a lot of historical models need to have some update, you know, and that's one -- that's essentially what we're doing now. In fact, one of the things we've done that Bill Shack's group is helping us with is we've -- we've put together this big matrix and -- and we'll have to come in again when we're more mature and talk about the probabilistic LOCA code development.

We've had a matrix of the all the different materials and possible degradation mechanisms that apply for those materials and the matrix we're trying to fill in is who do we talk -- who -- who's got the best model. Who does the community at large think has the best model? We're trying to fill in this very large matrix at this point and it's a -- it's a significant exercise and -- and it's one that, you know, as you would attest to, it's -- it's not a trivial exercise by any stretch of the imagination.

So, for this point number three, we are spending a lot of time doing exactly that.

MR. FORD: Okay.

MR. TREGONING: Sorry, Lee.

MR. ABRAMSON: No, that's -- that's -- that's good.

Just to, you know, summarize it as I -- as I see it, this -- for the expert elicitation part, this is not a model development exercise. What we're trying to do is to use what already has been developed and then as -- as essentially input through the base cases and other discussions and then to go beyond this as far as getting what the relationship of the LOCA distribution is -- LOCA frequencies is to what's already known.

We're not developing models. We just want to use everything that's been developed already.

Next -- next slide please.

Here again, this is a general I guess rationale or -- or rundown as to the distinction between formal and informal use. Advantages of the formal use are you get improve accuracy and credibility. In particular, we feel that this -- this kind of a process should be more acceptable to industry, the public, anybody who's interested in the use.

There's a reduced likelihood of bias and we try to address this through the elicitation training which I'm going to go into in some detail a little bit later.

There's enhanced consistency in a sense that the expert panel is the one that we use very extensively to formulate the issues, to help formulate the questionnaire so that everybody hopefully is -- understands the questions, understands the issues in the same way and then, of course, through the documentational process, we feel there's improved scrutability in documentation and this in particular I think could be very useful when you have regulatory decisions that have to be made. Hopefully, these will address some of the potential objections to this -- to the results of this process.

Now, there are obvious drawbacks in this. It said increase time and resources. It's quite time consuming and, you know, and costs quite a bit to bring everybody together both in staff time and, of course, the people involved.

In a sense, there's reduce flexibility to make changes because you've got, you know, like a -- there's a lot of inertia in the system once you get going with it that you spent already a good deal of effort and so on. So, it -- it is more difficult just because you have a large structure.

On the other hand, we're very much aware of the importance of doing this and I'll go into this later and we did make a number of I think very significant like mid-course corrections in the course of this.

Another possible drawback is there's enhanced vulnerability to criticism. Precisely because we try to make this as transparent a -- a process as possible, this -- this means that there is more opportunity for people perhaps to criticize this since it's clearer what we're doing. When you use an informal judgment, it's not you say well, it's based on your expertise, your experience. It's kind of hard to question that, but here we try to be very explicit about it.

Now an essential aspect of -- of this is to use experienced practitioners. This saves time and resources because if you have a flawed process, you might form the pitfalls and a good -- and you're have to do it over again.

A good example of this what happened a number of years ago, was in preparation of NUREG 1150, you know, the PRA for the five nuclear plants. There was extensive review and criticism of it afterwards and as a consequence, they had to do part of -- they had to repeat the expert elicitation over again.

So, we're trying to avoid -- avoid these -- these pitfalls.

MR. WALLIS: Well, one way to do that is to build some reviewers into the process as it goes along and you've got all these experts who are some way connected presumably with the nuclear industry or something similar. If you had sort of a review group which was independent which would comment on the process itself and its credibility and so on at the same time as they do the work, might avoid some of this business of having to do it over again. Because when it goes into the outside world, it's criticized.

MR. ABRAMSON: Yes, that certainly would be a possibility, but, you know, we try to have experienced -- I've -- I've been involved with this for a number of years. So, that's again my experience and, of course, I served a number and so on of -- of this and yes, that certainly would be another -- another aspect of this which we have not explicitly done. To have an affect, I guess you could say a -- a built in peer review group which would be involved not just at the -- after the process is over, but in the whole course of the process. Yes, that is a possibility.

MR. WALLIS: But, you don't do that. Do you?

MR. ABRAMSON: We're not doing it for this exercise.

MR. TREGONING: Not explicitly other than what we're doing here today. Things like that.

MR. ABRAMSON: Yes, with this.

MR. TREGONING: So, you're right. We're

taking a bit of a calculated risk in the sense that if we get to the end and -- and there are any big issues that come up, we do -- running a bit of a risk of having to do it over.

MR. ABRAMSON: Okay. Now, with this slide, this slide details -- is -- is the particular structure and philosophy if you will of what we're doing for this -- for this elicitation. All right.

Key element is we're delaying the quantitative assessments until after the panel discussions and issue analyses. This is somewhat akin to a jury trial where, you know, the jury instructed to avoid discussing the case and don't make any judgments until all the evidence is in and so, we're trying to get people to discuss these in -- in a great detail, a number of meetings, a lot of analyses and the only time that we actually ask for -- from the panel members -- themselves as panel members for a quantitative judgment is in the individual elicitations.

Also, and I said after the discussions and issue analyses, it's -- it's essential in this process to have a common understanding of what the issues are, what the questions are, and to develop the structure and this is what we use the panel for very, very extensively to do all of this. So, we don't want -- we -- we want to try to avoid people making let's say premature judgments before it's clear exactly what it is we're going to be asking them.

All right. The way we started this we developed the base cases and Rob has already spoken about this and you'll hear in great detail from David Harris soon about one of these base cases.

Now, as I think Rob suggested or said already, the base cases are the only absolute numbers that we've developed for the case. Everything else -- everything else we've asked from the experts is all relative to the base cases or other quantities that are derived from them.

And the reason we did this on a relative basis is because we're asking for frequencies, LOCAs or phenomena which have not been observed or extrapolations well beyond the state of -- the knowledge, the state of experience of people. Well, this -- and we're talking about extremely low numbers. This is something that there is no information. People don't have any basis for doing this. You can come up with something if people, you know, put a gun to your head figuratively and say give me some number, but it's not clear what it means.

So, I think it -- it makes a lot more sense to ask for relative comparisons, as relative to something that they do know something about. After all, these are experts in some physical phenomenon and they're very, very familiar with this and so, we're just asking them to extrapolate beyond what they know, compared to what they do know, go beyond this. So, these comparative means I think are -- is much more natural to -- to try to -- to try to elicit than it is to try to get some absolute numbers and that's why we do this all on a relative basis.

MR. WALLIS: It's all -- it's all based on physical phenomena. Is there any --

MR. ABRAMSON: Yes.

MR. WALLIS: -- incorporation of human error in some way?

MR. ABRAMSON: There -- there is -- there is some aspect and Rob will go into this. One of the first questions that we ask, we have a questionnaire, is the effect of safety culture and this is where the -- that's very explicit where, you know, people are involved. Safety culture both from industry point of view and regulatory point of view. So, Rob will go into this. So, we ask about people's opinion about this.

MR. TREGONING: There's also -- if you look at the operating experience database, a lot of the events that you see tend to have some aspect of -- of human error involved with them. So, we also have some historical basis to look back on with respect to that.

MR. ABRAMSON: Yes. Now, what is -- what is it that we ask -- what is it that we actually ask the people to come up with? How do we do it? Well, there is some quantitative to be assessed. Okay. Whatever it is and this is what we want to get a number for.

And as Rob already indicated, we ask for three values, a mid value X -- a mid value X sub M, a low value X sub L, and a high value X sub H. Well, these, of course, are all subjective and in effect, we're asking people to look into their minds and to come up with some points on a subjective distribution.

And the way we define it is the -- the mid value's essentially the median. It's the median of their subjective distribution and I use the word chance because this is not a probability. It's just some vague notion of what the people's might -- might be.

So, they're asking them to come up with a mid value such the chance that whatever number they come up with, the true value is less than that, is about 50 percent. That's why I put all this as approximate here to emphasize that these are all just subjective judgments and so, the chance of it being less than this, the chance of it being bigger than 50 percent, in effect, this defines the median. So, asking them to come up with a -- the median in effect of their subjective distribution.

And then to get the uncertainty, we asked for the lower 5th percentile. That would be the lower bounds. So, you're about five percent. There's a small chance, it's not zero, being less than this and there's a small chance of being higher than this.

So, that means if you take the interval X sub L, X sub H, this is the 5th percentile, this is the 95th percentile. It covers 90 percent. So, this is an approximate 90 percent coverage interval for X and I'm going to get into the significance of this in a moment when I talk about elicitation exercise.

In effect, we're asking people with this to come up with a -- a subjective 90 percent competence interval or coverage interval for their -- for their estimates and this is how they express their -- this is how we express their uncertainty.

MR. FORD: Is it fair to say though that those quantitative treatments are to a large extent based on gut feeling of panel members who are predominately mechanical engineers?

MR. ABRAMSON: Well, it is certainly the gut feeling if you like. Because these are all very subjective and they're asked to use everything that they know how they feel about it. As to their technical background, I guess so and -- and I -- and I'm going to come into this in a moment. The fact that it is not easy to come up with these answers. I'm going to come into this right away. We're talk about the training and this.

MR. FORD: Okay.

MR. ABRAMSON: I agree. I -- I think I understand where you're -- where you're coming from. Absolutely.

Okay. All right. Now, what I wanted to do in the next several slides is there are 11 points here which actually are the major elements of this whole process that we've gone through.

I should say too that the process itself as -- as I'm sure you're -- you're aware, this expert elicitation process has been used in a number of instances, 1150, use it in the PTS, and other instances of great deal -- great deal has been developed for the nuclear industry over the last, I don't know, 10/15/20 years and it is based to a -- to some extent if you can put an extent on, you know, research that's been done in -- in psychological -- psychological research and decision analysis to try to -- to try to -- how do you try to tap information of -- subjective information that experts have about something? You want to get quantitative information from it, but where there isn't any data. In other words, how -- how can you somehow code this information and that's what this whole process is about.

Well, the beginning -- the first step, of course, you have to select the expert panel and what you try to do is you try to get a full range of disciplines because there are a number of disciplines involved with this and get a variety of approaches. It's important to do this because again for this instance and a general for any kind of formal program like this, it -- there's going to be a -- it's going to be a complex situation where you do have a lot of disciplines involved and there's a lot of scientific uncertainty.

If there wasn't scientific uncertainty,

you wouldn't be doing this in the first place and the scientific uncertainty, they're going to be generally a variety of approaches and that's why you want to be able to consider all the approaches.

It isn't possible at this time to say that one is right, the other is not. You can't even perhaps even make any judgment about which is more likely to be correct or not. So, you have to try to take -- you try to cover the waterfront on this.

Then the next general step is a technical background development. Now, this is started by the project staff, but also individual panel members for example Dave Harris and other people who develop the base cases are very much involved in this and the purpose is to fill in the knowledge gaps and augment individual expertise.

Each of these -- each of the people on the panel is an expert in one or more areas, but nobody is an expert in all areas and so, therefore, if you take overlapping expertise, we trust is going to cover everything we need to know. But, for the individual members, there are going to be gaps in their knowledge. Some -- some large. Some maybe no so large and so, the purpose of this background information is to try to have a -- a common knowledge base for everybody in the panel.

MR. TREGONING: Yes, I mean I -- maybe I'll come a little bit --

MR. ABRAMSON: Please yes.

MR. TREGONING: The knowledge gaps that people had were identified both in the kickoff meeting and then also in this meeting we had in June. Once the elicitation questions were -- became more apparent. Also, people solicited information that they needed to help get through their elicitation. We provided as much of this as we could.

The way we did that is we had a common FTP site that we had set up that was essentially our -- the knowledge base of this project and the FTP site was accessible to all the experts. It had all the information. It still does. It was developed as part of this exercise and -- and obviously, each expert had their own gap. So, we had to develop things or provide things individually for each of them, but there were some common areas that -- that people needed to see information on.

MR. SIEBER: The extent to which you do that though determines whether they are the experts or you are the expert. Right?

How much influence do you feel that the

staff had by providing this information on the outcome of the expert's --

MR. TREGONING: Now, we provided information that the experts asked for.

MR. SIEBER: Okay.

MR. TREGONING: Or that the panel as a whole determined would be needed.

MR. SIEBER: Okay.

MR. TREGONING: And when we obtained the information --

MR. SIEBER: This is basic information as opposed to the --

MR. TREGONING: Basic --

MR. SIEBER: -- final result.

MR. TREGONING: Things like what's a typical layout of -- of -- of the RECIRC system look like in a PWR.

MR. SIEBER: Okay. Okay.

MR. TREGONING: How many welds are in there roughly? You know, give me a sense. That sort of information.

MR. SIEBER: Okay.

MR. TREGONING: Basic information that each expert needed to -- to have it at their disposal so that they could go in and answer these questions to the best of their ability.

MR. SIEBER: Okay.

MR. LEITCH: Then I -- I suppose and I guess I'm just coming back to the same issue. I suppose there's no expert in the field of sabotage or security issues.

MR. ABRAMSON: No. No.

MR. LEITCH: Because that's totally excluded.

MR. ABRAMSON: It's totally excluded.

MR. LEITCH: And it seems to me that -- that this is a significant issue when considering LOCA frequencies in today's environment. Like -- like I think it's an issue that could very well swamp everything else that you're talking about.

MR. TREGONING: Potentially, but again, the frequencies become important there. What I would argue is if we're successful and able to develop these conditional LOCA failure probabilities given a certain amount of damage and a certain stress magnitude that there are other exercises that could potentially fill in the blanks that would be needed to make an assessment in that regard.

MR. LEITCH: But, don't you think it would be appropriate to have someone, evidently you don't, but I mean it -- it seems to me it would be appropriate to have someone that could assess the likelihood of -- of sabotage of --

MR. SIEBER: Well, the goal is to -- to risk-inform 50.46 and the nexus between risk-informing 50.46 and safeguards information and terrorist activity is -- just isn't there in my -- in my view.

MR. LEITCH: Well, I don't know that the goal is to risk-inform 50.46. I guess is to see --

MR. SIEBER: That's why we're here.

MR. TREGONING: That's the objective.

MR. LEITCH: -- to see whether -- to see whether it's a reasonable approach to risk-inform 50.46.

MR. SIEBER: Well --

MR. TREGONING: We -- we would have to be -- again, what we're trying to do is develop frequencies that are consistent with historical uses and -- and historical PRA applications and I don't even know -- the terrorist question is certainly an important one, but I don't even know how well our historical PRAs in a global sense are equipped to deal with that question, you know, very specifically. I know we have -- I've got certainly work ongoing in those areas, but we didn't think -- not that it wasn't important, but it just wasn't appropriate for this particular exercise to delve into that.

If -- if -- a separate exercise would be needed and really -- I don't think you could have one expert in -- in -- in -- again because what little I know about the threat and vulnerability studies, one of the difficulties they have in general is coming up with these frequencies for these various proposed scenarios that people have concocted.

MR. ABRAMSON: So say that the experts -- you -- you would need very different kinds of people who work at the NRC. You need people, psychologists, social psychologists, and so on to try to assess what the actual threat is from terrorism activities and this is very important and I trust that various people that are working on this maybe in the Homeland Security. I don't know.

And, of course, as -- and the -- as you know, the NRC is working on vulnerability studies, vulnerability of plants to various acts of sabotage or terrorism which again is beyond the scope of this -- of this particular project.

MR. SIEBER: Now, you would caution us not to wonder too far into safeguards or otherwise classified information.

MR. ABRAMSON: Yes, the vulnerability stuff is -- are classified.

MR. SIEBER: Right.

MR. LEITCH: Now, I -- I just -- I'm not sure what it would take either, but I mean there are people could estimate what -- what kind of a sabotage event it would take to create a LOCA and -- and the possibilities of that being successful.

Now, as far as someone having the desire to do that, that's the more difficult question perhaps to evaluate.

MR. ABRAMSON: But, that's also an essential part of the equation as, of course, you recognize.

MR. LEITCH: Yes.

MR. ABRAMSON: And the vulnerability studies deal -- do deal with -- given that there's a -- an initiating event given there's a sabotage or terrorist act as well as the vulnerability of the plants to -- to do that and that -- that is work that isn't going on -- that is going on.

MR. LEITCH: Yes, okay.

MR. ABRAMSON: I don't know specifically.

MR. LEITCH: I -- I understand. I -- I'm just concerned about it because I think that that may very well swamp the other probability, the other LOCA frequencies from other issues we're discussing.

MR. TREGONING: It -- it could potentially, but again, we're -- we've -- we've tried to define the problem within the scope that we've been given. So, we're again -- we're only looking at the LOCA initiating of that. So, we're only considering class one piping and non-piping failures for the most part.

So, when -- when you get into terrorism and -- and other affects, you have to look at --

MR. SIEBER: Structures.

MR. TREGONING: -- structural failures and we're -- that's -- this exercise I don't think we could -- if we had one person or two people, I could think we could properly consider it within the framework that it would need to be considered to -- to have some sort of meaningful impact to this exercise.

There are certainly many -- there are certainly projects within the agency that are attempting to address that specific question.

MR. ABRAMSON: Those are the so-called vulnerability studies that are going on now.

MR. SIEBER: Yes, we're -- we're aware of those.

MR. LEITCH: But, we're aware of those. They don't --

MR. TREGONING: You're more aware of them that I am.

MR. LEITCH: They don't address the issues that I'm speaking --

MR. SIEBER: That's why I don't want to --

MR. TREGONING: Right.

MR. SIEBER: I'd like to get back to the subject if we could.

MR. TREGONING: Right.

MR. ABRAMSON: Okay. The last element on this page is the formulation of issues. This was started by the project staff. We had a straw man and so on would initial the compositions and -- and their -- their ideas are kind of divide and conquer strategy. We want to do is we want to ultimately result in a questionnaire which I'll talk about later and Rob will give you very specific examples of that.

We want to try to -- these are complex issues. We want to try to break down the questions that the -- that the experts are going to be ask to respond to into the smallest chunks possible. They can give us some -- some informed opinion on.

Another way of putting it is we want to be able to structure the questions so as to tap in as closely as we can to the expert's expertise, their experience, and so on based on the physical phenomenon. Because that's what we're talking about. This is all physical phenomenon and so, therefore, we're trying to break this down into extremely specific descriptions, conditions, and you'll see this in the base case, the material of the degradation mechanism, what type of material, so on and so forth.

So, that's the -- that's the -- the -- the intent of this is how do you -- how do you break down the issues? How do you break down the -- the overall goals to get an estimate of LOCA frequency? Well, how do you break this down to a lot of sub-questions which you can then combine and aggregate which is what we're going to do in order to come up with the final estimates.

Next one please.

All right. There were a number of panel discussions. We're all ready to discuss the number of meetings that we've had. I think we've had three meetings so far with the panel, the kick-off and then there were two others -- two meetings. Two meetings. That's right. Two meetings. Panel discussions.

And this resulted in the final formulation of the compositions and the elicitation questions. So, there was a great deal of discussion among the panel and the ultimate goal was to -- was to come up with a -- with a questionnaire and as I said, Rob will give you specific examples of that and it'll become clear exactly what the -- what the structure. Try to give you examples of what the structure of that was.

Now, an essential part of the -- of the -- of the process is elicitation training and in general, as I said before, the purpose of this -- the problem is how do you translate the expert's knowledge and beliefs into these quantitative estimates which you're trying to come up with.

The problem, of course, is that this is something that they have not done before, unlikely, unless they've been involved with exercises like this and a couple of people on the panel actually were on the PTS panel and maybe have had other experience with this. Vic Chapman was one who was with PRODIGAL. So, he's had perhaps the most extensive experience with -- with this kind of exercise. Something like going through a root canal I think says some of the people.

CHAIRMAN SHACK: Probably run a man-ben through on that.

MR. ABRAMSON: Who is that?

CHAIRMAN SHACK: He's run the man-ben through.

MR. ABRAMSON: That's right. Yes. Right.

MR. SIEBER: Root canals.

MR. ABRAMSON: Root canals. Right. Yes.

MR. SIEBER: They don't get better with --

MR. ABRAMSON: Yes, that's right. Yes. At least you have an anesthetic when you do that.

The problem, of course, is that we're asking people to make these judgments over which they, you know, they don't have data. They don't have experience. To extrapolate well beyond that and this is a difficult -- it's an uncomfortable process. It's a difficult process and it certainly is -- and I can understand.

Tell the -- the panel people this is not something that I -- I -- you would welcome as something like that. It's -- it's beyond what they've been asked to do and nevertheless, they all recognize the necessity for this exercise to do this because we don't see any other way to come up with the quantitative estimates that we're trying to -- that we're trying to get.

And so, the purpose of the -- of this training here is to address some of these issues and to give them perhaps some feeling of -- of comfort or at least some buy-ins of the process.

You want to skip ahead to couple of the slides there.

MR. TREGONING: Page nine in their handout.

MR. ABRAMSON: Page nine. Yes.

MR. SIEBER: Okay.

MR. ABRAMSON: Sources of -- sources of bias.

This is -- this is a slide which I used for the training and the purpose here is to let people know as to what the bias is, what researchers in this field have found over the years as the kind of biases that people are prone to when you try to do judgments like this sort of thing.

Now, there's a distinction between motivational and cognitive biases. The motivational biases are the ones that are due to emotional and psychological factors and the cognitive biases have to do with how we think about things. So, it's convenient to divide these into at least two categories.

The first one is social pressure and for example, you might have group think and -- and that's one of the reasons that we -- that we use individual elicitations as opposed to a group elicitation. You don't want to have particular people who might be swayed by -- by the group opinion and so on. There might be psychological pressure to do this. So, we tried to do this with -- with wording that.

There's also -- the interview is bias, a social pressure. How you ask the questions is very, very important and so on. In this case, we had a team and I'll go into this who actually did -- Rob was the one who asked virtually all of the questions. But, the questions were all based on a particular questionnaire which the panel was very instrumental in developing. So, we tried to avoid that.

And, okay, another -- another reason for social pressure, of course, this could happen individually is everybody comes from a particular background and so on and so, you have all the possibility of conflict of interest and so on with that way.

Another motivation bias is misinterpretation and -- and in other words where you might be guided by the -- you might be guided by the interviewer's viewpoint rather than your own and, of course, you can be subject to those individuals as well as group, but again, what we try to do is to have it -- we had a written questionnaire and so on so that people are not responding to just off-the-cuff requests for information.

Another possibility with misinterpretation is the kind of questions you ask. We asked -- the numbers we asked for as I showed you before were these three numbers, the mid value, the low value, and the high value. Like three points on the subjective distribution. We did not ask for mean values and we did not ask for -- for variances. I think that mean values is a -- is a -- is an abstract concept. It's a kind of an average and when you have such a wide distribution here as I'm sure people have, I think it's essentially a meaningless thing to ask for and variances are even more meaningless to ask for. Although we try to capture -- we try to capture the information there, of course, by asking these numbers. The mid value obviously is the center of the distribution and the two low and high value give an idea of the spread of the distribution.

Another problem is misrepresentation and that could be due to incorrect assumptions about the model and/or data. Well, that's where we spent a great deal of effort in trying to have a common set of definitions, understanding, and so on. The panel -- the panel as a panel decided on what the definitions of LOCA. We got six categories of LOCAs for example and so on and we try to define the quantities that we're talking about as -- you know, as -- as explicitly as possible so there was a common understanding and that's where this background information was very useful to give people a common understanding and -- and a vocabulary as to what we were talking about.

The last category here has wishful thinking and that is not to common I think. Relatively uncommon. I think an example of this maybe as you know for the -- we had -- recently we had, of course, the -- the tragedy of the Columbia accident. Before that about 15/17 years ago, there was the Challenger accident and there it was brought out that the managers of -- well, there was a kind of a semi-official estimate that the chance of a catastrophe such as what happened is one in a hundred thousand. That was characterized as -- as analysis by rhetoric because it was not based on any analysis whatsoever. It was based more on wishful thinking than anything else.

Okay. Going on to cognitive biases, there are a number of areas that -- that this applies to. I said this is do to how we think about things as opposed to how we feel about them and what's at the basis of this is that the expert's knowledge does not necessarily follow as logical, logical rules. That is your subjective knowledge doesn't necessarily -- or people's not going to say experts. This is people in general doesn't follow in this and in a sense, nobody is an expert on this. You know, the expert on your particular field, you know, field of expertise, fracture mechanics or whatever, but nobody is an expert on coming up with these -- in -- in knowing, you know, being able to -- being able to extrapolate beyond the data.

Now, what are some of the -- what are some of the biases identified. Well, there's -- there's inconsistency and this is probably the most common and this has to do with what the definition is. Definition's change. You may not be clear what the definition is.

The assumptions that people make both explicit/implicit. For example, sometimes people, you ask them the probabilities of things. The probabilities may not add up to one when you have a set of, you know, mutually exclusive and exhaustive events.

It may judge that alternative A is better than B. B is better than C and C is better A and this you can -- this you can have and -- and what do you do about this sort of situation and -- and this can happen all the time.

Then you have the problem about anchoring and that is where people are asked to come up with judgments. You might have a first impression and people say their first impression/their first answer and then you're asked to deviate from this and so, they tend to anchor on this first impression to adjust from this and the problem there is that there may not be enough adjustment back and forth. So, you have to be aware of this.

Oh, I should say that for our exercise, we necessarily had to do a great deal of anchoring. We anchored on all of the numbers we got out of base cases. So, that was a -- an essential aspect of this.

We tried to make people aware of this in sense to mentally loosen them up so that they would be aware of some of these pitfalls they could fall into and hopefully, avoid them in their -- in their elicitation answers.

Another one that's very common is

availability and this has to do, for example, a lot of people feel -- are very much afraid of flying. My wife is one of them and they feel well, planes are crashing all the time and why are they -- or the accidents, why it happens? Well, because any time there is kind of a -- an accident, it's all over the front pages of the paper. You hear about any kind of a fatal accident. You don't hear about the ones that are not accidents or near misses and something like that.

So, when something becomes available, you tend to overestimate the probability and this is a well-known phenomenon.

A very good example of course in -- in our business is the nuclear accidents, TMI, Chernobyl. This is one reason I think why people feel that I'm afraid of nuclear power.

And then something which is very much relevant to our case, underestimation of uncertainty. People are often much more confident than they have a right to be and this has been demonstrated time and again with those kinds of exercise that are done. When you ask people to get a -- a range, for example. Say a 90 percent confidence, their answer is more often than not -- a general rule of thumb is if you say you want 90 percent confidence, in fact, it's a factor of 2 too high. So, it's more like 50 percent confidence and actually, I've seen this in some exercises I -- I have done. I'm going to talk about this later to what extent this actually applies in this case.

The people are more -- are -- are more sure of their uncertainty -- less uncertain than they really have a right to be and you can demonstrate this when you ask them a so-called almanac-type question where you know the answer, but they don't. Numbers picked out of the almanac. I'm going to comment and I'm going to give you an example of this in a moment.

So, you know the answer. You're going to ask them what their bounds are and it turns out that -- that they're not all the well calibrated.

And so, we just try to make people aware of this so that when they do come up with their ranges as we've asked them to do with the low and the high values that they not underestimate this. We want to try to get as accurate representation of what they're real uncertainty is as -- as possible.

MR. WALLIS: This is like the problem of the expert. An expert in a courtroom is often expected by the lawyer to be sure about something.

MR. ABRAMSON: That's right.

MR. WALLIS: And yet we all know that in many cases, the expert cannot be sure and knows it, but if you present yourself as being too uncertain, then you're going to be crossed examined and they say how can you be an expert if you're so uncertain.

MR. ABRAMSON: That's right. That's right. How can you be -- if -- if you're uncertain, then you don't know what you're talking about.

MR. WALLIS: Right.

MR. ABRAMSON: That's right. Exactly.

MR. SIEBER: It's a function of the fee.

MR. ABRAMSON: The higher the fee, the less the uncertainty.

MR. SIEBER: That's right.

MR. ABRAMSON: Okay. All right. And the next side that I want to have is the next one in your package, yes, on the elicitation exercise, elicitation training. Okay.

What I did is I first went through in the -- and this is in the kickoff meeting on this slide on discussion of motivational biases and then we wound up with an elicitation exercise and this exercise had a -- had a -- had a couple of motivations.

First of all, we want to give people

practice in answering the questions that we were going to be asked to ask, namely, to come up with a mid, low, and high value.

Secondly, we wanted to try to demonstrate to them because we know that they were very uncomfortable and very skeptical about this process and I absolutely agree with them. I -- you should be. If you're not skeptical, then, you know, then, you know, you -- you don't understand what we're asking you and if you're not uncomfortable, you probably also don't understand what we're going to be asking you. So, I think we're -- I think we managed to get this across pretty well.

And we -- what we wanted to try to do is to demonstrate that going through an exercise like this that there is some value in this process. Okay. In effect that there -- there is -- you get some information from the group opinion. In other words, N heads are better than one. So, that's -- that was one of the purposes of going through this exercise. Actually, demonstrate to them.

And I'm just going to go through very, very briefly just on this one slide without going into any great detail about the kinds of questions we asked and -- and some of the results we got.

I started I said these are all almanac-type questions. So, I went to the almanac and I -- and I got questions about -- about health conditions. Okay. Well, I started with a relative easy one. This is one that they got practically triple if not a home run on -- on in a sense.

According to the 2000 census, how many men 65 or over were in the United States? That was the question. How many men are there?

MR. KRESS: Did -- did you give them the total population of the U.S. as an anchor point?

MR. ABRAMSON: No, I did not. No, I did not.

MR. KRESS: So, they -- they had to know that.

MR. ABRAMSON: They had to know this. That's right. They had to know this.

Now, of course, they did know this. Okay. They'd have a pretty good idea. It's almost 300,000,000 now, about 250/275,000,000 in this, but you see this is a subset of it. How many men? We're talking about a subset. First of all, over 65 and men, too. So, they had to ratio it down in some way in their minds. But, nevertheless, they had a basis for it like, for example, I don't think anybody said more than 100,000,000. That's a ridiculous estimate or 5,000,000. That's also ridiculous. So, people had a pretty good idea and this borne out in the results.

Again, what we asked for is we asked for three numbers, the low, the median, and this weight and then what I did -- I got more results. I'm just going to show you the -- the coverage intervals.

We took for each one of the people -- by the way, we had 17 people who answered this question. We had 12 people from the panel. I guess only 11 actually were able to make the meeting. But, we also had everybody else, all of the other people were asked to contribute -- were asked to get involved with this. As I said nobody is an expert or nobody is an expert. We're trying to get as many people involved. So, we had a total of 17 people who were asked this and out of those 17 people, their low value and their high intervals cover the correct value. By the way, the answer is 14.4 million.

MR. WALLIS: You mean two people got it completely wrong even with the --

MR. ABRAMSON: Two people, right, got it completely wrong.

MR. TREGONING: Their interval did not --

MR. ABRAMSON: Their interval did not

cover this 14 and a half million. Okay. And their -- and the estimates were all over the lot, but -- but if you looked at the interval as 88 percent, now nominally, this was a 90 percent interval. So, these are well calibrated. These are very well calibrated and I say this is not surprising because again, this is something -- this is like an easy question. Okay.

This is a -- this is something straight down the middle of a plate if your a baseball fan. Because they -- they have a pretty -- they -- they know very much what the population is and they -- and they know that men are about half the population roughly although men 65 or older would be somewhat less than that. So, you have to -- and, you know, of course, you don't know this. So, you have to try to come up with something.

But, they had some rough idea. Certainly much closer than an order of magnitude I would say probably for most of them. So, that's not surprising.

MR. TREGONING: The other thing a preponderance of the panel fell into this distribution.

MR. ABRAMSON: Yes, that's true. Right. That's right. Well, in that cohorts --

MR. SIEBER: Lot --

MR. TREGONING: Rapidly --

MR. ABRAMSON: Or rapidly -- rapidly approaching it. All right. And that --

MR. KRESS: No, tell me again. What's the 15 and the 17?

MR. ABRAMSON: Oh, the 17 people were the number of people who actually were involved in the exercise. This is the people who answer the question and of those, we did -- as we looked at their intervals, so, the intervals were the -- the -- interval between the low value and the high value. This is nominally 90 percent confidence -- 90 percent coverage.

MR. KRESS: I was interested. Was that a factor of three?

MR. ABRAMSON: Between what low and high?

MR. KRESS: Yes or factors.

MR. ABRAMSON: I don't -- I don't have --

MR. KRESS: Because I sat here and did that exercise and I was wondering what their range was.

MR. ABRAMSON: Oh, what their factor of three. Yes, there would -- I don't know what the factors were. I -- I don't have that in front of me.

MR. TREGONING: With that particular

question, we were pretty -- the median was about right, too.

MR. ABRAMSON: The median was pretty close. Yes.

MR. TREGONING: The median guess was somewhere I want to say 17,000,000 or something.

MR. SIEBER: I --

MR. ABRAMSON: Well, yes, let me tell you. All right. Let me see if I can give some. Let's see now, the mid value. Okay. Let me tell you about the mid values.

The median of the mid values was 20,000,000. The correct answer is 14. So, it was a little high and if you look at the upper quartile, another way I did this was -- was box plots. I -- I presented. So, the upper quartile was the upper 75th percent of the responses. That was 28,000,000. So it was a factor of higher and the lower quartile was 16,000,000 also high. So, the estimates tended to be high. The estimates were high. They were biased high.

MR. WALLIS: More people like us in other words.

MR. ABRAMSON: Yes, right. That's right. Exactly.

MR. SIEBER: Well, that's -- the only people we know are people that are old.

MR. ABRAMSON: Yes, precisely. That's what I said. Right. Exactly. So, it was biased -- it was biased high.

MR. WALLIS: Going to live longer obviously.

MR. ABRAMSON: That's right. Yes, it was biased. It was biased high. That's right. The general answers were biased high.

CHAIRMAN SHACK: Your coverage on the -- the 88 percent, now is that taking the lowest of the low values and the highest of the --

MR. ABRAMSON: No. No, it's not. What it's doing, we took the individual intervals. We had 17 intervals and the question was did these intervals have 14.4 billion in the center and on those -- somewhere in the interval and almost 15 out of the 17 did.

MR. SIEBER: Right.

MR. ABRAMSON: That was the definition of the -- the intervals are suppose to be 90 percent coverage intervals. In other words, 90 percent of the time if they're well calibrated, they will have the right answer in that and, in fact, that's what happened.

MR. TREGONING: You obviously could expand your interval if you wanted to -- to be sure that you would be covered.

MR. ABRAMSON: Yes, well, you could cover. Zero and 300,000,000 or something like that.

MR. TREGONING: Right. Right.

MR. ABRAMSON: But, people were trying -- obviously, people were trying to be, you know, serious about this and that's why we -- that's why we used a low -- we did use a minimum value and we didn't use a -- a maximum value.

CHAIRMAN SHACK: You didn't ask for bounding values.

MR. ABRAMSON: We -- we -- we're not asking for absolute bounding values.

MR. KRESS: Well, how do you think they established their -- their range. For example -- for example, you know, you can be very sure if you know what the population of the U.S. is. So, you don't put any uncertainty on that.

The half is pretty sure. Now -- now, that you want -- then you're getting down to how many of this half are in the 65 and older range and that's where you put your uncertainty.

MR. ABRAMSON: That's right.

MR. KRESS: But -- but --

MR. ABRAMSON: You're uncertain about your -- your --

MR. KRESS: I -- I was struggling. I was trying to do your exercise there. I was struggling with now how am I going to put an uncertainty on that particular aspect of my -- my estimation and I didn't have any basis for it. I just literally pulled it out of the air.

MR. ABRAMSON: It's not -- you're right. You're absolutely right. It is not easy to do and it's uncomfortable, but what I'm trying to demonstrate with this exercise if you take the group as a whole --

MR. KRESS: Yes.

MR. ABRAMSON: -- each one individually, you -- you do it.

MR. KRESS: No matter how they --

MR. ABRAMSON: You don't feel very comfortable about -- but, as a whole, it's better than you might think. It really is and that's what I'm trying to demonstrate to the people. That there is some information of some sort in the group opinion and the purpose, of course, is suppose to make them feel more comfortable about, to get some buy into the process so then when they -- they do come up with their answers in the elicitation, that they will -- will try -- they'll exert some mental and if you like maybe emotional effort to try to come up with something which represents their best guess.

MR. KRESS: Well, let -- let me ask you --

MR. TREGONING: For the purposes of the training, we didn't go into their rationale.

MR. KRESS: I understand.

MR. TREGONING: And actual elicitation --

MR. KRESS: But -- but, you do -- but, you do in the elicitation.

MR. TREGONING: That's right.

MR. KRESS: So -- so, if I were being elicited on this particular item number one --

MR. TREGONING: Yes.

MR. KRESS: I can tell you how I come up with my -- my best guess.

MR. TREGONING: Tell us how you got their best guess. Right.

MR. KRESS: But, I just pull the rains out of the air. Now, is that a -- is that acceptable?

MR. ABRAMSON: Yes, absolutely.

MR. TREGONING: If that's how you did it, that's acceptable. We note that as a rationale.

MR. ABRAMSON: You see -- you see what you might do --

MR. WALLIS: You have no better method, Tom.

MR. TREGONING: Right. Right. If that is your only method and you had no better way of doing it, then the point of the elicitation is not to try to snow us in anyway. We want to know how you came up with it.

MR. FORD: I find this very troubling. I really do. You've got a group of 12 people. Some of who will recognize. For instance, just take one problem, not this generating problem. The failure of frequency for cracking in four inch schedule 80 pipes in the BWR. How many of those 12 people will have been told beforehand that there are subsets within that failure frequency dependent on, for instance, connectivity? That current purity. Will they know that?

Since they're to come up with a -- a arbitrary mean and low and high value, that's no value whatsoever if they don't know what the key parameters are within that frequency.

MR. ABRAMSON: Well, we'll --

MR. TREGONING: You want to respond to that?

MR. ABRAMSON: Well, as I -- well, that's why we had the base cases. The base cases were extremely specific conditions and you'll hear about that from Dave Harris in a moment.

MR. FORD: Okay. Good. Good.

MR. ABRAMSON: And so we tried to do -- the questions we asked them was to be as -- to make as specific comparisons as possible defining all of the conditions, all the physical parameters as we could and you'll get -- I -- I can't tell you no more than that.

MR. FORD: Okay.

MR. ABRAMSON: And so, we didn't ask them what do you think this is? That's -- that was the -- that's where we spent most of the effort of this whole exercise is defining just those conditions, just the questions to ask and what order and so on.

MR. FORD: Okay. I'll -- I'll wait for Dave's presentation.

MR. ABRAMSON: Okay.

MR. FORD: Okay.

MR. ABRAMSON: Okay.

MR. WALLIS: When you did question two, did you know the answer to question two?

MR. ABRAMSON: Oh, yes. Yes, I know the answers. I can tell you --

MR. WALLIS: No, when -- when the panel did question two, did they know the answer to question one? Because the guys who were way off on question one --

MR. ABRAMSON: No.

MR. WALLIS: -- would probably be way off on all the other questions.

MR. ABRAMSON: No.

MR. WALLIS: On the second question, maybe not the third.

MR. ABRAMSON: I'm not sure if I -- I know -- I don't know if I told them the answers to that -- if I gave them the answer to this right away. No, because I'll tell you -- let me tell you in a second it won't -- it won't matter.

Consider the following chronic conditions. Let me just go into that in a moment. These eight chronic conditions, arthritis, cataracts, you see all these things. Chronic conditions. Okay. Now, here are the questions. There were three other questions.

First of all, I -- I focus on many

American man age 65 or older suffer from these chronic conditions and when I say how many, I -- I neglected to say here -- we ask is the rate per thousand. The absolute rate. Not the total number, but the rate per thousand.

MR. WALLIS: Oh.

MR. ABRAMSON: Okay. I left that out here.

MR. KRESS: And was the question how many suffered from all those at the same time or whatever?

MR. ABRAMSON: No, one -- no, one at a time. One at a time. One at time. Right. Okay. One at a time.

MR. TREGONING: One or more for that first question.

MR. ABRAMSON: No. No. No, how many -- no, the question was -- all right. I don't have the question here, but I --

MR. TREGONING: Oh, that's right.

MR. ABRAMSON: Now, wait a second. Consider arthritis. Okay. Arthritis. The question is what is the rate of suffering of people? How many suffer from arthritis?

I can tell you the answer is around 40 percent.

MR. WALLIS: I don't think -- I don't think you know the answer.

MR. ABRAMSON: I do know the answer from the almanac.

MR. WALLIS: A lot of -- a lot of people are not diagnosed.

MR. ABRAMSON: Well, this is not -- okay.

MR. WALLIS: People that have been diagnosed with arthritis.

MR. ABRAMSON: These -- all right. If you're right, the question should be what does the almanac say and these are --

MR. WALLIS: We all have hearing loss of some sort. Everybody.

MR. ABRAMSON: Well, these are -- these are the official statistics. Whether in fact it represents the actual situation, I don't know.

So, actually, what you -- you raise is a good point. The question was you have a number, but what does it mean? Where does it come from? What's left out and so on and so forth.

MR. TREGONING: Right. And actually -- hearing loss was actually -- it was called severe hearing loss.

MR. WALLIS: So, what do you mean by

severe?

MR. TREGONING: That's right.

MR. WALLIS: Under what circumstances? Condition about? Who's speaking?

MR. SIEBER: It means your hearing aid doesn't work.

MR. TREGONING: Okay. You had a group. So, the whole purpose of this is to get the experts to realize that the exact verbiage of the question is incredibly important and you need to put as much effort into understanding what the question is asking first than you actually do trying to answer it.

So, the fact that we had some -- when we discussed this exercise, the fact that some of these questions were vague in people's mind was a point that came out.

So, what was incumbent upon us is when we developed the questions for the experts, we had the experts -- we developed our first set of questions in March. They had to read them first.

What exactly do you mean? We had several iterations of just making sure the questions and what we were asking not only were understood, but were consistently understood from expert to expert to expert.

MR. FORD: Are we going to see some of those questions?

MR. TREGONING: Yes, we have -- I can provide you with all of the questions. We don't have time to go through --

MR. FORD: No. No, I just want to get a feeling of what depths did --

MR. TREGONING: We can go through one question and then I have flow charts for other questions that are -- we're giving you the easiest question, the most straightforward one just because that's the one that we could hope to get through in a relatively short amount of time.

MR. WALLIS: Well, I think what you ought to do is ask this question of the public and then ask it of some MDs and see if the experts do any better.

MR. ABRAMSON: Yes, and it wouldn't surprise me if -- if they may -- I think -- I think -- I don't know. I haven't tried this with different pieces of the public, but it wouldn't surprise me that much if they do as well as the MDs possibly.

MR. WALLIS: So, you don't need experts. Just ask the man on the street.

MR. ABRAMSON: Well, yes, remember -- well, the purpose -- the purpose of this is to say even though you're -- nobody is a real expert in this. That's why you use these questions that they are not an expert in. The question that we're going to ultimately ask them there is not data. We're asking them to extrapolate beyond what they know.

Nevertheless, there is value in the group judgment. That was the purpose of this. This is going to be -- the numbers we're going to come up with are going to be some -- in some sense a group amalgamation of what we have and so, we want to try to demonstrate to them that there is some value in this process and that's what we're trying to do here. These overall statistics.

Let me just go through this quickly. So, we asked for here is an absolute rate. The absolute rate. For the arthritis, it turns out to be about 40 percent. For cataracts, it was about 12 -- about 12 and a half percent and so on.

And so, we asked them to come up with the absolute rate per thousand. All right. Now, we had a total of 90 of these confidence -- these -- these 90 percent coverage intervals. We had a total of 90 and of those 55 had the -- were correct. So, we had 61 percent coverage when nominally it will be 90 percent. So, we saw that it went down very considerably from the 88 percent. Which is not surprising because they have much less information about it.

Now, the next two questions was we asked for the ratios and this -- the reason I did this, of course, is this is exactly the sort of question I'm going to ask them. Relative values. This was in absolute numbers and absolute rate and they wanted to see -- we're asking the ratios and particularly the ratios we see -- the ratio of the rate for men and now we use 45 to 64 to 65 and older. So, this is like middle aged to old.

MR. SIEBER: Two to one.

MR. ABRAMSON: Medium break compared to large break or something like that.

MR. KRESS: So, you -- what do you mean? You mean men over 65 are old?

MR. ABRAMSON: No. I said -- no, the -- old here -- 65 -- this is an inequality. Greater than or equal to 65.

MR. KRESS: Okay.

MR. ABRAMSON: Okay. I'm in that category. So, no, absolutely I'm sure many people here are. No, absolutely not. Sixty-five and older. Okay.

So, in other words, you compare two

groups. The 45 to 64 to the 64 plus and again, men and the ratio of the rates. All right. They did better. Seventy-two percent. Because it's getting a relative value and then similarly, we did under 45. So, this is like the young, the relatively young to a 45 to 64.

So, we tried to go back. We used this as the base case. So, 65 and old. Then 45 to 64 is the middle-aged and then finally, the younger ones say 45. So, we had the three categories here corresponding to our three categories and you'll see in a minute of 25 year of -- 25, 40, and 60 year of life of plan. So that was the idea.

And here we again got a total of 71 percent for these ratios.

So, this showed us -- well, first of all, it showed a couple of things. First of all, it showed that -- that they got reasonably good coverage. This is pretty good.

MR. WALLIS: But, of course, here they know that men die at age 80 or 90.

MR. ABRAMSON: Oh, yes.

MR. WALLIS: They -- they don't know when the nuclear power's going to die.

MR. ABRAMSON: No, we only go up to 60

yet.

MR. SIEBER: Sixty years and one day.

MR. ABRAMSON: Okay. Anyway. So, we got -- we got some -- so they said even though you may -- even though individually they may feel really uncomfortable, still the intervals did a pretty good job of covering what they were suppose to do and I have a lot of other data to, but I don't want to go over that.

The purpose is not to go -- the answer to the purpose is -- is to give them an -- is as I said two reasons, to give them practice in coming up with these numbers and secondly, to try to get some more comfortable feelings, some buy-in for the process as a process. To show them that it can work.

MR. WALLIS: Let me ask you though. Here you found out that you've gone on something like number -- number two, a 61 percent score.

MR. ABRAMSON: Yes.

MR. WALLIS: Are you expecting from this elicitation process to get something like a 61 percent liability?

MR. ABRAMSON: No, I -- I have no -- I -- I have no expect --

MR. WALLIS: What kind of -- what kind of confidence do you expect to get out of this assess -- this --

MR. ABRAMSON: I -- I -- we are -- I have absolutely no intention of putting --

MR. WALLIS: It seems to me very important. Because if I can only get a 60 percent confidence level --

MR. ABRAMSON: You're right.

MR. WALLIS: -- I'm not very happy.

MR. ABRAMSON: You're right. I have no intention whatsoever of assigning a confidence to the results. We will give you -- what we will show you is the uncertainty and the variability and the results along with the rationale and so on. You know, as much detail as -- as -- you know, as -- as appropriate. As much detail as you want or as much detail as is necessary.

We expect we're going to get very considerable uncertainly bands because there are uncertainly bands like this and the -- what confidence -- I -- I refuse to put a confidence on the -- on the result. I think it's essentially a meaningless exercise. But -- but the whole --

MR. TREGONING: You can't put confidence on something you don't know.

MR. ABRAMSON: That's right. Yes. But, on the other hand, the whole process by going through this process and you'll see the detail, how we phrase a question now and so on and so forth. I think we hope and the documentation of all of this and the rationales that this will get people saying that this gives you a -- a reasonably good basis for going to the next step which is any kind of regulatory or rule change or anything of that sort. So, that's the purpose.

No. No, we don't know. We don't know and we can't know what it is.

MR. TREGONING: One of the things I -- I think it's good for perspective here. Obviously, the panel's going to struggle with the difficulty of what we're trying to do. We've struggled with this throughout this entire process, but I think perspective in some sense is in order in the sense that this is the third time as an agency we've attempted to evaluate these LOCA frequency distributions.

The first time was back in WASH 1400 days back in '75/'76, but we really had no operating experience data. So, at the time they took all their estimates from primarily other industries and -- and primarily it was the oil and gas industry. If you think about that, there's really no relation between materials, degradation mechanisms, quality assurance and again I say oil and gas. It was mainly oil and gas transmission. So, that was -- but, again it was all that they -- it was the information they had at the time.

When this was updated in '95, what was done was a very focused study where they looked at precursor events in class one piping and what was precursor events essentially leak -- reported leak events which by themselves were relatively small in number. We're looking at a handful in class one piping of -- there were less than ten events total within the operating experience database.

And again, these were things that were reported within LERs only. So, it certainly wasn't even necessarily a full assessment of the type of degradation that you could get in class one systems.

And then there was a simple rule of thumb, conditional failure probability given a leak that was applied to this precursor data and used to develop LOCA frequencies. Again, it's not -- I'm not disparaging this earlier work, but what we're trying to do here is in a sense a quantum leap compared to what's been done in the past. We think it's -- we think it's appropriate here because we're trying to use the data in a much finer sense for more rigorous probabilistic applications than we've ever done in the past, but we certainly realize that what we're doing is a quantum leap greater than what we've ever done in the past to try to develop these LOCA frequencies.

CHAIRMAN SHACK: You did the probabilistic calculations in the '80s with PRAISE.

MR. TREGONING: Yes.

CHAIRMAN SHACK: You left those out. I mean that's a -- another shot at this.

MR. TREGONING: Yes. Okay.

CHAIRMAN SHACK: Sorry.

MR. TREGONING: No, that's okay.

MR. ABRAMSON: You want to go back? I think it's page six, number four in the panel -- at the panel discussions.

MR. TREGONING: This right?

MR. ABRAMSON: Okay. Continuing along with the structure of the process we used, all right, there were extensive panel discussions. I said we met for what is it? Twice.

MR. TREGONING: I think the sixth. I think you -- because you -- you covered the training.

Right?

MR. ABRAMSON: Oh, I'm sorry. Oh, that's right. I went down in six. Excuse me. That's right. I'm at six. Okay.

Then the next step after this was the elicitation questionnaire and we had I think literally I don't know hundreds of questions. Many, many questions. This went through many iterations, a number of iterations between the project staff and the expert and the expert panel and we wanted to get obviously clear questions. We wanted to be sure that we're -- that what we were -- how they interpreted the questions, what we really wanted to do. We were concerned about the logical structure of this because it was complex structure to do it in a -- in a -- in a way in which it would -- the information flow would seem to flow more naturally and so on to be -- and to try to minimize the confusion.

So, that was the purpose of going through this and we finally did come up with what was a questionnaire which -- which people responded to.

Now, we had a total of 12 elicitation sessions. The first two of these were full elicitation sessions. These lasted about -- all of them lasted a full day really and we consider these pilot elicitations. We use the result of these to revise the questionnaire to some extent. I guess we did do some revisions of the questionnaire.

MR. TREGONING: Fairly intensive.

MR. ABRAMSON: Fairly intensive right. Because there's no -- there's no -- as I say with any kind of a survey instrument, it's, you know, it's an axiom in the survey business, you need to pilot test it and that's what we did here.

And then also it turned out that our approach, the emergency fault loading was -- just didn't make any real sense. So, we really completely revamped that as a result of these first two elicitation sessions.

So, these were extremely valuable as -- as -- as pilots which we -- I'm not surprising they do that. Okay.

And then as I said, we had 12 individual elicitation sessions. Now, first of all, there was preparation by the expert. All the experts were sent the questionnaire and they were asked to complete it as completely as they possibly could and, of course, to state their rationales. We emphasize this throughout the process. That was very, very important. It's not just in numbers, but the reasons for the -- reasons for this and what we're going to do eventually, you know, is come -- is summarize these and so on and feed these back to the panel as I'll go into later.

So, that was their -- that was their homework before.

MR. FORD: Excuse me. Will we see an example of one of these today?

MR. TREGONING: Of -- of actual elicitation responses?

MR. FORD: Yes, just to give us a feeling as to --

MR. TREGONING: I don't --

MR. ABRAMSON: I don't know. I don't think we're prepared for that.

MR. FORD: The depth to which this has gone into.

MR. TREGONING: I don't -- I don't have -- I don't have one available in the presentation.

MR. FORD: Okay.

MR. TREGONING: It could be made available. One thing -- one thing we need to do before we make them public is we did -- we're trying to insure a level of a degree of confidentiality --

MR. FORD: Sure.

MR. TREGONING: -- so that all the experts feel like they can state their opinions without any --

MR. FORD: I understand.

MR. TREGONING: So, whatever we would make public would need to be scrubbed pretty thoroughly --

MR. FORD: That's right.

MR. TREGONING: -- for me to do that.

MR. FORD: The reason why I ask it is I -- I say it again. The value of this whole thing depends on, you know, how much has gone into these. How much thoughtful questioning has -- on -- how much thoughtful thinking has gone into the answer to those questions?

MR. ABRAMSON: You're absolutely correct.

MR. FORD: So, I'd like to see the question and the depth of the answer.

MR. TREGONING: Okay. The questions I can provide readily.

MR. FORD: Okay.

MR. TREGONING: And -- and we will do so. In fact, have I sent those to you, Mike?

MR. SNODDERLY: I've --

MR. TREGONING: Okay. We'll -- no -- we will send for --

MR. SNODDERLY: I haven't --

MR. TREGONING: -- we will certainly provide those. The question responses, we had planned to provide those in a -- in a synopsis form of which we're currently working on. How much individual detail I'd be able to provide, I'd at least want to make sure that they were fully scrubbed before we --

MR. FORD: Sure. I agree. Absolutely.

MR. TREGONING: But, I don't see any -- other than that, I don't see any problem with providing it.

MR. FORD: Okay.

MR. ABRAMSON: Then at the elicitation session itself, we, of course, had the -- the expert and then let's see. There was -- the team was a normative expert. I'm the normative expert on the -- on the whole process itself.

Then we had -- that should really be experts. Rob was the one who asked -- asked virtually all the questions, but in addition to that, we had was it three other people. We had Allen and two from the NRC who attended part of -- part of the sessions who were experts or knowledgeable in various areas, data analysis and then we also had what's his name? Gary, Jerry, somebody else.

MR. TREGONING: Paul Scott.

MR. ABRAMSON: We had Paul Scott. Yes. We had several other people. Two or three other people in the room who were -- who were there as -- as knowledgeable about the various phenomena.

CHAIRMAN SHACK: So, fracture mechanics --

MR. ABRAMSON: Fracture mechanics. That's right. Yes.

MR. TREGONING: Anywhere from five to ten people depending on the elicitation.

MR. ABRAMSON: Yes, that's right.

MR. TREGONING: I think the fewest we ever had were five.

MR. ABRAMSON: And -- and then we had a -- well, first of all is we tape recorded everything. So, we have those available in case there's any questions and then we had somebody taking very careful notes and summaries as well of this.

So, that was the --

CHAIRMAN SHACK: How long does the expert work on his questionnaire and rationale? I mean he -- he -- he completes the questionnaire and state rationale and discusses it with you. That's the process?

MR. ABRAMSON: I'll come -- I'll come --

I'm coming to that. Okay.

Now, at the -- at the session itself, so this is something that goes to -- the session itself what we do is we went through all of the questions. We went through it one-by-one through the questions and got their answers. Sometimes they were able to answer them. Other times they -- they didn't -- they didn't -- either they weren't expertised or they didn't understand or they didn't have time or something like that.

Our purpose was first of all to make sure they -- clarify the questions and the issues and where they did answer, we asked in great detail about what it is they did and all their -- their -- their mid values, their high values, their rationale and so on. So, we went over. Many of them had printouts of their -- of their answers. They went through and they had a -- a -- a rubric or what is it a copy of the questionnaire and they just filled in the answers. So, we went over those.

And our purpose was to first make sure we -- that we understand what they were saying, that they understood what we were asking for, and so on and so forth.

We reviewed the responses first for

completeness to see if we had everything and consistency. There were a number of times when they -- and that was one of the purposes of this. Because we asked -- deliberately asked some questions to provide consistency checks on these things to see if, in fact, they were consistent. Not to catch them up obviously, but to try to make sure in their own mind to do this. Because again, it's very easy as I mentioned before if you're coming up with probabilities say which you want in this case, the numbers don't add up. Well, this is what we're looking for. Similar sorts of things.

And so we went through -- so, that -- so, that -- so, that the -- the time that we spent essentially was going through the questions, their particular answers, their rationale, making sure that -- that we understood each other, mutual understanding of -- of the -- and also looking for consistency, inconsistencies and so on.

We also -- at the end, we also -- we always ask a question at the end. The last half hour or so was on a feedback on the elicitation process itself. We want to get how -- how they felt about it so far. It isn't finished yet and so, when I say generally speaking the results were -- were fairly positive on this and we -- and we got some good ideas as to, you know, lessons learned and so on which we'll deal with -- which we'll talk about later when -- when we talk about the final elicitation results.

Now, this was during the meeting. Now, as follow-up, I think nobody -- nobody actually completed all the questionnaire for various reasons. So, their homework was to complete the questionnaire for the ones -- the -- the questions that they were -- had felt knowledgeable about. Some of them -- some areas they didn't know anything about. They said they were very uncomfortable. We said all right, just leave that out. That's one of the reasons we have a panel of 12. We're not relying on everybody for all -- all the answers.

To complete the questionnaire and also complete the rationale development. So, they all had homework to do to go back and to -- and to finish doing -- doing it. Hopefully, with a better understanding of what it was that we were asking them.

All right. Now, those results have been coming. Rob I think indicated we just about have everything -- we have most of the material that the experts promised us.

MR. TREGONING: I think we've gotten

updated responses from everyone. We still -- we're at the point where we need to go through the updated responses --

MR. ABRAMSON: Right. That's the --

MR. TREGONING: -- and -- and scrub them again before they're ready to be included in the analysis.

MR. ABRAMSON: Okay. Fine.

MR. TREGONING: So, there may be further iteration with various experts --

MR. ABRAMSON: Okay.

MR. TREGONING: -- as we go through their responses.

MR. ABRAMSON: And now the next major step, and that's what Rob and I are going to be working on over the next several months I'm sure, is to take their answers and to compose them and to come up with what we want mainly the LOCA frequencies.

Now, we're going to do this in -- in two ways. First of all, we're going to take each experts' responses in so far as we can and come up with -- with their implied or calculated LOCA frequencies are based on their responses and we'll do this insofar as we possibly can. Not everybody may have given us -- people may not have given us everything. We asked for

PWRs, BWRs separately.

So, we'll do what we can with what we have. So, this will be like a self-consistent estimate from each of the experts. So, they're be expert numbers.

And then, of course, what we want to do is we're going to take the answers to each questions for the panel and we're going to combine this and come up with if you like a panel -- a panel answer for every question and then combine these for the panel frequencies. So, we're going to do it both ways. Both individually and get the panel responses. All with associated uncertainties and so on.

So, that's going to be our job to take the answers and to -- and to combine them to come up with the -- with the -- with the LOCA frequencies which, of course, is the object of this exercise.

MR. WALLIS: Now, I'm not sure if you -- do you have a mathematical rationale for how you treat this? I mean suppose you get a lot of outliers. You get a lot of disagreement among the experts. Are you going to -- how do you present it? Do you present --

MR. ABRAMSON: Well, what I plan to present -- no, what I plan to present -- I think it's very important in this case because there is so much uncertainty is not to minimize the uncertainty and so, I plan to present is the, in effect, the full range of uncertainty where -- where it's -- uncertainties where we get some credible answers or credible answers. Yes, absolutely. We're going to give you the full range.

MR. WALLIS: Well, that's -- that's not -- I mean if you get 11 experts saying one thing and one expert saying another you reach a different conclusion. Although as it spread, then if the spread is more uniform between the experts.

MR. ABRAMSON: Well, I'm going to present the --

MR. WALLIS: All kind of measures of uncertainty you can present.

MR. ABRAMSON: Well, I think -- I think a good measure -- I think what I plan to present as far as this probably is -- is the box plot. It think it's an excellent idea. It gives you three numbers. You got the median. You got the upper quartile, the lower quartile and then you got the extremes on either end. It's a very, very good -- the five-point summary of data and I think it's -- it's -- it's just what you need for this sort of thing.

MR. WALLIS: Then if there are any

peculiarities about grouping of experts.

MR. ABRAMSON: Of course.

MR. WALLIS: And you also -- you also present that, too.

MR. ABRAMSON: In effect, that's built into there. But, if there is anything in particular, we'll present that. But, we'll -- we'll try to summarize the data that way. I think that's a very relevant --

MR. TREGONING: If we notice any biases based on background or anything like that, we can certainly explore that.

MR. ABRAMSON: Yes. Yes.

MR. TREGONING: Our -- our plan is not to censor anyone. If there's a one outlier, he might -- that person may be an outlier for a very good reason.

MR. ABRAMSON: Well, this is where the rationales are important. I mean that's why we -- that's one of the reasons we asked for the rationale is we want to try to have some basis for saying whether, in fact, this opinion should be considered at all. Something like that or, you know, bring something up.

So, that's why we ask for the rationales and -- and we said -- is it -- I said the philosophy they were planning to use is not to under -- under -- not to distort -- distort the real uncertainty there is in this situation.

MR. WALLIS: Are you going to come up with a conclusion that says we recommend this number be used with this range of uncertainty?

MR. ABRAMSON: I -- I -- well, as far as, I -- I don't know. Are we -- are we -- are we -- is part of this exercise to come up with a recommendation or is this to come up with the results? I don't know.

MR. TREGONING: We'll -- we'll have results.

MR. ABRAMSON: We're going to have results.

MR. TREGONING: And the results will be not one set of numbers, but one -- one number, but --

MR. WALLIS: A big distribution of stuff.

MR. TREGONING: -- effective distributions.

MR. WALLIS: Right.

MR. TREGONING: Yes, for -- for what we're trying to --

MR. ABRAMSON: Well, I think frankly -- I mean speaking as a -- like I say as a decision analyst, this is the job of the decision makers to do. It's not our job as -- as analysts to do. I think our job as analysts --

MR. WALLIS: Well, I hope you make a more rationale decision.

MR. ABRAMSON: I think our job as analysts is to present the results. How the decision -- how this is weighed into the regulatory decision, taking account of all of the uncertainties and other factors, is -- is -- that is what the stuff that the -- that the -- ultimately the Commission needs to do.

MR. TREGONING: We have -- in my mind, we have two objectives.

MR. ABRAMSON: Yes.

MR. TREGONING: Not only to develop the results. Develop thorough documentation behind the results so that the documentation and the rationale and the approach that was used to develop the results can be used by the decision maker to determine how they want to apply these results.

MR. ABRAMSON: That's right. We want to give them as stellar a basis for the decision as we possibly can.

MR. KRESS: So, you're -- you're final product is going to be a -- a distribution of frequency versus LOCA size.

MR. TREGONING: Versus break size.

MR. KRESS: Versus break size.

MR. TREGONING: One for BWRs and one PWRs.

MR. KRESS: And one for PWR.

MR. ABRAMSON: Yes, that's what it'll be. The range of estimates.

CHAIRMAN SHACK: And it'll be PWR or BWRs with hydrogen chemistry and BWRs without hydrogen chemistry?

MR. TREGONING: It'll be just BWR generic.

CHAIRMAN SHACK: BWR generic. Interesting.

MR. TREGONING: Generic. We haven't -- we haven't -- we're not breaking it down -- we're not breaking the final result down to that level of --

CHAIRMAN SHACK: Maybe I'm getting ahead, you know, just thinking about myself. If I had this base case, you know, it seemed to me what I'd ask an expert is okay, you know, what's the difference likely to be in crack growth rate between a 10-inch pipe and a 22-inch pipe, you know? What's the different in initiation likely to be between a 10-inch pipe and a 22-inch pipe? Those are -- those are questions that an expert can answer for me.

Once he gave me those answers, I don't think I'd ask him anything more. I'd go off and I'd do the calculation for the -- the probability that the pipe would actually break.

MR. TREGONING: But, then you've got to -- you've got to believe in your -- you've got to believe that you've got models and calculational procedures that can take that basic information and give you a result that is less uncertain than if you would have asked the experts. The expert --

CHAIRMAN SHACK: Are some of the experts -- some of the experts going to do it my way?

MR. SIEBER: You're the ultimate expert.

MR. TREGONING: Again, each expert did their own -- each -- each expert used their own approach. Did -- did anyone -- did anyone specifically exercise their models considering the differences in initiation and differences --

CHAIRMAN SHACK: I mean because, you know, seriously I -- I -- you know, I don't know what an expert does to, you know, sort of decide a difference in -- in break frequency between the 12-inch pipe and the 22-inch pipe. Like I say, I mean you can ask experts questions they can answer like is the crack growth rate going to be any different in a 12-inch?

You know, that -- that's something an expert I think could answer.

MR. TREGONING: I don't disagree, but --

CHAIRMAN SHACK: Okay.

MR. TREGONING: -- you still have to take that information --

CHAIRMAN SHACK: Yes.

MR. TREGONING: -- and get the final result and that's -- that's non-trivial. So, we're asking the experts to make that link for us. I think when we go through what we've done, it'll become -- it'll become apparent. You may not agree with it, but it'll become apparent. We're -- we're getting into the details. That's the next part of this. Once we get after -- once we get through Lee's presentation.

CHAIRMAN SHACK: Is this a good time for a break?

MR. ABRAMSON: I've just got two more.

MR. TREGONING: Two more?

MR. ABRAMSON: Two more -- two more points to cover.

MR. TREGONING: Very quickly. Right?

MR. ABRAMSON: And we're just about ready -- finished. Okay. Just -- just to finish up the process.

The next -- after we do our analysis, we're going to have a wrap-up meeting, the panel and that will probably be -- probably February or something.

MR. TREGONING: At this point --

MR. ABRAMSON: At this point, our -- our best estimate is that it's probably over in the February time frame and at that, we're going to present all the results and the rationales to the experts. Summary of the results, the rationales to the experts and the purpose is to get a response to them, discussion of this, and so on.

So, you know, does this seem to make sense? What do they think about it and so on and so forth and they will have an opportunity if they want to revise any of their individual responses. Although, my previous experience is they probably aren't going to want to do this, but I think that this will -- that is to actually revise their answer, but they -- they have an opportunity to do it.

But, I think this discussion will be very valuable to us in order to be able to judge the -- the -- the credibility of the whole process as a whole and so on.

And then finally, we -- we're going to ask for final feedback on the process as a whole. How they, you know, how they felt about this? How it might be improved? Some -- some good aspects. Some things that might be improved and so on. Because they're very much interested in this.

And then finally, the documentation. We'll just -- you know, we'll write a report on this which will document all of the results in -- in detail.

MR. TREGONING: I think after -- after we have the wrap-up meeting and we've got feedback from the panel itself, then we'd be ready at that time to come back and present again in front of this body in -- in some form. Probably subcommittee first so that we can go into much more detail into the results, the analysis, the final -- the final answers that we're getting. We'd be ready to do that at that time.

MR. ABRAMSON: Yes, I think we would -- we would want to certainly have the -- the results of the wrap-up meeting before we present because that could -- that might very well change how -- how we're going to -- you know, how -- how -- we may very well find it modifying our -- our -- our aggregation and so on.

MR. TREGONING: But, again, after we get feedback and any --

MR. ABRAMSON: Feedback, yes.

MR. TREGONING: -- iteration that's provided by the panel on those initial results, once that process is complete, then I --

MR. ABRAMSON: Then we'll be ready.

MR. TREGONING: -- think we'll be ready to come back here --

MR. ABRAMSON: That's right. Yes.

MR. TREGONING: -- essentially.

MR. ABRAMSON: Yes.

MR. FORD: And so, is that -- is that kind of meeting early next year which presumably going to be writing a letter in the March/April time frame?

MR. TREGONING: I would think it would be in that time frame.

CHAIRMAN SHACK: Well, you're going to deliver it to the Commission in March. Right?

MR. TREGONING: We're -- we have an SRM requirement to deliver it to the Commission by the end of March.

CHAIRMAN SHACK: Right.

MR. FORD: It could be February.

MR. TREGONING: We haven't scheduled this meeting yet. So, that's why I would -- I would hesitate to schedule an ACRS meeting at this point until we schedule this final meeting first.

MR. SNODDERLY: This afternoon we're going to be briefed by Eileen McKenna of NRR about how they're going to respond to the SECY and when would be an appropriate time for us to write a letter on this process and also the staff's approach to -- for responding to the SRM. So, I would suggest that at the end of the day we would conclude where -- when we want to follow up in -- in future action.

MR. FORD: There's no formal letter being asked for before spring of next year?

CHAIRMAN SHACK: Yes, that's correct. You're in the middle of the process. So, I mean --

MR. TREGONING: We're just here for status reporting today obviously.

CHAIRMAN SHACK: So, we can begin to understand how an expert elicitation works and give our opinions.

MR. SNODDERLY: As opposed to having distributions dumped on -- on your lap in -- in March.

MR. FORD: So, what is the documentation? Is it something like a NUREG that goes out? Is it the official document of the agency?

MR. TREGONING: Ideally, yes, we would like -- the NUREG process can take some time. So, we'd like to have something before that, but eventually, it would certainly be a NUREG.

MR. FORD: I think it would.

MR. TREGONING: I don't want to -- I don't want to sign up for having a NUREG by March.

CHAIRMAN SHACK: No.

MR. TREGONING: But eventually we certainly would. This might be a good -- okay.

MR. ABRAMSON: This completes. Thank you.

CHAIRMAN SHACK: Let's take a break then for 15 minutes and well, yes, let's be back at ten of 11:00.

MR. TREGONING: What's -- we're scheduled for the morning. What sort of flexibility would the panel like to have with that?

CHAIRMAN SHACK: We don't want to miss the -- the ending date. So, people are going to be bailing out here in the afternoon. So, we're going to probably hopefully maybe catch up a little bit of time somewhere in the next -- either that or it's going to come out of lunch.

MR. TREGONING: We're going to get into the detailed technical nature now.

CHAIRMAN SHACK: Yes.

MR. TREGONING: So, if we -- if we --

we'll tend -- I don't think we're going to catch up.

CHAIRMAN SHACK: Okay.

MR. TREGONING: That would be my --

CHAIRMAN SHACK: We'll probably take it out of lunch.

MR. KRESS: Yes, we -- we can shorten lunch.

CHAIRMAN SHACK: We're going to shorten lunch. Be my guess.

MR. TREGONING: We're -- we're -- again, we're -- we're here today and we're -- we're willing -- we're more than willing to sit down and go through as much detail as necessary. That's why we're here. So, whatever -- whatever's sufficient. Make sure we do that. Okay.

(Whereupon, at 10:38 a.m. a recess until 10:55 a.m.)

CHAIRMAN SHACK: I think we're ready to start again. Turn my mike on and make sure it's working.

MR. TREGONING: So, now we're going to get into some more technical detail. Again, some of this has been presented already in the July, but we're going to have the chance to go into it in more -- in -- in greater detail.

So, what I'm going to do now is talk about the issue formulation that the panel went through in developing the framework for the whole exercise. So, you can get a sense for how that evolved.

Then I'm going to lay out the conditions of these base cases that we've touched on. Why we're using those, how they were defined, what they're used for.

Then Dave Harris is going to get up and provide excruciating detail on how he -- on his one particular approach for calculating this set of conditions.

Then after that, I'm going to summarize some of the results, move on to the elicitation questions that we're using, and then look at status.

We've got a lot of ground to cover. Like I said earlier, we'll -- there's a lot of detail in here. We can go into as much detail as you'd like.

CHAIRMAN SHACK: Is a fracture mechanic a guy who does fracture mechanic's analyses?

MR. TREGONING: Is a fracture mechanic? He's something -- it fixes things that are broken. Right?

MR. SIEBER: That's Dr. Goodwrench.

MR. TREGONING: So, slide nine in your --

in your --

MR. LEITCH: Just -- just the previous slide there. The --

MR. TREGONING: Sure.

MR. LEITCH: -- operating experience indicates an arrow into the formal --

MR. TREGONING: Yes.

MR. LEITCH: -- expert elicitation process. So, by that I would imply that -- that operating data, the same set of data is provided to all the expert elicitation panel or do they have their own perception of that operating experience?

MR. TREGONING: We -- we have operating experience database for both piping and non-piping precursor events that has been -- it's not -- it's been summarized and -- and in summary, the summaries have been given to the experts. The actual database this has been given themselves.

MR. LEITCH: Yes.

MR. TREGONING: We've got two different access databases that we've developed, one for piping and one for non-piping. Have precursor events in them and that's at the full -- that full availability to all the experts.

MR. LEITCH: Okay.

MR. TREGONING: Now, I can't guarantee that all the experts used it.

MR. LEITCH: Yes, they'll be individually biased by --

MR. TREGONING: Right. Some are more comfortable using that data at -- at a very low level and some were more comfortable just using the summary information that was provided for the data.

MR. LEITCH: Now, might I also understand from this figure that operating experience may be used downstream of the process to bias the results. In other words, there's going to be three different results coming out of this.

MR. TREGONING: No. No.

MR. LEITCH: Operating experience, elicitation, and -- and probabilistic.

MR. TREGONING: This -- this flow chart's not a perfect description, but what -- all it's trying to convey here is that the formal expert elicitation we're trying to extrapolate information that we get from operating experience and probabilistic fracture mechanics analyses. Use this process to give us the answer that we're looking for. This is this break spectrum of frequencies.

MR. LEITCH: So, we shouldn't have --

MR. TREGONING: This -- this other line is just to show that we've also tried to provide a link or a bench mark between our probabilistic fracture mechanics and operating experience wherever we can.

MR. LEITCH: So, that other line --

MR. TREGONING: This link is not trivial also.

MR. LEITCH: Yes.

MR. TREGONING: So, it's a very difficult thing to do.

MR. LEITCH: Yes.

MR. TREGONING: And I'll -- we'll -- we'll show -- you're going to see as we get on how we do this. So, I didn't -- this is essentially in a cartoon step our process. I didn't want to go over this just because --

MR. LEITCH: But, simplistically, I could think about operating experience and probabilistic fracture mechanic as feeding into the --

MR. TREGONING: Yes, that's what these arrow says here.

MR. LEITCH: -- formal expert --

MR. TREGONING: These -- these are fundamental to this process.

MR. LEITCH: Yes. Okay.

MR. TREGONING: But, this process takes this information and extrapolates it --

MR. LEITCH: Okay.

MR. TREGONING: -- as required so that we can get the answers that we're looking for.

MR. LEITCH: Okay.

MR. TREGONING: Slide nine, this is -- this is our approach. I've seen this -- I've shown this to you before and I'm going to be using it as like an index throughout the presentation, but really -- and Lee's talked a little bit about this. I'm going to go through much greater details.

So, the first thing I want to talk about and this -- I -- I reported this back in about May of '02. We -- we conducted in March of '02 a preliminary elicitation. I've got a slide just to refresh your memory as to why we did that and what that found at the time.

The next step was selecting the panel and the facilitation team. We discussed a lot about this in the July meeting. So, I didn't have -- I wasn't planning on covering this fully again today.

What I wanted to make sure we did is looked at what the panel, the work the panel has done first into developing a -- the technical issues, the basis for the elicitation. This is constructing the approach we're using and also defining what significant issues there are that affect LOCA frequencies.

Then we'll jump into quantifying these base case frequencies. Again, these are estimates that have been developed for well-defined conditions for piping. Needed two estimates which use standard PFM analysis and two estimates which use operating experience analysis.

While the estimates were independent, these four people worked as a group to develop background information that the whole subgroup shared together. So, while these were individual calculations, there was a basic set of background knowledge that all the four shared and not only the four, but that basic set of background information is also available to the rest of the expert panel at large.

So, this was a subgroup within the full panel that was conducted and at the June -- we had the kickoff meeting in February. We had a review meeting in June. Between February and June, these four people worked to get their estimates as closely -- as close as they could to calculating the set of conditions that we defined as a group.

We came back in June. Each person presented their assumptions, methodology, and results.

We wanted to decrease the burden. So, we didn't ask these people to write reports, but we did in the meeting is we had a common presentation template so that -- for assumptions. If you wanted, you could take the same slides out of each of the four members' presentations, each expert, and see the different assumptions that people used. You could see the different approaches and then you could see the different results that people got.

So, we tried to do it in a systematic way so the information was readily transparent and summarized in a way that the rest of the panel could use and make their judgments with respect to it.

CHAIRMAN SHACK: This operating experience analysis is this one of these empirical sort of D to the N type scalings. Is that what they're -- they're doing?

MR. TREGONING: They're -- they're using -- this is how we've done it in the -- this is LOCAs have been done in the past where you look for precursor events and then you make assumptions for how the precursor events translates into the probability of -- of the LOCA essentially. So, that's essentially what that analysis is.

So, we're going to talk about this generically and then Dave Harris is going to provide detailed information on one specific approach and then I'm going to come back and summarize the results of all the four different calculations. You'll get a sense for the variability as well as the absolute numbers that we're getting in just these approaches.

We'll delve into the questions. We'll talk a little bit about the individual elicitations and again, the -- the rest of the schedule. This is essentially where we're at now somewhere in here.

So, I'm going to use this slide as a template to show where we're at through the rest of the presentation.

MR. FORD: Just to make sure I understand.

MR. TREGONING: Sure.

MR. FORD: This -- this is starting to make sense now.

When the -- the -- the PFM analyses and that would be people like Dave, Pete Ricardella, and so on --

MR. TREGONING: Yes.

MR. FORD: -- and they will take the five base cases, the three PWR and the two BWR cases and they will chunk through the fracture mechanics analysis.

MR. TREGONING: This is correct.

MR. FORD: And then there will be a separate subset of people like I assume Karen Gott and somebody else will do the operating experience analysis?

MR. TREGONING: There were two different people that did the operating experience analysis.

MR. FORD: Right. And then they -- and then they all get together with the whole group of 12 people and say hey, guys, this is what I did.

MR. TREGONING: We had a two-day meeting. One day -- one day of the meeting was essentially just the presentations from each of the four panel members and then -- each of these four members. The other thing as a group, we decided based on these initial presentations hey, we'd like you to go back and look at some other things.

For instance, one of the issues that came out of -- our of your work, Dave, is that you had done some calculations without considering the affect of material aging on the basic strength and toughness properties.

MR. FORD: Right.

MR. TREGONING: Well, we got some information from the panel that said go back and -- and run your calculations again, but apply degradation factors from the strength and toughness situations. See how that effects the results.

So, we did a number of sensitivity studies and those sensitivity studies were defined by the mail panel themselves. They don't necessarily make up the base cases, but they could be used by the experts to determine when they make their relative assessments how important those variables are.

MR. FORD: So -- so, unlike the impression I got from the description of this elicitation process, there was some internal review -- self-review process going on. For instance --

MR. TREGONING: Yes.

MR. FORD: -- when you did your analysis, then some -- could come back and say that's completely wrong. Go back and redo it.

MR. TREGONING: We had that as a group and then the other thing at the individual elicitations, the very first question we asked each expert was how -- we asked some specific questions about the base case calculations. How well do you think we did as a group? Did you think some certain set of results was more accurate than another set of results? Do you think the variability that we're seeing in the results is consistent with the uncertainty that we might expect or is it due to the fact that somebody's model's wrong or -- or the problem somebody analyzed is wrong?

So, we asked -- not only did we get feedback with the group, but we asked each individual expert at the beginning of their elicitation specific insights and opinions about this base casing -- base case process that we went through.

MR. FORD: Now, I made the somewhat socky comment earlier on about the fact that there was a -- a predominance of mechanical engineers --

MR. TREGONING: Yes.

MR. FORD: -- on -- on your panel. Calibrate me in the case, for instance, for the BWR piping.

MR. TREGONING: Yes.

MR. FORD: I only need for -- both the feedwater and for the stainless steel piping. The synergistic effects go on -- take into account changes in the water chemistry or the material or the fabrication sequences.

MR. TREGONING: Yes.

MR. FORD: In your group meetings --

MR. TREGONING: Yes.

MR. FORD: -- were there synergistic effects taken into account? A pure mechanical engineer may not have understood existed.

MR. TREGONING: And I want to --

MR. FORD: Well, for instance --

MR. TREGONING: I just want to be clear I understand what you're -- I understand the question you're asking before I attempt to --

MR. FORD: Well, for instance, in the -- maybe this was going to come out in your -- in your talk, but in the probabilistic fracture mechanics assessment of the LOCA probabilities for BWR piping --

MR. TREGONING: Yes.

MR. FORD: -- was the fact that the conductivity would have a distribution amongst all the -- was there a feed? Was that fed into it? Into the analysis?

MR. TREGONING: Do you want a comment specifically on PRAISE? I mean you -- that's a variable input to PRAISE essentially.

MR. HARRIS: That's a variable input to PRAISE and we just fixed that at some representative number and didn't consider that.

MR. FORD: Okay. So, the fact that the coolant conductivity has changed over the years, markedly or by almost a -- an order of magnitude, would not be represented by these analyses?

MR. TREGONING: It wouldn't necessarily be represented by the base case frequency calculations. Not -- that is true and then what the expert would be asked to do would say okay, given this change in conductivity, how would that potentially in a relative sense affect how those numbers should behave.

MR. FORD: And my -- and my question is was that question asked?

MR. TREGONING: Not specifically. We didn't for the simple reason that that's a very specific question.

MR. FORD: Yes.

MR. TREGONING: If we looked at every variable that was important and you did, we'll look at -- I have lists of all the variables that we as a panel said that -- that are important.

MR. FORD: But, it affects your reality in -- by -- by two orders of magnitude.

MR. TREGONING: Okay. I would agree it's an important consideration. We left that -- we left each expert to raise the issues that they thought were most important and to address those issues.

MR. FORD: Okay.

MR. TREGONING: So, we didn't specifically say what is the effect of a change in conductivity. We said what are some issues that would affect these calculations.

MR. FORD: Okay.

MR. TREGONING: And what's the magnitude of the affect of the change. Each expert brought their own -- everyone has their own drum that they beat of things that they think are important.

MR. FORD: Yes. Yes.

MR. TREGONING: We were trying to get a sample of what other things people think are important.

MR. FORD: Okay.

MR. TREGONING: A lot of people that had more knowledge of operating experience said, you know, the loads that were applied in that analysis, I think that they're not realistic of this --

MR. FORD: Okay. Okay.

MR. TREGONING: -- of -- of this system and here's why and I think if you had realistic loads, here would be the affect on your results.

So, there's a lot of variables --

MR. FORD: That's true.

MR. TREGONING: -- that come into play that affect the final results of which that's one of them.

If we ask very specific questions like that, we would -- we'd never get there. We'd -- we'd never be able to get to the answers that we -- that we're trying to obtain.

MR. FORD: Okay.

MR. TREGONING: As it is, the questions that we asked -- like Lee said, we took all of the day of intense face-to-face interrogation to get the answers essentially and this was after again, heading into this meeting even, each expert would have spent -- I think the average was two weeks to a month of preparation time and even developing their answers.

MR. FORD: Okay. Okay.

MR. TREGONING: And that varied with experts.

MR. FORD: Okay. Good.

MR. TREGONING: I think --

CHAIRMAN SHACK: But, even in the 1980s vintage BWR, I sort of surprised you wouldn't use a distribution of conductivities. I mean in 1980, you know, plants ran over a pretty wide range of --

MR. TREGONING: Right.

CHAIRMAN SHACK: Probably a hell of a lot wider in 1980 than it is today.

MR. TREGONING: Right. Right.

CHAIRMAN SHACK: I mean

MR. FORD: .1 to .2.

MR. TREGONING: Right. Right. No, that's -- that's -- there's no doubt about that and again, this -- this is one of the reasons, you know, all the models that we have each model has strengths and weaknesses. We have no one model. We're trying to develop a model potentially that -- but, I would argue there's no one model that can adequately assess all these different variables. If there were, that's what we would have used for this exercise.

But, because we don't have that, we're telling here the people -- we're bringing the people together that have looked and -- and asked these kind of problems. Bring whatever model you have. Give us the answer that you have and like Lee said, we're -- what we're counting on here is that there will be N heads are better than one. That -- that the fact that we've got 12 different experts of -- with -- with different ranging expertise and material expertise is important, but it's only one facet.

CHAIRMAN SHACK: Sure.

MR. TREGONING: Which is why, you know, we don't have 12 material experts. We looked for people when we selected the panel that were broad and had expertise. So, a lot of the "mechanical engineers" that we have know something about materials. Maybe not to the level of detail of somebody like Karen Gott would, but they certainly have expertise in that area.

People like Sam Ranganath who's certainly familiar with IGSCC cracking. People like Gary Wilkowski who have dealt with PWSCC modeling in the past and -- and people like Pete Ricardella. They're mechanical engineers first, but they have been working in the area long enough that they at least are aware of and have an appreciation of material issues that are out there.

MR. FORD: Okay.

MR. TREGONING: Okay. I move on. This is just to refresh your memory of -- I -- I discussed this in great detail May of '92. This was a preliminary elicitation that we conducted. We also think this was important.

This was done in a very quick manner. We did this over about a month. We did it solely internally using only NRC experts.

Why did we do this? Well, there were two reasons. One, we were doing a feasibility study at the time to even look at the feasibility of -- of attempting this 10 CFR 50.46 exercise and we needed some quick numbers. So, that was one reason. For expediency purposes.

But, the more important reason is we wanted to identify beforehand issues, technical areas of expertise we were going to need to cover in the formal pattern, and talk about developing possible frameworks and structures, and also try to identify strengths and weaknesses that we needed to address in the formal elicitation.

So, this exercise we've used to shape quite significantly what we're doing in the formal elicitation. There were a lot of internal lessons learned that we got out of this preliminary exercise.

We also identified some technical issues for consideration. So, that when -- when the expert panel for this exercise did brainstorming, we were able to have technical issues that at least internally, we talked about they were raised in case -- again so that things weren't left. Things weren't forgotten.

Again, we did get results out this earlier exercise. Again, it was a much more -- it was a much quicker exercise. It didn't nearly have the quality assurances hopefully we're going to have in this, but we were predicting about a modest increase based on this for LOCA frequencies over what we've been using for 5750.

And at the time I presented it, I think I got -- some people in the panel here said well, that sounds about right and other people maybe it didn't sound about right. So, I -- I think we need to expect that. We had even -- it was apparent at the time that we had opinions within this group as to what we maybe should have found. So, have their own gut instincts as to what these numbers should be.

So, I -- I just wanted to refresh your memory because that is an important facet of this that we're not really focusing on, but we've used it to guide us at least initially in how we chose the panel and selected -- at least developed some initial frameworks and made sure that we had full coverage of the technical issue.

Once we had the panel selected, however, and we started down the process, we didn't want to bias them with this earlier elicitation. So, the results of this elicitation were not discussed at all. Even the mechanics of the elicitation weren't discuss to the formal panel. We wanted this panel to develop their own internally consistent set of estimates.

So, the next part I'm going to go into is a look at how the panel -- how they broke down and defined technical issues. This will get into some of the brainstorming that was done in February and lead us up to the development of these -- of these base case conditions.

So, first, we had to define our scope within the elicitation, what we were going to try to do specifically and address and -- and how we were going to start to break this problem down.

As Lee implied, what we're trying to do is break the -- break the global problem what are the LOCA frequencies for generic PWRs and BWRs into as fine a decomposition as possible yet still make that decomposition management. So, we're not breaking it down on an atomic level per se. We're trying to break it down on a level that we can get at as a panel at a whole.

So, that's what we're trying to do and what I'm going to be discussing in these next upcoming slides.

So, obviously, the first thing that we had to do we had to define what -- what a LOCA was to make sure we all had consistent understanding and we had to define how we wanted to break down or how we wanted to develop a LOCA and we said we ought to base it on flow rate.

Flow rate's what's been used historically and it's important because it determines what mitigating system you need for response. The flow rate at least for our panel seemed like a natural way to -- natural way to distinguish these LOCAs.

However, we didn't have any thermal-hydraulic people on the code. So, we did have to develop generic correlations between effective break size and flow rate. So, that was some other technical background work that we did in a generic sense that was provided to the panel.

So, even though our definition --

MR. WALLIS: Well, I'm sure I said this before, but the gallon -- gallons are a lousy measure of flow. Is it a gallon in the reactor or a gallon in the bucket outside? The densities are very, very different.

MR. TREGONING: Right. This is effective

makeup capacity.

MR. WALLIS: That's atmospheric conditions or what?

MR. TREGONING: At atmosphere conditions. Yes.

So, that -- you're -- you're right. We had to be very careful of how we defined --

MR. WALLIS: I wish you just wouldn't use it because then someone else might misunderstand it and use it under reactor conditions and --

MR. TREGONING: Well, we needed a -- I agree, but we needed a -- we -- we needed a cursory way at least to develop correlations.

MR. WALLIS: Yes, I understand that.

MR. TREGONING: And I -- I realize these -- these break -- these thresholds have been used historically and they vary from plant to plant and they're not -- you know, they're not accurate in any sense, but we --

MR. WALLIS: Yes, that's okay. We can -- we can move on. Let's move on.

MR. TREGONING: -- we've retained them for consistency as much as anything else.

So, the flow rates we have -- as Graham mentioned, three of these are historical levels.

They've been used in 1150 and other exercise as well as -- and we maintain them for consistency as much as anything. These are historically how we define small, medium, and large break. The new thing that we've done here is we added three I'll call them other large break categories, LB a, b, and c.

LB c is effectively equivalent to double-ended guillotine break of the largest pipes in the plant. So, that's -- that's effectively an LB c and what we wanted to do here we're -- and this is an important point, we're interested in absolute numbers.

Absolute numbers are important, but as important and in my mind even more important are relative differences between these various LOCA sizes.

So, I would argue we're going to have the greatest uncertainty in the absolute LOCA frequencies, but as -- as Lee showed with some of his census questions, if you look for relative differences, those questions are easier to answer. So, if we were off by even an order of magnitude let's say in this number, I would not be surprised.

However, I would expect to be within an order of magnitude if I compare this -- this absolute value or this frequency to that frequency and those relative differences are going to be important and when we get to the end of the day, what's the decision maker going to use. I think understanding these relative trends are going to be as important as the -- or possibly more important as the absolute numbers we come out of this exercise with.

Okay. Again, we did this crude correlation and the other thing we've asked each person to evaluate three time periods within this exercise, current and by current we've defined that as an industry average of about 25 years of operation.

MR. WALLIS: I'm sorry. I'm still not sure. Is Category 1 all breaks over 100 or between 100 and 1500?

MR. TREGONING: Greater than. These are -- these are --

MR. WALLIS: All over 100. All the way up to a million?

MR. TREGONING: All the way up to a million.

MR. WALLIS: Okay.

MR. TREGONING: So, by definition, this number will always be -- these numbers will always decrease.

MR. WALLIS: Doesn't made sense though.

MR. TREGONING: Why?

MR. WALLIS: Well, it's a cumulative then. It's no longer a small break if it means cumulative breaks all above 100.

MR. TREGONING: You're -- right. You're right. I ought to be -- these aren't the exact definitions we use. Normally, small break is a -- is a 100 to 1500. So, you're right. This is a cumulative.

MR. WALLIS: So, what -- it's cumulative. Okay.

MR. TREGONING: It's cumulative.

MR. WALLIS: Okay.

MR. TREGONING: Right. But, what most of the experts have said is what you expect that as you go up in flow rate size, the -- at the lower flow rate size, the smaller diameter things dominate -- dominate the larger things and you have to go up in flow rate size before you start to uncover the effects of failure in -- in larger diameter systems.

We asked them about three time periods. Again, current which is where we are today and again, that's roughly at about 25 years of average operation and we asked them about end of design which is about 40 years of operation and then take us to the end of life extension.

So, this -- these questions are to ask -- ask them to make an assessment of what the LOCA frequencies are today. Then project those in the future another 15 years. What you think -- what -- what are the trends that you see developing in this area and then finally really put on your Nostradamus hat and go out another 35 years and look for issues.

Obviously, and again, there's the question of how we're going to use this. Obviously, this information isn't -- isn't going to be used for an quantitative regulatory decisions.

What we're trying to get out of here is a sense from where people think we're going and some of the important issues that we have to be wary of in the future.

So, this -- this sense for where we're going in the shorter term is really of greater important. This we're really looking for ideas in topical areas. Things that people think could be important in the future. Again, we need to -- we need to look out for.

I've showed this before, but I -- I think it's -- it's good to show this pictorial issue structure. This is how the panel decided to break these issues down and -- and this -- this is the level, Dr. Ford, at which we have decomposed the problem. Okay. So, this level.

It's not quite to the level that you were talking about. It's -- it's at least one or two levels higher than that, but this is what we're finally looking for. These LOCA contributions.

First thing we did was break them into passive and active system LOCAs. The expert elicitation's only dealing with passive system LOCAs. These are things like failures of valves, failures of seals. Things like that.

This will be part of the final answer, but this will be based totally on service history at this point. Not any sort of -- it won't be modified at all by any of the information that comes out of the --

MR. WALLIS: So, is DC Summer a piping or non-piping?

MR. TREGONING: Piping.

MR. WALLIS: It's a component. It's a nozzle and a weld and a -- it's still a piping. So, anything that is not -- anything that's sort of a piece of a pipe or anything before it gets into a vessel including the nozzle and everything is a pipe.

MR. TREGONING: Well, I'll tell you how we -- we broke. You're getting into a good question and

I'll -- I'm going to address it here in a second.

Passive system LOCAs we -- we split into piping and non-piping contributions. We defined piping in the same sense that the ASME code does, anything up to and including the safe end. So, we included the safe ends welds in our definition of piping.

But, where it starts to transition into a nozzle let's say, that's not considered piping. That's back in the non-piping regime.

So, we consider all of the sources. We just classified it and just determined what bin we put them in. Okay.

So, piping -- again, we split them into piping/non-piping and then we further -- further differentiated between plant piping systems which could cause a LOCA. So, these are essentially -- in a crude sense, these are effectively all your class one systems.

And in non-piping, we talked about components that could fail, that could lead to a LOCA again. These are -- these are all things that are within -- that make up the primary pressure boundary for the most part.

So, once we identified the systems, we

said as a group, you know, if I look at any piping system and I have to determine whether it's going to fail or not, there's roughly five categories and we call them variable categories of information that I need to know to know how susceptible something is to failure. Okay.

So, we split these into five categories. Geometry, what's the size of the pipe, what's the layout of the pipe, what's the support of the pipe, how many welds are in the pipe, how many elbows, what was -- what was the manufacturing process of the pipe, those sorts of things.

Materials, what's the pipe made of. I said manufacturing. I think we actually grouped manufacturing within the materials. Were the welds field welds, were they shop welds, is it a weld that I expect a lot of repairs rates. These types of things were within the material designation.

Loading history, what's -- what's the typical loading or operating environment for the plant, what sorts of transient should I expect.

MR. SIEBER: Would that include fatigue cycles?

MR. TREGONING: Oh, yes.

MR. SIEBER: Okay.

MR. TREGONING: Aging or degradation mechanisms. Again, that this point we're not linking geometry materials. We're -- we're just -- this is brainstorming. We're saying these are all the aging degradation mechanisms that we've seen or that we possibly could see. We tried to be very generic when we developed this list of variables.

And then finally, mitigation and maintenance. These are the things that you do obviously to prevent failures.

So, we defined these five variable categories and we said specific -- for any given system, specific combinations of these will determine if you're likely to have a LOCA or not.

MR. FORD: Now, in answer to the question that Tom asked --

MR. TREGONING: Yes.

MR. FORD: -- he said that -- I root from all this is just going to be a generic for BWRs --

MR. TREGONING: Yes.

MR. FORD: -- frequency of LOCAs versus break size.

MR. TREGONING: Yes.

MR. FORD: But, what you're showing is that you're calculations are going down to a much smaller subset.

MR. TREGONING: Potentially.

MR. FORD: Potentially.

MR. TREGONING: Yes.

MR. FORD: So, this is where you're going to go within three years. By March of next year, you'll just have for BWR piping generic -- under normal water chemistry conditions generic.

MR. TREGONING: Now --

MR. FORD: For -- for one of the five subsets.

MR. TREGONING: Right. Right. Not quite. Not quite. What we did -- this is -- this is just how we decomposed the problem.

MR. FORD: Okay.

MR. TREGONING: Okay. We decomposed the problem in this way. In the elicitation, we developed two approaches to getting this -- well, actually, this answer. We have what we call a top down approach and a bottom up approach. Right.

MR. FORD: Yes.

MR. TREGONING: The top down says you look at these things from a very global level. Right. And based on operating data of let's say systems that are known -- that we've seen a lot of precursors in, these are systems that I'm worried about.

So, we have an approach that the -- because each expert has a different way they want to tackle it. Some experts wanted to use this type of approach. Oh, I'm very familiar. I've got a good handle on the operating experience. If there's a LOCA, I have a sense for what system you're going to see that LOCA in. Here's why.

So, we have the questions developed two ways. One way to allow them to address this question using that approach. The other ways a bottom up approach where we essentially -- when we break things down to this level, we ask the experts find the combinations of variables in each of these boxes that most like lead to a LOCA. List your most significant ones and then build your LOCAs from the ground up. Do this for each piping system.

MR. FORD: Right.

MR. TREGONING: And essentially summed them up so you can get the total contribution to a piping LOCA. So, we allowed the experts to do that approach as well.

In some ways, this approach is harder in the sense that you have more things that you've got to build up from the bottom. But, in some ways, your rationale is easier in doing it that way because -- because you can click -- you can -- you can make it clear in your mind what things you think are important and it's interesting because the -- and the material scientists in the group tended to want to do it this way and I think if I would predict, that would probably be how you would grasp it.

We had people that -- the PRA type of people that are comfortable looking at data that they said no, I could never do that. This is the only way if you ask me this question that I could get at that.

MR. SIEBER: They're commodity folks.

MR. TREGONING: Yes, they're big picture folks I like to say. They're big picture folks.

MR. LEITCH: I would think one of those five blocks would be fluid operating conditions. Is that implied in one of those?

MR. SIEBER: Well --

MR. FORD: I guess not. That comes under mitigation I think.

MR. TREGONING: If there was any -- yes, if people do things like -- like for thermal fatigue, if they do some special start-up processes to minimize thermal fatigue, that would be in this box. Is that what you're talking about or --

MR. LEITCH: No, I'm talking about different --

MR. SIEBER: Chemistry.

MR. LEITCH: -- different temperatures.

MR. SIEBER: Hydrogen water chemistry.

CHAIRMAN SHACK: Conditions --

MR. TREGONING: Yes, that -- that -- that either fell within this or -- or this category. We didn't have a specific category for operating environment per se. The nominal temperatures for all these things and pressures were roughly constant.

But, what we did is things that -- things that had an affect like the environment, we tried to pick it up into either materials or agent.

So, you're right. We could have defined a separate box for operating environment. The panel itself was just happy with five boxes. There's nothing necessarily unique about this way of decomposing. It was just the way the panel -- they thought that they included all the technical issues with only these five different boxes.

We did essentially the same thing for non-piping, but what we did is, you know, pipes are generally pipes. There's a lot of commonality in behavior. We were -- we were much more prescriptive in that we broke things down into components. Because these components would tend to have different ways that they would fail. We looked at pumps, steam generators, pressure vessel, pressurizers and values.

Now, this is obviously for PWRS. You don't have pressurizers and steam generators, they're not a concern for BWRs because they're not -- not in the primary side essentially.

CHAIRMAN SHACK: And the manway is part of the steam generator.

MR. TREGONING: Manways part -- right. And within each of these components, we broke down the failure mechanisms within these five levels also. So, we had the same variable categories. I just don't show that level of description. You'll see a table here to show you a little bit of what we did.

I think I --

MR. LEITCH: Can I assume to the active systems they're not considered by elicitation because there's enough service history and data that you can -- that you can derive the frequencies based on the data. Is that --

MR. TREGONING: That -- the -- the assumption that we're making is that that is indeed the case and that also that the data is not varying essentially with time. So, that we can use the past date to predict into the future. That's a common assumption of course, but -- but we're explicitly going to be making that same assumption.

MR. LEITCH: And will that be based on -- will you -- will you take a look at that for 2540 in 60 years or is that just going to be linearly extrapolated?

MR. TREGONING: Well, this will be -- again, this active system component is only going to be for the current LOCA frequencies. I don't think we've -- we necessarily want to project them. The only way we could project them likely would be assuming consistency. So, I don't know that it would benefit us much by doing that.

MR. SIEBER: Have you made any attempt to identify or speculate about phenomenon that we have not yet seen in service. For example, if you would jump back four or five years, you would probably not have included something like the Davis-Besse head.

MR. TREGONING: That's right.

MR. SIEBER: On the other hand you know --

MR. TREGONING: Or maybe not PWSCC either.

MR. SIEBER: Right. So, is --

MR. TREGONING: Not if you ask a materials person.

MR. SIEBER: -- is there something in there that says I'm not exactly sure what a future mechanism would be, but I'm going to put in a frequency allowance because maybe there's one out there that I don't know about.

MR. TREGONING: Within aging -- within all these categories, we had a catch-all category and with aging mechanisms -- I should have brought that one and I could. I only brought -- I -- I brought one of these tables that we developed because I didn't want to go through all five. I brought the loading one. But, again, I think this information could easily -- it's been made available I think, but I -- I can make this information available.

For aging mechanisms, we had the catch-all which were future mechanisms.

MR. SIEBER: Okay.

MR. TREGONING: So, if there was anything that possibly people hadn't even considered within the list that we developed, we gave them a way to essentially fudge their results a little bit. Say okay --

MR. SIEBER: And so, you -- it would be

the experts option to say I'm going to throw a certain percentage of the frequency into that bin --

MR. TREGONING: Yes.

MR. SIEBER: -- because I really don't know.

MR. TREGONING: And we saw -- what we've seen to date is when you look at the responses -- when we started asking questions out to 60 years, quite rationally a lot of experts --

MR. SIEBER: That would a fool --

MR. TREGONING: -- that -- that was -- that was a top -- that -- that was an area that had a larger percentage contribution than it ever did back at 25 or 40 years.

So, when we ask people to project out into the -- into the very far future which is essentially at 60 years or greater than our average operating experience now --

MR. SIEBER: Right.

MR. TREGONING: -- people reflected their uncertainty in the fact that there's probably something else that's going to come up that I can't foresee. I think it's going to be important. I can't define it any better than that, but I think something's going to be out there. So, we allowed people to be that vague.

MR. SIEBER: It's not clear to me that you had wanted in the -- in the fringes of the distribution. I think you'd want to shift the distribution to take that into account.

MR. TREGONING: But, it's not -- again, when you get out to 60 years, I'm saying it's not in the fringes anymore.

MR. SIEBER: Okay.

MR. TREGONING: For certain -- not every expert did that, but certain experts certainly had a large percentage contribution there. The defined failure mechanisms.

MR. SIEBER: Were I your expert, I would. You know the old saying. If ignorance is bliss, why aren't we happier.

MR. FORD: But, as you look into the future though, the -- this new program, the proactive materials degradation assessment.

MR. TREGONING: Yes.

MR. FORD: The output from that program will, in fact, lead into this. So, this will be a living document. It'll be a living development.

MR. TREGONING: Well, what we said with the LOCA frequencies and -- and it's -- it's consistent with the SRM guidance that we need to continually reevaluate what we're doing.

MR. FORD: Right.

MR. TREGONING: We're not -- this isn't an exercise that we're doing this one time and we're going to say oh, this good out to the end of license extension.

MR. FORD: Yes. Yes.

MR. TREGONING: We're going to be continually looking at the evolution of precursors that may undermine the basis of this assessment. You know, people are very good at projecting current things they know about what the future affect of them might be. People are obviously much worse in trying to postulate what some of these future things are that they haven't seen yet. So, that's a -- that's a harder -- a harder thing to do.

MR. FORD: Okay.

MR. TREGONING: Again, I think I've covered this. We essentially brainstorm what these variables categories are and -- and the panel defined it as five different ones. They also determined as in the flow chart that these categories are a function of the specific piping system that you're looking at and then the panel went in to develop applicable inputs within each variable category and I'm going to show you one here in a minute.

Then what we did is -- and I'm going to show a -- a summary table. We went in and looked at PWR and BWR systems. Identified where the LOCA sensitive piping systems were and then we looked at the -- at these individual categories and variables that we had developed and started picking out okay, for this system and this environment, these are the materials, geometries, loading, degradation mechanisms that are applicable. So, we developed -- we essentially screened these -- these brainstorm tables that we had developed for these single variable categories.

And that's the other reason -- that's the other point where the operating -- the actual history or the operating environment of that system came into play when we recombined these variables.

And again, part of that was when we did this we wanted to make sure even though we're developing generic estimates, we wanted to sample the range of plant variability that -- that people know about out there. Not just in terms of environment, but in terms of design, materials, things like that.

And from these, we developed master tables for BWR and PWR plants. These master tables were again -- this was another piece of the background information that was provided to the panel.

So, here I just show one and I show the loading category here. So, this was -- this was a table that we developed for the loading history category. So, these are all different types of loads which could affect or lead to LOCAs potentially.

So, again, we developed a table for each of those five boxes that I showed there. We developed one for materials, one for degradation mechanisms, one for geometries, and -- and one for maintenance and mitigation. So, I don't know that we want to go through this, but what you -- the way we -- we broke it down is we talked about main or primary types of loading and then we tried to -- to further define within subcategories different types of loadings that fell under that.

So, when you talk about thermal loading for instance, there's a number of different types of thermal loadings that can occur. Each of those types of thermal loading potentially has a different implication in terms of its severity leading to a LOCA.

So, we tried to be very -- very definitive and very clear about what were the types of things that could lead to a LOCA and -- and again, we also tried to be as -- as inclusive as we could as a group.

We -- does anyone care to go over this in anymore detail or keep going or --

MR. SIEBER: Yes. Keep going.

MR. TREGONING: Keep going. Okay. So, here's an example and I know you can't read this and I apologize for this, but this is an example of one of the master tables that was put together for BWR LOCA sensitive piping.

So, what you see here this is the piping system in this column. These are the materials which are applicable. These are the piping sizes that you have. Safe-in materials, weld materials, significant degradation mechanisms, significant types of loads, and typical maintenance and mitigation procedures.

So, this is for -- this is for BWRs. There was a separate done for -- for PWRs and -- and these tables can be also provided to the panel if there's interest.

And again, these master tables are what we sent the experts home with and they developed their elicitations questions. If they were concerned with let's say RHR failures, they at least had some sense of the types of -- the types of variables that were important within RHR.

MR. LEITCH: What does REM mean in the right-hand column? Litigations, maintenance systems. It says REM.

MR. TREGONING: Yes, these were remaining -- we -- what we essentially said we -- we didn't differ -- we had developed a whole table of maintenance and mitigation procedures. For the BWRs, we didn't necessarily identify any particular maintenance or mitigation procedures which were a function of a particular system. So, it's essentially that everything remaining in that table is applicable.

So, you know, depending -- and again, they're also a function of the degradation mechanism that you're looking for. So, if you've changed your water chemistry, obviously, that's important for IGSCC type of phenomena. So, the water chemistry and issues like that were actually considered within mitigation.

I've got -- I don't know if you -- we have -- we have very detailed meeting minute notes from the kick-off meeting that I know you summarized. That had -- because these tables again we -- they're -- they're heavily acronymed. I think within the context of that document, they're much easier to review and I've provided that document to -- to the ACRS. It's been summarized. I don't know if it's included this level of detail or not, but we can certainly -- can certainly make that document available if that's -- if that's of interest.

MR. FORD: I would be very interested.

MR. TREGONING: Okay. I don't see any reason why we can't. Again the confidentiality would be the only potential issue. So, we may have to go through and scrub wherever there's names in the document. That would be I think the only thing we would need to do.

MR. WALLIS: Well, you've got all these different materials. Does that mean there are different materials in the same plant or different plants have different materials or --

MR. TREGONING: Usually, different plants have different materials.

MR. WALLIS: So, you'd have to know something about where these materials are in which plants and all that. You need more detail than is given here.

MR. TREGONING: This is correct. This is correct and we talked about that -- again, at least for the -- for the -- it's more of an issue for the

PWRs than the BWRs in that, but the -- the BWRs, of course, we had a --

MR. SIEBER: The frequencies you're going derive though are going to be used in the generic sense by plant class. It says specific knowledge of individual materials in a given plant is not necessary for the 50.46.

MR. TREGONING: Not --

MR. SIEBER: It's not to write rule.

MR. TREGONING: Right. Certainly that's right.

One of the things we tried to stress that we are developing generic estimates. However, it -- we -- we stress to the experts if there's a particular plant configuration that you know about, it may not be generic at all. However, that specific configuration could greatly -- could -- could lead to greatly different estimates than I'm providing you here to make us aware of that. So, if there's -- again, if there's any specific design or fabrication or material combination that one particular plant's using, that may not be part of the estimates, but we want to know about that during the elicitation so we can figure out if we need to deal with that in a separate manner.

MR. SIEBER: I would think one of those

issues would be pump seals, coolant pump seals.

MR. TREGONING: Right.

MR. SIEBER: There is variability not only in the flow rate but in the frequency.

MR. TREGONING: Yes, pump seal LOCAs are not -- we define them within the active system component LOCA.

MR. SIEBER: Right.

MR. TREGONING: Now they're not a --

MR. SIEBER: But, it's a -- it's a LOCA nonetheless.

MR. TREGONING: It's a LOCA nonetheless and -- and I think as I go up, the distinction that we use between active and passive system or active system LOCAs are things which have a maintenance rule associated with them.

MR. SIEBER: Right.

MR. TREGONING: And the maintenance rule is designed so that the -- so that you essentially stay at historically low failure frequencies. So, that's why we have separated this one out. We don't have that same sort of maintenance procedure for dealing with passive systems. We do inspection, but it's certainly the same as active --

MR. SIEBER: That's was ISI is for.

MR. TREGONING: Right.

MR. SIEBER: In-service inspections should cover that inspection.

MR. TREGONING: Right. But, it's -- it's -- it's not the same. It's not the same rigor of what we're doing here where you're testing components maybe up to their design requirements to insure functionality. We don't go back in for a lot of these pipes and apply proof testing loads again or anything like that.

MR. SIEBER: I'm thinking of an operating incident like the lost of service water that would overheat a pump seal which would not be detected in any maintenance that you do on an active system except to the extent you may be able to predict the loss of the service water. But, one you lose it, it's a matter of time until it starts to leak and it's over the small break size.

MR. TREGONING: Yes, again, we would -- we're included pump seal LOCAs, but in the sense of -- of what they've done historically.

MR. SIEBER: Okay.

MR. TREGONING: What the historical data has shown. So, we're not -- again, the expert panel, they're no experts in that sort of -- in that sort of process. So, we're -- we're trying to keep things as confined as possible.

MR. SIEBER: So, I take it the expert panel was expert in basically materials and fracture mechanics and things like that as opposed to operations.

MR. TREGONING: No, we have people that are -- well, operating loadings, piping design.

MR. SIEBER: Just plant configuration and human errors and things.

MR. TREGONING: Yes, we don't have any -- again, we don't have any human error experts on the panel.

MR. SIEBER: Okay.

MR. TREGONING: Again, they're more again mechanical, mechanical type engineers that have -- some of which have much more experience in operating history and --

MR. SIEBER: Yes, we're also human.

MR. TREGONING: That's correct.

MR. WALLIS: Well, I'm looking at a -- I'm looking at one thing here say hydrogen explosions. I guess that's in deflagration. Would that be?

MR. TREGONING: Yes.

MR. WALLIS: This has happened.

MR. TREGONING: Yes.

MR. WALLIS: And it -- and the -- the part of happening had to do with the way the plant was run.

MR. TREGONING: Happen, but not in a -- not in a class one system. So, we've --

MR. WALLIS: But, it still -- isn't it still a LOCA the way it happened? Didn't it lead to loss of primary water or am I -- am I -- it didn't. Okay. I'm -- I'm --

MR. TREGONING: All the deflagrations have been secondary in nature.

MR. WALLIS: Okay.

CHAIRMAN SHACK: They ran with the thing blown up.

MR. TREGONING: Yes, in Germany. In Brundesble, they certainly ran with the thing blown up.

MR. WALLIS: That's right. How did they ever get deflagration in the secondary? I thought deflagration was due to the radiolytic some oxygen which has to be in the primary water. Then it -- then it burns.

MR. TREGONING: I mean the mechanism's correct.

MR. WALLIS: Well, then -- then it must

have been the primary circuit that had the deflagration.

MR. TREGONING: Yes, my --

MR. WALLIS: Which is a LOCA. Anyway, I -- I'm just questioning.

MR. TREGONING: No, these were definitely not -- now the Brundesble one was nearly a LOCA only in the sense that when the pipe blew up, it was close to some LOCA sensitive components and the shrapnel could have lead to a LOCA potentially.

MR. WALLIS: Yes. Okay. Well, they're considering that kind of thing I'm sure.

MR. TREGONING: We -- yes, but the focus again and we've tried to keep the experts focused on this. We're looking at LOCAs as the primary initiating event not mitigative LOCAs per se.

So, we're really focusing on when the LOCA's occurring. When the failure of the primary system is the first thing that happened. Because that's consistently how they're use within the PRAs. So, we're trying to be consistent with making sure we're solving that -- using that definition.

MR. FORD: Just to -- just to understand -- if you go onto the next one. Just to understand your thought process here. You choose the recirculation line and specifically 304 under normal water chemistry and the feedwater lines as your base cases for BWRs primarily because (a) you had a good operating base.

MR. TREGONING: Yes.

MR. FORD: Unfortunately, you had all that crack --

MR. TREGONING: Well, I wouldn't say good operating base. We had a lot of --

MR. FORD: That's --

MR. TREGONING: -- a lot of data.

MR. FORD: Yes, and it was your ingoing assumption that that had the highest LOCA frequencies. Therefore, you had -- that's why you chose that as a base. You have plenty of data, operating data and you had a reason to suppose if you were forced at a certain time period, i.e. March of next year, to draw a LOCA frequency versus break size, you had the data to come up with that and support such --

MR. TREGONING: But, again, we're -- what we developed in the base case, I want to be very clear. We're not -- those aren't LOCA frequencies. Those are -- those are frequency estimates that all the elicitation answers are based on.

MR. FORD: Right.

MR. TREGONING: And then from those responses, we developed the LOCA frequency and when we developed the base cases, we did want to -- and we'll get into that in a minute. We did want to pick things that we thought were specific conditions that would tend to be significant. You don't want to analyze things that are insignificant.

So, but -- but still, we just -- we -- these were well defined, one set of conditions for each of those variable categories that we talked about for the most part and we asked the experts to consider all the different possible variable combinations within that entire system.

MR. FORD: Yes.

MR. TREGONING: So, didn't necessarily have to be even the biggest contributor to LOCAs in a given system.

MR. FORD: But, the rationale for -- if you look to March of 2005, for instance, you could well be in a situation of drawing a similar regulatory curve, but now for -- can't specific conditions of say a 316 recirculation pipe operating in hydrogen water chemistry and it'll be displaced.

MR. TREGONING: Yes.

MR. FORD: And people could make a plant

specific justification for putting in mitigation actions or whatever it might be.

MR. TREGONING: These generic frequencies that we're developing, the intent is to again, they're average frequencies at least currently for -- for the global estimate average of how the plants generally are run. You can always come in and make a case that you're plant is better than this generic average.

MR. FORD: Right.

MR. TREGONING: Because of specific steps that you've taken.

MR. FORD: Okay.

MR. TREGONING: So, we're not preempting that process at all.

MR. FORD: You are choosing a worse case scenario.

MR. TREGONING: For that particular one, we did. Yes. Yes.

MR. LEITCH: But -- but, when the expert panel comes back and -- and does a -- a ratio, they could -- that ratio could be more than one or less than one. Right?

MR. TREGONING: Of course. Of course.

MR. LEITCH: In other words, you could say that the --

MR. TREGONING: Of course.

MR. LEITCH: -- typical plant is better than that.

MR. TREGONING: That's right.

MR. LEITCH: Because all but 304 has been replaced.

MR. TREGONING: That's right. That's right. That's exactly right.

And we -- that's why we try -- that's why it was incumbent upon us and we tried to take great pains in -- in this -- we did this in this June meeting. Having the experts understand exactly what we calculated. So that when they made opinions on that, they knew what we were trying to analyze. Because their opinions are exactly right. They have to make an assessment. Okay.

These guys looked at these old pipes and normal water chemistry. Well, that's not the plants I have nowadays. I think there's a factor of five improvement let's say because of better materials, better water chemistry, better water chemistry control. So, I'm going to put a factor of five on -- reduction on these estimates. That's -- that's exactly what we were looking for from the experts.

Non-piping, I -- I think I covered this.

We essentially did it in the same way. The only thing different we evaluated approximately 25 different locations within these primary components and again, the pressurizer, reactor, steam generator, pumps, and valves where passive system failures could lead to a LOCA.

So, what do I mean by different locations? Like the pressurizer, within a nozzle, within the shell, within the heater sleeve. Different parts that are susceptible to different types of things potentially and they have different margins and different sizes also.

We -- the panel then developed what these failure mechanisms were. They also tried to identify components with any possible existing either precursor or some sort of failure data. Because for non-piping, we -- we -- when we started this exercise, we didn't even have a good operating experience database that had been accumulated. So, one of the things we tried to do is in this exercise was develop at least in a -- in a very cursory sense, we developed an initial one of these and you'll see that in a minute.

And again, the -- the panel developed these inputs for these five variable categories that were relevant for each non-piping system.

MR. WALLIS: Are there -- are there probabilities for all these boxes? It seems to me going to be the problem -- problem of round off. Then if they're very reluctant to put zero in any box, you're going to have to add up a huge number of rather small probabilities. You might get something significant which is just an illusion.

MR. TREGONING: If we had a lot of 10^{-6}. We're not adding enough to --

MR. WALLIS: Add up 110. Well, you --

MR. TREGONING: We're not adding up a hundred now.

MR. WALLIS: You've got a lot of categories though.

MR. TREGONING: Right. But -- but --

CHAIRMAN SHACK: But, you're be dominated by the one that's 10^{-4}.

MR. TREGONING: Right.

MR. WALLIS: But, if none of them are, you'll add up 110 in minus 6s. You might -- this might be complete illusion.

MR. TREGONING: Or you -- if you really had 110^{-6}, then, you know, I -- I think that -- why would that not be appropriate?

MR. WALLIS: Because they might have been reluctant to put down any number less than 10^{-6}. I mean that's just --

MR. TREGONING: Again, we didn't -- we didn't ask for numbers 10 to the -- we didn't ask for numbers like that. We asked for relative ratio.

MR. WALLIS: A relative definition.

MR. TREGONING: Then that's -- that's -- because we didn't want to -- estimating small numbers is a very difficult proposition. It's -- it's -- it's something that's incredibly difficult to do.

So, we didn't ask them to do that beyond what was already done for the base cases and -- and that's specifically for that reason why.

I don't think -- we'll have other problems. I don't think that's going to be the problem that we're going to have.

But, I -- I certainly appreciate your concern and that's something that we -- we have to be careful about it obviously if we do see that happening.

And then the final point, we developed master tables. Just like for piping, we did also for non-piping.

Just wanted to show one -- we didn't -- we weren't as complete at filling these in. We only filled in areas that we thought we really needed to provide information to the panel.

But, this is a table for pressurizers. So, these are the different locations. Here's the shell. Here's the manway, the heater sleeves. Sort of bolted relief valves as part of the pressurizer and then pressurizer nozzles.

Talked a little bit about the materials. Roughly a little bit about the geometries, the degradation mechanisms.

We also added comments. So, for the heater sleeves, we had said hey, if you're really going to have a LOCA, these are small enough diameter that you're going to need several of them to fail simultaneously to really give you a LOCA. So, that's something you need to consider when you're providing your -- your opinions.

So, again, we developed a table for each of these components that were non-piping -- non-piping components.

Okay. Now, we get in -- are there anymore questions on that before we get into the really fun stuff?

CHAIRMAN SHACK: Better go on. We're --

we're running a little late here. We want to get to Dave and make sure we have enough time for him.

MR. TREGONING: Okay. Yes, and I think -- yes, bécause -- okay. Let me keep going then.

The next part, I'm going to set up Dave here a little bit. I -- I think we've covered a lot of this, but I want to make sure the framework that we've used for developing these base cases is fully understood. So, I'm going to develop the generic framework. Dave's going to come in and present specifically how we've attacked this.

As I mentioned, we're anchoring our elicitation responses with these base cases. The base cases specify very specifically the piping system, size, material, loading, degradation mechanism or mechanisms, and mitigation procedures.

We defined five base cases, two BWR, three PWR. The recirc system, the feedwater in the BWR. PWR, the hot leg, surge line, and HPCI injection makeup and this is one specifically for BNW reactors because this is an area that we've had -- we've had some experience with a lot of cracking. So, this was the one where we were the most specific about the type of plant it really was.

Again, the LOCA frequencies for each base case condition is calculated as a function of flow rate and operating time. They're the same flow rates and operating times that we're trying to define the -- the bigger scope of the problem for and as I mentioned, we had four panel members that individually have estimated frequencies. Two with operating experience. Two from PFN.

MR. LEITCH: When you -- when you talk these systems, you're talking -- like for example in the BWR, you're talking non-isolatable parts of the system?

MR. TREGONING: Yes.

MR. LEITCH: With the number of welds. In other words, like in the feedwater system.

MR. TREGONING: Yes.

MR. LEITCH: You're counting the number of welds --

MR. TREGONING: Yes.

MR. LEITCH: -- that would be non-isolable.

MR. TREGONING: Non-isolable. That's right. That's correct.

MR. LEITCH: Okay.

MR. TREGONING: And that's -- that's what we're dealing with -- with all of these non-isolable failures.

MR. LEITCH: Yes. Okay.

MR. TREGONING: So, again, let me set up an approach. This was an iterative process between the facilitation team and the expert panel as a whole. So, the panel defined the conditions that they wanted the base case team members to go back and solve. The base case team members went back and solve those, but as they needed, they got -- they -- they solicited information from the panel. Like Dave said hey, before I can do this, I need loading information for the system.

Well, somebody on the panel went out and provided generic loading information for these systems. So, we had feedback throughout the entire process and we got back together in June, presented the results. They got more feedback from the panel. Then these team members went back in some cases and refined their calculations.

So, again, I've said this. This -- this was the -- these are the rules essentially of the analysis. We looked at LOCA frequencies at three different times. A fundamental aspect of this is we agreed a group we wanted to try to bench mark all the results as much as we could using the service experience for leaking crack. So, this is essentially the precursor data of which we do have some actual data on.

Now, in some cases for specific degradation mechanisms, this is actually even pretty sparse, but at least in many cases, these were at least areas that we thought we had actual data that we could use to try to bench mark.

Again, what we tried to do is we had -- we tried to have each of the calculations -- they attempted to capture as closely as possible the conditions that were established by the panel. However, they didn't do that. Some of these did a better job than others just because models had -- certain -- certain models had limitations they couldn't specifically address some of the issues that were framed by the panel.

So, we weren't able to do this to a consistent degree and I think as -- for -- for part of this reason, that's going to lend itself to some of the variability we got in the final estimations.

Other than just the specific calculations, we also did sensitivity analyses. Here we only used PFM results. We didn't try to do sensitivity on the operating experience. But, we looked at the effect of seismic loading and the effect of ISI.

We didn't just apply one loading history. I think for most of these we had several different loading histories that we perturbed to look at that effect. I said we looked at the effect in material aging on properties. I don't have that bullet here and we also looked at the effectiveness of various mitigation techniques.

For instance with the BWR problem, while our base case looked at normal water chemistry and standard 304 stainless, one of the perturbation cases we did is we put a weld overlay on it. So, single variable change and looked at the effect of that one change on the result. So, that sensitivity analysis was done.

Here I just want to -- this is -- this is the definition that -- that we've been working through throughout all of this for the various base cases. So, this is the summary table that each of the experts -- this is essentially the problem each of the -- each of the experts -- each of the four experts tried to solve.

So, again, we defined the system which I had already mentioned. We defined at least within the system for the most part even very specific piping sizes even though we're realizing a given system has a -- has a distribution of piping sizes which are applicable. We defined the material that we were going to use and again for the recirc, we were very clear in stating that this was original 304 stainless. We specified the safe end material, the weld material, and then the degradation mechanisms that we were going to look at.

For -- for the BWR1 case, we were focusing on IGSCC. For the feedwater, we were looking at thermal fatigue and fact. So, really, ideally you were considering the contribution from each of these and adding these.

This was one case for instance Dave's model doesn't have a fact model. So, his analysis of this was inconsistent with the intent. When you see his results, they're really only showing what the thermal fatigue aspect of this is.

That's why again it was very important to present to the panel what was actually solved.

For the PWRs, we looked at thermal fatigue and PWSCC and hot leg.

MR. WALLIS: The loading is nominal service loading. That's the only loading considered?

MR. TREGONING: Nominal loading that one

would expect over the history of the plant.

MR. WALLIS: So, do you include feedwater water hammer?

MR. TREGONING: Normal transients that would occur within the service history. No big transients though.

MR. WALLIS: Why not?

MR. TREGONING: We could have, but again, we want -- these were -- these -- these were baseline numbers. Baseline numbers.

MR. WALLIS: Well, I don't know. I -- the feedwater lines certainly PWRs have been severely damaged by water hammer. This -- where this gets fed into this -- this sort of a table. That's all.

MR. TREGONING: It doesn't get fed into this table, but that's where the experts come. That's where the experts earn their money again because they have to -- they have to be able to extrapolate these results relative to what they think are the most important LOCA issues and we didn't -- we didn't want to skew these by saying all right, we're going to look at water hammer. Because water hammer's not a typical event. We wanted our baseline estimates --

MR. WALLIS: That's not a -- LOCA isn't a typical event either. So.

MR. TREGONING: Right. Right. But, again, what we're trying to do -- the primary exercise here was to develop generic LOCA frequencies that are representative of typical operating experience up to 60 years. So, we didn't want to analyze things that had a frequency of occurrence that was less than one in 60, okay, for -- for any single plan.

So, yes, we've had water hammer failures. They're -- they're certainly important, but we -- we asked the experts to consider their importance relative to these nominal calculations.

So, to get at Peter's, this -- this -- this -- you've said this is a worse case. Well, there's aspect of these from the material standpoint that are -- that make it a worse case, but there's other aspects that maybe -- with respect to the loading that don't necessarily make this a worse case.

So, it's not -- these aren't all cut and dry in a sense. We -- we weren't trying to be overly conservative or overly un-conservative. What we wanted to do was pick a set of things which we thought we had a shot at analyzing and that we thought were at least representative of some of the big challenges that we're facing generically. So, that -- that was really the -- that was really the intent behind this.

MR. WALLIS: Another little puzzle. I think most LOCAs would be caused by unusual loadings of some sort.

MR. TREGONING: Well, again, given that we've never had a big LOCA, the fact that you would need an unusual load to provide that --

MR. WALLIS: We haven't one -- none in the normal service either. So, normal service either. So.

MR. TREGONING: Right. Right.

MR. WALLIS: But, the only time I know pipes have been severely damaged has been rather unusual conditions.

MR. TREGONING: Right. And we would -- and certainly if you look at -- if you go back over the operating database, with -- with each event that you had, you tend to have something about --

MR. WALLIS: I guess I'd take that back. I -- I -- there seemed to me to be more causes of damage by unusual conditions than by just normal nominal service loading. There have been events with nominal service loading.

MR. TREGONING: Well, of course.

MR. WALLIS: Yes.

MR. TREGONING: I mean if you look at --

MR. WALLIS: Right.

MR. TREGONING: Certainly our IGSCC event database, I don't think a lot of that was associated with atypical loads.

MR. WALLIS: Right.

MR. TREGONING: What we're seeing now with CREM cracking and PWSCC, I -- I don't think people would argue that those were due to --

MR. WALLIS: No, that's right.

MR. TREGONING: -- abnormal loads.

MR. WALLIS: That's right.

MR. TREGONING: We've seen a lot -- a lot of information on socket weld failures that I don't think they would be considered to be unusual loads.

MR. WALLIS: Yes.

MR. TREGONING: So, we've tried to distinguish. That's why we have the second part of it where we say let's say an unusual load happens. What do you think the likelihood of failure under those conditions are?

MR. WALLIS: Yes. Okay. Yes. Yes. That's right.

MR. TREGONING: So, that's why we have that second part. But, that second part is -- this is hard enough. The second part's even harder as you're going to see here.

MR. WALLIS: I guess the normal service loading is becoming more challenging as we get experience.

MR. TREGONING: This is the challenging. Yes, the -- these -- these base cases are challenging to --

MR. WALLIS: Right.

MR. TREGONING: -- analyze as you're going to see here in a minute. When you have to extrapolate them, that's why we're doing the elicitation. Because the extrapolation itself is also very challenging. Just --

MR. LEITCH: The base case is not necessarily conservative or non-conservative. The criteria for the base case is what do you think you've got the most evidence for. Is that --

MR. TREGONING: We tried to as a group take -- we wanted to sample degradation mechanisms. We wanted to sample systems and -- but, we wanted to focus on systems that people thought were important especially for the big LOCAs. If you --

MR. LEITCH: Yes.

MR. TREGONING: -- you see here most of these big. We've only got one relatively small diameter pipe.

MR. LEITCH: Yes.

MR. TREGONING: So, we tried to pick some of the things that people thought -- again, well, if you asked me if we were going to have a LOCA, what do I think the cause would be and what do you think -- what system do you think it would be in. We'd tried to capture some of those within here. Again, we didn't want to be exhausted. We also wanted to -- to define these in such a way that we thought we had a shot at calculating them. At least a -- at least a running start.

And I -- I can't stress this enough. I've had -- at least one person after the elicitation came up to me and said that, and this is somebody that's been working in -- in this related field for about 35 years and he said, you know, in a sense that this -- this was easily the hardest most difficult thing he had ever had to do over his entire career and I -- quite frankly, I think that was the proper perspective. Because this is on the surface of it a very daunting challenge for anyone to undertake and we've tried to make this as painless as possible.

But, we're still asking very difficult questions. There's no doubt about that. We're asking questions that if they were obtainable by other means, we would use these other means.

And now I leave this in --

MR. LEITCH: What happened to page 23?

MR. TREGONING: That's Dave's presentation?

MR. SIEBER: That's an interesting page.

MR. WALLIS: It doesn't seem to be. It seems to be before his presentation. Page 23.

MR. TREGONING: Oh, I'm --

MR. WALLIS: This one here.

CHAIRMAN SHACK: You're going to come back and wrap up.

MR. TREGONING: I'm going to come back. I'm going to come back. I'm sorry. I've change -- I apologize. You're right. I -- I had one slide out of order in your handout.

MR. WALLIS: This looks like a very interesting slide because you've got two experts here of extremely different --

MR. TREGONING: It is very interesting and that's why --

MR. SIEBER: We'd like to meet Expert C.

MR. WALLIS: Expert C seems to be an extremist. I mean it's either very likely or completely unlikely.

MR. TREGONING: We're going to come back, but I think -- we're going to get into more detail on one approach and then what I'm going to do is come back and summarize all the approaches for various results and I -- it's going, you know, like -- like Bill had said this is going to be an interesting discussion. I think that'll be a very interesting subset of the discussion that we'll have.

MR. WALLIS: So, you're going to discuss page 23 then?

MR. TREGONING: Oh, of course. We'll -- we'll discuss that in great detail. How quickly I'm able to go over that will be a function of this group.

But -- but, now I'm -- we're ready to go into Dave's presentation. Keep going?

CHAIRMAN SHACK: Yes, let's go for another half hour. Then we'll break for lunch.

MR. TREGONING: Dave's probably got -- we're estimating probably an hour depending on how much you guys want to grill him.

CHAIRMAN SHACK: After a half hour, we'll know how it's going.

MR. SIEBER: So will he.

MR. TREGONING: Hold on, Dave. Let me go back here real quick.

MR. FORD: You've got -- you've got two copies of your thing?

MR. TREGONING: Now, you're going to another presentation.

MR. KRESS: A separate set of handouts.

CHAIRMAN SHACK: We don't know which one he's giving first.

MR. TREGONING: This is the only one you haven't looked at yet.

MR. FORD: But, this is -- yes, I know, but I think it's the --

CHAIRMAN SHACK: We're leaving Rob and going and then we'll come back.

MR. TREGONING: Here we go. Yes, I'm sorry. It's just placeholder.

MR. WALLIS: When we see slide one, we'll know whether we've got the right one or not.

MR. SIEBER: There's a lot of slides.

MR. TREGONING: What do I want to do here? I want to go back to this. Sorry, Dave. I'm having trouble getting the -- my cursor to work. Let me try it this way. Okay.

MR. HARRIS: I'm David Harris. I'm with Engineering Mechanics Technology, San Jose, California.

Before I get started, I'd like to add a little of my perspective on this expert elicitation. You were talking about how difficult this was. I compared it to my Ph.D. oral. This is the worse thing I've gone through since my Ph.D. oral and it was quite an ordeal.

MR. WALLIS: Is that what you're talking -- you're speaking about today's presentation as well?

MR. HARRIS: No, well, hopefully today's presentation won't be that bad.

MR. TREGONING: That's a given.

MR. HARRIS: Do I have -- well, I can talk into this thing.

MR. TREGONING: Yes, you can talk into those. That's why I gave it to you.

MR. HARRIS: Yes. Well, we've already discussed today about local frequencies as a function of the flow rate that were evaluated for these base case systems and these were estimated by probabilistic models for crack initiation and growth and -- and what I'll be discussing is my particular efforts in this regard.

I was one of the four sub-panel members that came up with estimates of the LOCA frequencies for these base case systems.

We've already discussed how these base case systems were selected by the expert with a list of the systems. So, we can move on to the next slide.

The LOCA frequencies were estimated for expected dominant degradation mechanism for each of these systems. We considered IGSCC and in some cases, BWSCC and others, the DID in others.

Conspicuously missing from my list is FAC. We don't have a probabilistic model in PRAISE or hardly anywhere else as far as I know for FAC. So, that's something that we weren't able to address in our analysis, but it's something that then later on the expert panel can factor in their estimates of what the -- so, what would be the influence of FAC relative to thermal fatigue in a feedwater nozzle.

MR. SIEBER: Seems to me though that if -- if we extend ourselves beyond nuclear power plants into coal fired plants where the conditions are sort of the same, FAC is the dominant failure mode. Would you agree or disagree --

MR. HARRIS: Yes. No, I agree.

MR. FORD: But -- but, surely when you say there's another model, isn't the EPRI model, what's it called, checkmate --

MR. HARRIS: It doesn't -- it's not probabilistic.

MR. FORD: Well, I know it's not probabilistic. But, can you not just put in a distribution of inputs into that? No?

MR. HARRIS: Well, theoretically, you could.

MR. TREGONING: Yes.

MR. HARRIS: I don't think anybody's done that.

MR. FORD: You're intimating, David, a dead stop on FAC. Maybe not. Is there a potential where you go forward or --

MR. TREGONING: No, there is a ways to go forward. All Dave's mentioning is within his current model that he used for these calculations. He doesn't have a FAC module.

MR. FORD: I understand.

MR. HARRIS: Or even within our expert panel.

MR. TREGONING: Well, now because the Westinghouse SARA code had a FAC model built in and we did have a Westinghouse person on the panel. So, we did have a FAC model. Now, we've argued about the -- the goodness of that model.

When we -- when we look at the probable -- when we're doing our probabilistic LOCA code development, a FAC model's going to be a prominent sub-module.

CHAIRMAN SHACK: Of course, now it's dominant only for the feedwater.

MR. TREGONING: Right.

CHAIRMAN SHACK: For the stainless steel lines.

MR. TREGONING: That's right. It's carbon steel consideration.

MR. SIEBER: But, on the other hand, someplace along in your presentation if you would just give me -- your estimate of how important FAC would be from a LOCA standpoint.

MR. TREGONING: Yes, he's -- how would you bench mark --

MR. SIEBER: How would you do it?

MR. TREGONING: -- a ratio in your estimates considering FAC and you did that in your individual elicitation, but you didn't necessarily do it as part of these calculations.

MR. SIEBER: Just -- yes, just give me a feel for where you think it would come out.

MR. TREGONING: I think you're going -- I think we're going to have this discussion later.

MR. SIEBER: All right.

MR. TREGONING: So, put it off --

MR. SIEBER: Well --

MR. TREGONING: -- until you see the summary results. I think it's going to be --

MR. SIEBER: Okay.

MR. TREGONING: -- and clear.

MR. SIEBER: Okay.

MR. HARRIS: Yes, I -- I didn't plan on discussing that today, but it's something that I had to think about in my individual elicitation.

MR. SIEBER: All right.

MR. HARRIS: Because in the individual elicitation, I took these numbers and did a lot of massaging on those.

MR. SIEBER: Okay.

MR. HARRIS: As the other expert panel members did and then I had to factor in FAC over and above what I did to these numbers.

MR. SIEBER: Right.

MR. HARRIS: Because there's some numbers here that I don't believe. This is just grind through the model and what do you get.

MR. SIEBER: Right.

MR. HARRIS: That's kind of what we're talking about now.

Now, you'll see some numbers that none of us will believe. You just grind through the models. This is the model. This is what you get.

Then another question is what do you do with it and each panel member's going to be doing different things with it.

MR. SIEBER: Okay.

MR. HARRIS: I mean I even took some of the -- I took my own numbers and threw some of them away when it came time to sit down and make the estimates.

MR. SIEBER: That's what makes you an expert. Okay.

MR. KRESS: One your first bullet, you didn't apply all those mechanisms to the same pipe.

MR. HARRIS: That's right.

MR. KRESS: You picked -- you picked out one for each -- the one is -- should be applicable for the given pipe.

MR. HARRIS: Yes.

MR. KRESS: Okay.

MR. HARRIS: We have our -- our five base cases. For each base case, we selected the dominant mechanism.

MR. KRESS: Okay.

MR. HARRIS: And the dominant mechanism we considered in -- in my efforts was -- were one -- was one of these three.

And we have initiation and growth models that can be considered for each of these mechanisms and we considered material aging and overload events and so, we have a -- a mechanics-based model for each one of these degradation mechanisms including both initiation and growth and then we -- some of these inputs to the mechanics-based models we take to be random variables and transform a deterministic mechanics-based model into a probabilistic model.

The next slide, and we used Monte Carlo simulation to -- to generate these results. I used Monte Carlo simulation to generate these results. I think our other like Vice Chapman he uses Monte Carlo simulation.

So, the models were primarily -- made use of Monte Carlo simulation.

MR. TREGONING: Yes, but he didn't have

all the random variables built into his model as you did. So, he had to couple his Monte Carlo simulation with deterministic extrapolations of the results to try to make them consistent. Which it's interesting in the sense. Because that leads to differences as you might expect between the models.

MR. SIEBER: Yes. Okay.

MR. HARRIS: So, the computations that I'll be talking about were performed using the PRAISE software which has already been mentioned some this morning. Was originally developed in 1980 with NRC support. Developed for probabilistic analysis of fatigue crack growth from pre-existing defects and I give you the NUREG number here if you want to go back that far to look up some of this -- the technical bases of these.

The IGSCC initiation and growth models were developed in the mid-1980s. There's a reference for that.

The fatigue crack initiation capability was developed in 1999. So, this is the most recent advancement in -- in the PRAISE software. Using the probabilistic strain-life correlations that were developed by Argonne National Lab and are reported in various NUREG reports.

The next view graph is a -- provides an overview of the PRAISE methodology for fatigue crack growth.

MR. KRESS: Your -- your middle box there. That one. That would appear to me to be plant specific. What -- what did you do about that kind of thing?

MR. HARRIS: Well, there's a list of transients and frequencies at which they will occur. That's a generic list for say PWRs.

MR. KRESS: Yes.

MR. HARRIS: Typically, we operate with that list.

MR. KRESS: Okay.

MR. HARRIS: Okay. And in some cases, you can get more plant specific. If you have that information, that's -- that's just another input to -- to the analysis.

MR. TREGONING: One of the things we tried to do, some -- sometimes these lists are generic design basis transients. If -- and -- and obviously sometimes they're quite conservative. So, we took effort into scaling those down to make them more realistic. Again, that was something that the panel did by themselves, but as you might imagine, an understanding of true load history is something that's -- that's -- that's probably the biggest area of uncertainty in a lot of these analyses. Just not a lot of information saying, you know, this is the actual load that -- that this piping system is seeing over its life.

So, we tried to be -- we didn't want to be so conservative that we're using design stress. We wanted to make them realistic. Realistically as we thought we could.

MR. HARRIS: That -- that's one thing we did as part of the refinements in my calculations. It was -- someone would say I don't -- I don't like that load history. I think we have a better one than that. I think your stresses are too high and the transient occurring too often. Why don't you use this and the basis of this and so, we did some modifications on our -- on our stress histories.

MR. TREGONING: That was the area of sensitivity analysis. Probably did most of the work in. We -- we could obviously -- such an important area.

MR. HARRIS: Yes, taking this bottoms up approach, you know, real important -- real important part of the problem is the stress history and because basically I'm a mechanical engineer and my background is at fracture mechanics and so, one really important thing that I need is the stress history and -- and if I -- you give me the stress history, you know, I can beat it to death in the fracture mechanics calculations.

You only have to go out and look at realistic stress histories. You can get those in a number of places and I'll give you an example of one in -- in one of the slides.

This -- this is sort of the -- the heart of the whole thing and -- and we could talk for days about this, but we won't.

Basically, you have an initial crack size distribution that we then combine with the stress history in our fracture mechanics solutions. They get crack size as a function of time.

MR. KRESS: On -- still on the middle box there.

MR. HARRIS: Oh. Okay.

MR. KRESS: Do you treat -- do you treat seismic events the same as operating transients although they're -- they're different frequencies and they're different magnitudes and --

MR. HARRIS: Well, there's --

MR. KRESS: -- essentially in the way of fatigue --

MR. HARRIS: Just another stress cycle.

MR. KRESS: -- fatigue.

MR. HARRIS: Just another stress cycle.

MR. KRESS: Okay.

MR. HARRIS: And the -- but -- but, they don't -- but, they occur only with a certain probability.

MR. KRESS: Yes.

MR. HARRIS: Whereas most of these others, most of our other cycles --

MR. KRESS: Those others are real -- I mean you got database or something and the other's a probabilistic thing. I was just wondering. You can't just add those up can you?

MR. HARRIS: Well, what we do -- interesting you ask that question because PRAISE stands for Piping Reliability Analysis Including Seismic Events. That was originally put together just to look at -- at the effect of seismic events on -- on the -- on the failure probabilities and so, we looked at the normal operating conditions and the transients you expect on a day-to-day basis and then superimpose on a seismic event.

MR. KRESS: Okay. That sounds like the way it ought to be.

MR. TREGONING: Typically, that's how probabilistic fracture analyses have done. You -- you assume that it -- the event occurs with some magnitude at some point in time. So, you're not -- they usually don't consider the frequency of the seismic events within the analysis.

Quite often you do sort of a conservative analysis where you let your degradation mechanisms run as long as they're going to run up to the end of whatever time period you want to estimate and then say oh, by the way, now let me put a seismic event on this. That'll help me determine what my sort of downing frequencies are.

MR. WALLIS: These look like circumferential cracks?

MR. HARRIS: Yes. We're looking at -- yes. Semi-elliptical ID connected circumferential cracks.

MR. WALLIS: Yes, they're really quite -- axial cracks can also lead to splits presumably.

MR. HARRIS: Presumably, but especially in C-molded piping. Most of these -- most of these transients put on a -- put on more of a cyclic.

MR. WALLIS: Axial stress.

MR. HARRIS: So, as far as fatigue goes, usually, it's a circumferential crack.

MR. WALLIS: Unless it's somehow more susceptible to crack growth because of the way this stuff was made in the --

MR. KRESS: In your -- your initial crack size distribution, is there a database for that? Do you have --

MR. HARRIS: That -- the initial crack distribution and this -- and the stress history are probably to two most important inputs to the whole problem and coolant conductivity and so --

MR. KRESS: And you have a database for those.

MR. HARRIS: What we do is -- is we use a crack size distribution that was generated by the PRODIGAL code. Where Vic Chapman gets together a bunch of experts and they talk about weld defects.

MR. KRESS: Okay.

MR. HARRIS: And then they put together a Monte Carlo model of what size defects could be in there, grind out their model, generate some results that we then do curve fits to get our crack size distribution.

MR. TREGONING: That's pre-existing clause.

MR. KRESS: Yes, that's -- that's what they did originally for PTS.

MR. HARRIS: It's a very similar process they went through.

MR. TREGONING: The difference with PTS are those are the only flaws they're concerned about.

Here we have to consider and in many cases which are much more important, the flaws that initiate away from these preexisting defeats.

It happened -- because your preexisting defeats will occur as a function of your -- your -- your procedure, your fabrication procedure, but quite often, your initiating cracks that occur during these. They're going to occur at your worse locations in terms of stress.

So, the likelihood of having a preexisting defeat there tends to be rather small. So, a lot of these -- essentially dominated by the initiation and -- and I don't need to tell you, but with CREMs that's certainly the case also. The initiation phase of the -- the development of cracking is -- is very --

CHAIRMAN SHACK: I was just going to as

Dave what he did for -- the crack size distribution for initiated cracks which is a --

MR. TREGONING: Yes.

MR. HARRIS: Oh.

MR. TREGONING: That's right. That's -- good. I'm glad you asked that question and not me.

MR. HARRIS: Okay. We just took it to be the number that ANL used in their correlation. So, what was that? .3 inches.

CHAIRMAN SHACK: Okay. So, .3 inches and it's twice that length.

MR. HARRIS: Oh, we -- we took the aspect ratio to be a random variable.

CHAIRMAN SHACK: Oh, so you took that as a random variable.

MR. HARRIS: Yes, but we -- we took the depth at -- at --

CHAIRMAN SHACK: .3 inches.

MR. HARRIS: Yes.

CHAIRMAN SHACK: Okay.

MR. HARRIS: And I was -- I was glad somebody put a number there so I didn't have to worry about it. I like putting .3 inches because we could talk for days about what should have been --

MR. TREGONING: You could have a

distribution there.

MR. HARRIS: Yes, or you could. You could.

CHAIRMAN SHACK: Well, but that -- the -- the life he's -- or the -- the cycles he's using for failure sort of presuppose you're going to end up with the .3 inch crack. So, I mean you -- you could change the size and change the -- the number of cycles.

MR. TREGONING: That's right. That's right.

CHAIRMAN SHACK: But -- so, that's -- that's reasonable.

MR. TREGONING: Or it's consistent.

CHAIRMAN SHACK: It's consistent. Yes.

MR. KRESS: Your final result of this then is that left-hand bottom box?

MR. HARRIS: Yes.

MR. KRESS: What's the -- tell me what that right-hand bottom box is. I'm not sure I know what that is.

MR. HARRIS: This is the leak -- the leak rate is a function of the -- it's called crack opening displacement.

MR. KRESS: Okay. Given this value, you convert that to a leak rate?

MR. HARRIS: Yes. Yes, you have a leak rate comes in down here. What's --

MR. KRESS: Okay.

MR. HARRIS: -- for a given -- for a given crack size and crack opening, what's the leak rate. That allows us to separate out different leak categories over here in the --

MR. TREGONING: And LOCA size.

CHAIRMAN SHACK: Are you base case calculations including inspection by ISI and leak rate detection or not?

MR. HARRIS: Yes. Yes.

CHAIRMAN SHACK: Oh, they are. So, you're taking credit for those.

MR. TREGONING: If you have a -- if you have a -- if you have a leak that you predict in your analysis that's greater than tech spec leakage, it's -- it's defined as a non-LOCA at that point and that's -- that's obviously a pretty big percentage of defects that we get. Yes/no?

MR. HARRIS: Yes. Yes.

MR. TREGONING: I didn't want to answer.

MR. LEITCH: In that lower left-hand box, there's a dotted line that I can't quite read on either --

MR. TREGONING: Yes, this --

MR. LEITCH: What is that? Is this -- there's small leak, big leak, and then the dotted line says something. I don't know what it says.

MR. HARRIS: Small leak, big leak.

MR. SIEBER: LOCA.

MR. HARRIS: LOCA with the seismic event. LOCA without a seismic event.

MR. LEITCH: Oh. Okay. LOCA with seismic. Yes.

MR. HARRIS: And now, this is -- this is just for fatigue crack growth for -- for initial defects and then this has been added to and the cartoon gets much more complicated. We've -- this has been added to over the years to include initiation in both the stress corrosion tracks and initiation of fatigue cracks.

CHAIRMAN SHACK: But, your initiation model for the SCC is still a 1980s' version right where it says it's a deterministic rather than a probabilistic.

MR. HARRIS: No, I'd call it -- it's probabilistic, but it's based on 1980s technology and -- and understanding of the problem. We have a probability of initiation. Rather than an initiation time, we have a statistical distribution of initiation time.

CHAIRMAN SHACK: Okay.

MR. HARRIS: And the inputs to that are the coolant connectivity and the degree of sensitization, stress levels. I'm sure I'm forgetting some, but there's a whole bunch things that go into that probabilistic initiation model. That gives you the probability of initiation as a function of time and operating -- what I'd call operating conditions.

CHAIRMAN SHACK: But, as I recall, I mean you had to -- you had to adjust the -- the residual stresses rather severely to get the -- the answer to come out right and you did that.

MR. HARRIS: That's right. So, we take that model. We put it altogether. We have a -- we have initiation model and then once it's initiates, how does it grow until it becomes big enough to be governed by fracture mechanics and then once it's governed by fracture mechanics, how does -- how does it grow from there because there are still scattering or da/dt K relation and then you get all done and you can generate numbers and then you compare that with service experience and see where you are and then --

then it didn't agree and so you do some adjustments and at that point, we chose to adjust the residual stresses.

We adjusted them down by like a factor of five.

MR. TREGONING: Downward?

MR. HARRIS: Downward. In order to get our failure probability as a function of time to agree with --

CHAIRMAN SHACK: And that always puzzled me. Why didn't you adjust the initiation rate downward? I would -- I would have thought that was the bigger uncertainty.

MR. HARRIS: Well, at that time, I just felt that the biggest uncertainty was in the residual stresses.

CHAIRMAN SHACK: Okay. So, that was a judgment at the time.

MR. HARRIS: That's just -- yes.

CHAIRMAN SHACK: Okay.

MR. HARRIS: Yes. And maybe -- I don't know how it would have worked out, but if I started making adjustments in the initiation velocity, maybe I'd had to do something really radical to that and I don't view a factor five in residual stresses as being horribly radical.

MR. TREGONING: Ideally, I think what you would do is -- because there -- you have to play with parameters to get the models to work out right. So.

CHAIRMAN SHACK: It's -- it's a question of which parameter you play.

MR. TREGONING: What you do ideally is you -- you play with several of them and see what -- independently and see what the impact is on the final result. So, if you played with initiation times versus the stress history -- play with stress history, you get a different final result. If you would have done the same thing with initiation time, the question would be what would be the final result.

CHAIRMAN SHACK: Yes, the one thing I probably believe is the welding residual stress is about the yield stress. So, I -- I can't come up with a factor of five.

MR. TREGONING: Yes. Yes.

MR. FORD: I think what you meant to say -- what you meant to say was your uncertainty in residual stress wasn't a factor of five. Uncertainty of stress on crack growth rate or initiation was the factor of five.

MR. HARRIS: We adjusted the stresses.

MR. FORD: No.

CHAIRMAN SHACK: He adjusted the stresses by a factor of five.

MR. FORD: Well, okay.

MR. HARRIS: I think it was five. I might -- I might not be --

CHAIRMAN SHACK: It was .2.

MR. HARRIS: I remember a .2 in there. Yes. I remember a .2 in there. Yes. Yes.

And if I was to do it today 20 years later, I'd probably do it differently. I think the whole -- the whole model would probably be different now than it -- that it was 20 years ago because we know a lot more about the problem now than we did 20 years ago.

MR. TREGONING: This just goes to show you that your results always come back to haunt you.

MR. FORD: On that very point, it's a good point. You have to start somewhere. I notice you're using crack initiation and propagation models for cracking by in the '80s and models have improved markedly since then.

MR. HARRIS: Yes.

MR. FORD: Is there any plan to go back and look at -- to see if one of the better models that exist now would materially affect your results or will you just stick with a conservative end result?

MR. TREGONING: There's -- there's no plan to go back and reevaluate the base case number as model.

MR. HARRIS: Certainly not between now and next March.

MR. TREGONING: Again, the bigger follow-on exercise, that's exactly the focus of that. The development of its probabilistic LOCA because we realize and -- and I think if nothing else this exercise that we're going through has caused us to look at -- people have been using -- a lot of people worldwide are using PRAISE technology. I mean let's not -- let's be clear. They're using this technology to make predictions now. This is what a lot of people are making decisions on.

It was certainly state-of-the-art with respect to IGSCC back in the mid-'80s. We've learned a lot about that -- about that mechanism since then and now we have a new one called PWSCC which I don't know if Dave's going to get into. But, we had to develop some ad hoc corrections to the IGSCC model to attempt to model PWSCC for this exercise.

Now, you know, again, that's something as we do this further development, we're going to try to develop more from first principles. But, that's -- again, that's just a much longer time frame endeavor that we're really just starting now.

CHAIRMAN SHACK: And -- and just on your comment, Peter, they didn't use a bounding -- you know, they tried to use their best estimates of the crack growth rates even then.

MR. TREGONING: Right.

CHAIRMAN SHACK: So, they're not as bad as you think. You know, they're -- they're 1980's crack growth rates though under water chemistry and sensitized stainless steel.

MR. HARRIS: I've -- I've looked at this very recently at the da/dt K relation that's in place and compared it with more recent correlations. I was surprised it didn't look that bad.

CHAIRMAN SHACK: Yes.

MR. HARRIS: It's got some funny features, but it didn't look that bad.

CHAIRMAN SHACK: Yes, didn't look that bad. The initiation model I -- what can I compare it with?

MR. HARRIS: The question of residual stress is you need to know more than just the magnitude. You need to know the spacial variation, too.

CHAIRMAN SHACK: But, your factor of two was applied to --

MR. HARRIS: Everything.

CHAIRMAN SHACK: -- everything.

MR. HARRIS: Everything.

CHAIRMAN SHACK: .2.

MR. HARRIS: Okay. So, that -- that's a pass through the fatigue -- fatigue -- fatigue growth portion of the model. This was the first part put together in PRAISE and I think it's the part that's stood the best -- the test of time best. I mean it's still being used worldwide and -- and then we've added models to it since and the IGSCC models getting kind of old and but the fatigue initiation model is pretty current I believe.

So, moving on --

CHAIRMAN SHACK: Just another question. Just on tech -- when you did it in the '80s, you had a hard time dealing with the initiated cracks because your computer just wasn't fast enough as I recall.

MR. TREGONING: What do you mean? Dealing with them in what sense?

CHAIRMAN SHACK: That he couldn't do the

stratified sampling and -- and so, as I -- I think you even sort of quit before you could really get confidence estimates on your BWR crack sizes.

MR. HARRIS: Yes.

CHAIRMAN SHACK: I assume I mean since computers are umpty dump thousand times faster now, that you can really run these things out now and it's not a problem

MR. HARRIS: It still can get to be a problem and the problem I ran up against in -- in doing the work we're talking about here and computers are -- are so much faster and -- but, we still -- we don't have like a stratified sampling on the stress corrosion cracking.

CHAIRMAN SHACK: But, with the initiated fatigue crack --

MR. HARRIS: Yes.

CHAIRMAN SHACK: -- presumably you have the same problem now.

MR. HARRIS: Right. Right. We can -- we can -- we can do that. I mean I'm sure there's ways to do that. It's just not part of what --

CHAIRMAN SHACK: What was done.

MR. HARRIS: What was done and -- and part of what I'll be talking about is that even now I can't get -- like we want to know the probability of a greater than gpm leak in a 20-inch line. That's going to be a pretty small number and in order -- and we don't have a way to stratify on that.

CHAIRMAN SHACK: So, you can't run that long.

MR. HARRIS: So, I can't run that long. I mean I -- you say well, all you have to do is run longer. I mean I was coming up on things that may take five years to do this thing I mean even now.

MR. TREGONING: And you're effective frequency limit cutoff is about 10^{-9}, 10^{-10}. Right?

MR. HARRIS: Yes.

MR. TREGONING: Something like that.

MR. HARRIS: Yes.

MR. TREGONING: So.

MR. HARRIS: Yes.

MR. TREGONING: That's still within the ballpark of the things that -- that we're talking about here.

MR. HARRIS: But, 10^{-9} might be three days and 10^{-10} is a month.

MR. TREGONING: Right.

MR. HARRIS: I mean it -- boy.

MR. TREGONING: Order of magnitude --

MR. HARRIS: Yes.

MR. TREGONING: Sure.

MR. HARRIS: Order of magnitude is a lot.

MR. TREGONING: Yes.

MR. HARRIS: And -- and so -- and I'll be getting into this briefly. So, I came up with somewhat I'd call an ad hoc model just so I could get some numbers and this is where we're going to start -- where we start to see some really small numbers.

The computer time's still a problem and you could probably do something like Latin Hypercube sampling or stratified sampling and generate some numbers. That's just not the word -- that's just not what we were signed up to do at this point.

So, we already talked some about random variables. Fatigue crack growth is one of your random variables. The initial crack depth, we've talked about that already a little bit. Fatigue crack growth rate for -- for giving delta K, critical net section stress, the probability of detecting a crack during inspection. These are -- these are the random variables in our deterministic model.

Then -- then you'd also have random variables associated with initiation.

Additional random variables for stress

corrosion, cracking. Was it time to initiation for a given set of conditions. Here's -- here's the variables that we considered. These are inputs to our model for distribution of initiation time. Residual stress as we also take to be a random variable that's been ratcheted way down and then the crack growth rate.

The da to t K relation has some randomness in it.

Additional random variables, fatigue crack initiation, cycles-to-initiation for a given cyclic stress, the aspect ratio. The depth was at this .3 inches, but we still have a random aspect ratio.

We -- we've already talked about a lot of this stuff.

Not that the operating conditions are considered as deterministic. So, we're still taking -- in the vast majority of cases, taking our stress history as -- as given input. Residual stresses can be random, but the applied stresses are generally considered as deterministic.

And, of course, a important part of any of these efforts is the characterization of the -- of the random variables.

Next slide. Given example -- no. Initial crack depth distribution probably the most important. We already talked about Vic Chapman and then PRODIGAL. There was an ASME PDP paper that -- that -- that provides details of all of this. So, we have for a given -- for phoeritic and austenitic material of a given size, we have a aspect -- we have a default distribution of crack depth. It's lognormal with a given mean and -- and median and standard deviation.

Now, I believe the next. As an example of the -- of characterization of scatter in your input variables, we have here an example of what was done in the original PRAISE efforts for the da/dN delta K relation for austenitic stainless steels. This is the data that was available in about -- about 1980 and we took all this data and we fit a curve to it. We come up with this relation here.

MR. KRESS: Did you -- did you leave a one-half off of that?

MR. HARRIS: Pardon.

MR. KRESS: Did you leave with an exponent of one-half off of it?

MR. HARRIS: I -- I -- I can't hear you at all.

MR. KRESS: I'm sorry. Does that need a one-half on the 1-R?

MR. WALLIS: Yes, it does --

MR. HARRIS: This exponent.

MR. KRESS: No inside the bracket.

MR. HARRIS: Oh, this -- oh. This should be a square root of 1 minus. All right.

MR. KRESS: Yes, that's why I was asking.

MR. HARRIS: Oh. Oh, yes, that should be a square root of 1 minus R.

MR. KRESS: Okay. I'll -- I'll fix it on mine.

MR. HARRIS: Okay. Okay. Yes.

MR. WALLIS: Now, is this -- is this Ford the same Ford that we have here today? The Ford data.

MR. HARRIS: I'll bet it is. Up here.

MR. WALLIS: Why is his data so much different from everybody else's?

MR. FORD: You know, darn it, I knew somebody would ask that.

MR. WALLIS: And there's a consistency here. The different groups of people seem to get grouped different parts of the picture.

MR. FORD: I think my data is obtained in water.

MR. HARRIS: Well, a lot of this was in water.

MR. FORD: There's low temperature water.

MR. WALLIS: All those outliers in the north -- in the --

MR. HARRIS: These are all -- they're all Ford data.

MR. WALLIS: They're all Ford data. Yes.

MR. FORD: Thank you, Dave.

MR. HARRIS: A lot of this was in water. This is various -- this is with and without water and at I 50 F and at room temperature. At that time, things were just kind of tending to fall together.

Interestingly enough I think as time as progressed, this -- this -- this scatter band has increased --

MR. WALLIS: Well, the question is are these -- are the conditions characteristic of the reactor conditions then? If -- if there's -- in this picture or is this just taken for austenitic stainless steel under any conditions?

MR. HARRIS: Well, this was austenitic stainless steel under a wide variety of conditions and within the scatter, then they all kind of look the same at that point in time.

MR. WALLIS: I'm not sure that they do though.

MR. HARRIS: Well --

MR. WALLIS: And so anyway.

MR. HARRIS: Yes.

MR. WALLIS: We could spend a long time on this.

MR. HARRIS: So anyway.

CHAIRMAN SHACK: I mean you -- it's true that if you took them at very low frequencies in BWR water, those things would just keep marching -- up, up, up, up.

MR. HARRIS: Up. Up. Up.

CHAIRMAN SHACK: Yes, so this -- this is a good relationship for a certain range of frequencies or in a PWR probably over most frequencies, but, you know, this is 1980.

MR. WALLIS: But, the outliers are either Ford or GE and they're in opposite directions.

MR. SIEBER: There's one Ford data point that's in the band.

CHAIRMAN SHACK: Well, some of this is heat -- the heat --

MR. WALLIS: And I just -- I'm just saying this in order to make sure that you're -- you're being self-critical. I'm sure you are. I mean some -- probably some of these data bounds are more relevant to the problem than others and just to lump them altogether like this may not be appropriate.

MR. HARRIS: And if I was to redo this today, I'm sure I'd do it much differently and they wouldn't all be lumped together like this. Because -- because we know more about the problem now and we have a lot more data now. Even the -- changes. The N's not 4 anymore.

So -- so, it would be preferable to redo this and -- and put more detail into this and build a more detailed model of your crack growth rates and a lot of that information is available. It's just not been put into this type of a code yet and I put this up here just as an example of how we -- how we characterize the scatter in the data and put that into our probabilistic model.

MR. TREGONING: Let's -- I think let's be clear. That while the crack growth information is important, a lot of the spirability's at pretty high K levels and the percentage of life spent at these K levels is relatively small. So for a lot of these things I still think initiation is governing. Initiation and some sort of the lower end of your curve is governing a lot of the --

CHAIRMAN SHACK: Well, the scatter's

probably not any better at the lower end. You just don't have enough data to show it.

MR. TREGONING: Right. I guess -- yes.

MR. HARRIS: Well, maybe --

MR. TREGONING: -- is important, but as you get toward the end of life, it's not as important anymore. That's the only point I'm making. If it fails at t or t plus one month, it doesn't -- you know, it's -- it's pretty much irrelevant.

MR. HARRIS: Yes, but still what's down here is really important, too and you say well, the scatter doesn't seem so bad --

MR. TREGONING: More important down there.

MR. HARRIS: -- but that's because we don't -- it's really important, but we don't have any data down there at least at that point. We do now. All this data was --

CHAIRMAN SHACK: Well, actually, the -- the high end is what's going to control your LOCA. The low end is going to tell you when you get to the leak. You know, once the leak -- once the crack gets through a wall, the Ks go up and --

MR. TREGONING: Well, of course, but if you get -- if it gets through-wall and you get a one gpm leak, you're done.

CHAIRMAN SHACK: Right.

MR. TREGONING: So, they may not control the --

CHAIRMAN SHACK: The thing that probably saves you from the uncertainty here is that you end up with the detected leaks and the only -- the only thing a faster crack growth rate would do is get you to the leak faster.

MR. TREGONING: Faster leak. That's right. With standard fatigue you see that all the time.

CHAIRMAN SHACK: Oh, yes. Yes.

MR. TREGONING: You have a thumbnail type of crack that again unless it's affected by the environment, you tend to predominately get leaks before you get breaks. It's when you add the -- the role of the environment and the fact that you could have a lot of --

CHAIRMAN SHACK: And those residual stresses that we reduce by a factor five.

MR. TREGONING: The individual stresses that you can get.

MR. FORD: Graham, joking aside. I mean if you -- I'm just connected up my points. You'd expect that variation under the operating conditions

I was working at in the 1980s. At lower frequencies, you would expect that difference to exist.

The application I think that Dave is applying is higher frequency applications where you wouldn't see that. Data has got -- curve he's using, mine he's using is more applicable to higher frequency conditions.

MR. TREGONING: What frequency was you --

MR. FORD: Oh, I was 10^{-3} hertz.

MR. TREGONING: Then it took a long time to do your experiment.

CHAIRMAN SHACK: That's the problem yes.

MR. KRESS: So, can I insinuate from that that this curve will overestimate the crack growth?

MR. FORD: It underestimated if -- if you're doing little frequencies and --

MR. KRESS: Yes, you were saying that the frequencies --

MR. FORD: Right.

MR. KRESS: -- really existed higher.

CHAIRMAN SHACK: You turned it into A dot rather than da/dN.

MR. KRESS: That's right. Yes.

MR. HARRIS: And there's -- there have been some -- in the ASME pressure vessel code in the meantime, there are some other crack growth relations that have been suggested and I think they tend to be about the same and then higher down here and as part of the sensitivity studies, we did as -- as part of this LOCA elicitation, we changed the crack growth rate to that code recommended relation and found that it didn't have a huge effect.

So, you know, we've looked -- we've looked at more modern crack growth rates and -- and fooled PRAISE into considering those and it was not an overriding factor.

So, we've come up -- we use this crack growth relation and we -- we characterize and consider C to be a random variable. It's lognormal at this median and this second parameter of a lognormal distribution. So, we use this lognormal distribution of C to describe the scatter in this data and that's an input to our Monte Carlo model.

So, calculations are performed for most likely failure location within a system. We in the panel defined the systems that we were to look at and then as -- in the probabilistic fashion mechanic's calculation in order to get a system failure, let me just use failure in a very loose term, in order to get a failure probability for a system, I'd go in and --

and -- and try and select the most likely point in that system, point or points in that system, that would fail and then get the failure probability for that location.

So, my calculations are -- are done on a location-by-location basis and we'll -- and we'll get more into what locations we looked at and then how we -- how we've combined these, but basically, I'm trying to focus -- I do focus on a location.

And then the calculations for that location are performed as a function of the flow rate and that's just controlled by the probability of getting it through-wall crack of lengths sufficient to exceed that flow rate.

The flow rates are calculated using the SQUIRT software which was developed by Battelle with NRC support. That's the calculation that -- that we do to get the -- the leak rate through a crack --

MR. WALLIS: This is on the flow rates which we're -- we're talking about for LOCA?

MR. HARRIS: Yes, these are the --

MR. WALLIS: You'll never get 500,000 gpm through crack.

MR. HARRIS: No, not through a crack.

MR. WALLIS: You're talking --

MR. HARRIS: But, you have a crack that's such that it breaks the --

MR. WALLIS: Those will be the small -- really small leaks. Yes.

CHAIRMAN SHACK: He's really doing this mostly for his leak detection --

MR. WALLIS: Right.

CHAIRMAN SHACK: -- to find out what -- yes.

MR. WALLIS: That's right. That's right. That's right.

MR. TREGONING: SQUIRT's not applicable when you get to --

MR. WALLIS: No, that's right. It's the leak detection issue.

MR. HARRIS: Yes. Yes, we weren't -- we weren't using SQUIRT to determine the 500,000 gpm.

MR. WALLIS: No.

MR. HARRIS: The NRC gave us a table that says you have to have a pipe size. The complete severance in a pipe of this size in order to get this flow rate and then to get 500,000 gpm, I just get the probability of a sudden and complete pipe severance in a pipe of that size.

MR. WALLIS: How -- how about the -- the

fish mouth thing? The split in the side of a pipe. Does that come into this, too?

MR. HARRIS: That doesn't come in.

MR. WALLIS: Doesn't come into to this.

MR. HARRIS: It doesn't come in.

MR. WALLIS: I thought that happened.

MR. HARRIS: Are you thinking -- you mean like an axial crack?

MR. WALLIS: Yes, opens up like a fish mouth.

MR. HARRIS: Oh, we're concentrating on circumferential cracks because we think that will dominate the problem.

MR. WALLIS: That's what this is.

MR. HARRIS: You get --

MR. TREGONING: The class one pipes of the -- of the -- typical manufacturing techniques that we have. Cir cracks clearly provide the biggest challenge for --

MR. WALLIS: Yes, because of the way they're made. Right?

MR. TREGONING: Not only the way they were made, but axial cracks you have a lot more margin in terms of leak detection prior to getting failure and that's -- that's as big a consideration.

CHAIRMAN SHACK: But, it's also the way they're made. Because you don't have seam welded pipe in a nuclear plant.

MR. TREGONING: It's also the way they're -- you don't have seam welded pipe. But, you might -- with seam welded pipe, you have some --

MR. WALLIS: A split. All right.

CHAIRMAN SHACK: If you go in a coal plant.

MR. TREGONING: Yes. Oh, yes, that's a whole different story. Yes. Well, and again, we see our --

CHAIRMAN SHACK: That's a whole different story.

MR. TREGONING: -- if you see failure in non-class one systems and that's why you have to be very careful about operating experience. You see those sorts of things. We've seen our worse failure due to either seam welded pipe for FAC-type failures in carbon steel pipe where you've essentially seen burst failure with no precursor evidence. I mean truly if they would have happened, there would have been huge LOCAs in the primary system, but you have to be careful because their just applicable.

So, I apologize for that. I think Dave

had leak rate. It should be leak rate instead of flow rate in that third bullet.

You ready?

MR. HARRIS: Yes, so as I mentioned, the stresses in the frequency of occurrence of these stresses are important and they're required for the dominant location in the system. They pretty much define the dominant location within the system where the stresses are highest.

The stresses then were drawn from a variety of sources. Here are our five base case systems and this table then talks about where the stresses came from. We concentrated on the hot leg depressor vessel joint. That's our example for the main coolant piping. It's also our example for the 500,000 gpm leak.

These came from a NUREG/CR-2189. This is the original PRAISE development in which there is a complete set of stresses that were available for the circumferential welds in the main coolant piping in a commercial plant.

We also -- this also included seismic events of various magnitude.

The surge line we obtained from this NUREG 6674 which is a fairly recent set of results for various components as put together by PNNL. This is part of our development and -- and exercise of the fatigue crack initiation capabilities in PRAISE.

So, we have a set of cyclic stresses for the surge line we can get from this -- from this effort.

The HPI location, there's also a set of stresses in this 6674.

The recirc line, I had an old analysis laying around that had seismic events in it, DOH stresses and in the feedwater, we're back to a NUREG 6674.

So, this is where the set of stresses came from. As part of my charter, I was to gather up stresses for our base case systems and -- and supply them to whoever was interested in them. Vic Chapman primarily and I think he used my stresses to the extent that he could in his efforts.

MR. WALLIS: This is -- this is fatigue? This is fatigue you're talking about here?

MR. HARRIS: Well, fatigue except in the recirc --

MR. WALLIS: So, how do you -- how do you get the end, the number of cycles?

MR. HARRIS: Oh, that's -- that's part --

that's part of the information that we get from the references. We get the stresses and the cycles.

MR. WALLIS: For many of the cases, there are very cycles. It's normal operation. You just heat it up and cool it down. You don't do that very often.

But, if you've got something like an instability in -- in the -- in the circulation patterns and the HPI line, you've got hot water here and cold water there. You can get --

MR. HARRIS: Yes.

MR. WALLIS: -- tremendous number of cycles --

MR. HARRIS: Yes. Yes.

MR. WALLIS: -- in a short time. You're dealing with completely different beasts. I would think getting the N right is very important.

MR. TREGONING: It is.

MR. HARRIS: Yes.

MR. TREGONING: You have essentially -- you have essentially stress frequency pairs that you get out. That's the operating problem. This stress magnitude let's say at the -- operating at this frequency, tend -- you tend to have the higher stresses operating at fewer cycles and the lower stresses at higher.

MR. WALLIS: Right.

MR. TREGONING: But, it doesn't always work out that way. If really that striping, you can get some pretty --

MR. WALLIS: Right. That's right. That's why I worry about it. Big ends.

CHAIRMAN SHACK: Well, in the HPI line presumably those were thermal fatigue stresses and somehow they made some sort of estimate of the -- of the frequency and the cycling that went on for the thermal fatigue there.

MR. TREGONING: The HPI line, my understanding is they actually went in and not only measured but --

CHAIRMAN SHACK: Oh. Okay.

MR. TREGONING: -- also measured in concert with analysis strain-gauge pipes and then from the strain-gauge readings, they predicted the thermal striping type of loading that they were getting.

Dave -- Dave's mentioned some of this, but again there was also stress information provided by the expert panel.

CHAIRMAN SHACK: Yes.

MR. TREGONING: And the stresses that Dave used was provided to the panel. They looked over the stresses and said in some cases, well, these look okay and these don't look okay. Go back and run your models using a different set of numbers and here's how I would modify them.

So, these are really your initial starting points as much as any --

CHAIRMAN SHACK: Yes. Yes. That is one of the great difficulties with this problem is that if Dave given stresses can add analyze these pipes up the wazoo, you know, what is the probability of getting a thermal cycling stress somewhere in the system as a -- as a thing he can't compute very well and I'm not sure exactly how you estimate that.

MR. WALLIS: Well, it's -- well, how you run the plant can make a difference.

CHAIRMAN SHACK: Well, it's -- it's -- it's even more than that.

MR. WALLIS: You can let your HPI line leak or something. You know, you can get yourself in trouble.

MR. HARRIS: Well, yes, and we will -- and some of these stresses, we did make modifications.

MR. WALLIS: I mean HPI valve I'm thinking rather than a pipe leak. You let it leak and you don't pay any attention.

MR. HARRIS: We -- we did quite a bit of -- of a sensitivity study on the surge line looking at different -- different stress histories and -- and it was intended that our stress history did incur -- include thermal striping. So, we had lots of cycles of that lead to thermal striping and in the -- and in the HPI nozzle, we did some -- we consider the failure of the thermal sleeve. Just -- just let the thermal -- we're going -- we're going to do the following when the thermal sleeve has failed and then what happens.

This first time through we didn't consider that and they said well, wait a minute. These thermal sleeves failed. That's really not the problem you should be doing. That's part of -- that was a big part of the June meeting where we brought up -- I said okay, here it is and then people say well, no, not -- that's not what you should be doing. What you should be doing is this and then since June, we go back and make those changes.

MR. FORD: The residual stress proved files especially for IGSCC. A huge effect and unfortunately, residual stress profiles are very, very high variance for the various classification of pipes. How did -- how did you deal with that? Did you always take the worse case scenario or the mean and the -- how could you deal with that?

MR. HARRIS: Well -- okay. Back -- back in -- back in the mid-'80s when you're putting these models together, they came up with -- with statistical distributions of residual stresses --

MR. FORD: Right.

MR. HARRIS: -- for different line sizes. We had large, medium, and small.

MR. FORD: Right.

MR. HARRIS: And so, for each of those, we had a different statistical distribution.

MR. FORD: You'd use those.

MR. HARRIS: And we'd use those and then we factored them in order. We ratcheted them down by a certain amount in order to get better agreement with service experience and then used those.

There's also a spacial variation that's important, too.

MR. TREGONING: So, you're using the ratcheting numbers in these calculations just to be clear.

MR. HARRIS: Yes, and I recall that's what we did.

MR. TREGONING: That's a problem. The

stress -- the plant stress history is deterministic.

MR. HARRIS: Yes.

MR. TREGONING: The residual stress history is probabilistic, but they've been modified.

MR. WALLIS: Well, what's the likelihood of some thermal striping going on somewhere in the system, but no one has actually detected yet? But, it's been going on.

CHAIRMAN SHACK: That's what the expert --

MR. WALLIS: Is that the sort of thing that is detected if it doesn't lead to a leak or to something obvious?

MR. TREGONING: Well, again, if it -- let's say you've got a plant where it hasn't been detected. It's -- it's going to become evident at some point in time.

MR. WALLIS: If there's a leak, but where is the -- what's the other way of detecting it?

MR. SIEBER: Well, it's through a LOCA.

MR. WALLIS: So, you're going to wait until something fails before you detect it?

MR. TREGONING: Well, if -- if we -- if -- let me be clear. If we -- if all of these mechanisms were such that we had precursor --

MR. WALLIS: But, your inspection -- your inspection of the piping should detect it. Shouldn't it?

MR. TREGONING: You hope, but again, you don't have 100 percent certainty.

MR. WALLIS: Okay. You're putting that into the analysis.

MR. TREGONING: If -- if all of these things had a precursor event, we wouldn't need to do this analysis. Because precursor event then we could detect with 100 percent certainty. That would give us enough assurance that we would never have a --

MR. WALLIS: No, I'm thinking about precursor condition in the plant. It should have been going on for some time.

MR. TREGONING: The condition's part of that.

MR. WALLIS: Like the thermal conditions in the pipe line.

MR. TREGONING: That's --

CHAIRMAN SHACK: But, if it leads to a one gpm leak before it leads to a LOCA, he's going to detect it.

MR. TREGONING: Detect.

MR. WALLIS: We'd hope so.

MR. SIEBER: And -- and those are pretty

rare anyway.

CHAIRMAN SHACK: We brought that before Davis-Besse and --

MR. TREGONING: We just found out TMI they were operating for years with a .5 gpm leak that they hadn't identified. That was -- it's a bit disconcerting.

MR. WALLIS: Well, their core was leaking progressively worse, too

MR. TREGONING: I'm sorry.

MR. WALLIS: Their -- their pressure operating relief valve was leaking progressively worse up until the time of the accident.

MR. TREGONING: So, we're assuming that the tech specs are going to be maintained in this.

MR. SIEBER: Striping only occurs when the flow rates are very low. You know, as far as turbulent flow and -- and usually just by looking at the geometry, the designer can pick out the spots where striping may occur and do something about them either by increasing the flow or putting in a thermal sleeve or something like that.

MR. TREGONING: It's exactly that.

MR. WALLIS: This is the frequency.

MR. HARRIS: This is an example of the --

how stress is -- this is a surge line elbow with no seismic stresses and this is the stress amplitude. Some big, big numbers. This is the number -- expected number in 40 years. Some big, big numbers.

MR. TREGONING: So, those are sort of ordered pairs by order of decreasing stress magnitude. Obviously, these are pseudo elastic stresses.

MR. HARRIS: So, this is the type of -- this is the type of information that we need in order to do our PRAISE analysis. We need this and even more for the stresses.

As far as crack initiation, all you need is the stress DID and the number of cycles. This is -- this is what you get -- this is what you need for the initiation part of the problem. But, then for the crack propagation part of the problem, you also need to know the through thickness distribution of these stresses.

So, the next view graph --

MR. RANSOM: What are some of the small but high frequency stresses due to? These identifiers?

MR. HARRIS: This particular list is rather cryptic. Quite often the list will have names in there that'll talk --

MR. RANSOM: I'm wondering like hump vibrations, some of those very high frequency things or --

MR. TREGONING: Now, this is a surge line. So, it's a pretty big pipe. My guess would be the -- these would be some sort of thermal thing.

MR. RANSOM: Yes, I'll bet that's --

MR. TREGONING: It wouldn't be mechanical vibrations. No.

MR. RANSOM: No.

MR. TREGONING: Well, yes --

MR. RANSOM: No.

MR. TREGONING: -- not to that level.

MR. HARRIS: Well, see even -- even 17,040 years not a very high frequency in hertz.

MR. WALLIS: No.

MR. HARRIS: So, it wouldn't be vibration.

MR. WALLIS: On the contrary vibration would be millions or something.

MR. HARRIS: Yes. Millions quickly and -- yes.

MR. TREGONING: Small lines can be small by that --

MR. HARRIS: This is not very many cycles a second.

MR. RANSOM: Those are operational cycles then?

MR. HARRIS: Yes, these are expected operational cycles and I would expect in the surge line these have something to do with thermal striping.

MR. RANSOM: Right.

MR. HARRIS: Okay. So, these are the surface stresses. We need to know the radial gradient of these stresses because that -- this radial gradient affects the -- the -- the crack growth rate. The relative amounts of uniform and radial gradient stress were defined by procedures that would given in this NUREG 6674. In some cases, these stresses are very large.

At any rate the -- the list like we just saw combined with this decomposition in the uniform and radial gradient gives us an estimate of the stress histories that we need for our initiation and growth calculations.

Then the calculation procedure that we used depends on the degradation mechanism. In the -- in the hot leg to pressure vessel joint, we considered fatigue crack growth from initial low light defects. We also considered -- this was done by using the Windows version of PRAISE which is something that's easier to use than the PC version.

We also considered PWSCC initiation and growth. This was -- we had to modify WinPRAISE in order to do that.

And the surge line we considered fatigue initiation and growth. We're now the -- the high stresses that are away from the -- from any of the wells. So, we have to go in and look at the -- at the high cyclic stress location and consider fatigue crack initiation and growth.

So, there we used pcPRAISE in conjunction with an ad hoc procedure to get the estimate for larger leak rates and so forth.

MR. WALLIS: Is that 1:00?

CHAIRMAN SHACK: I'd suggest we take a break here for lunch. I think we're going to have to take a large chunk of this out of Eileen's time which hopefully she really didn't need all that she had. Because she's certainly not going to get it.

MS. MCKENNA: I think -- I think it's fair to say that we will be back at a later date.

CHAIRMAN SHACK: So, I -- you know, I think we'd -- we'd like to get through this in probably as much detail as the members want. We'll try to --

MR. TREGONING: Today, this was the focus of today.

CHAIRMAN SHACK: Yes.

MR. TREGONING: We put Eileen's presentation in case we got to it. So, she -- she can do it I think relatively quickly.

MS. MCKENNA: Is there an expectation as to time?

CHAIRMAN SHACK: Well, if we take a half an hour for lunch, if that's okay with the members, I would guess -- I'd say 2:30. We'll have time for a relatively short presentation from Eileen.

Just looking at what Dave has to get through and getting back to Bob. I mean I think -- or Rob. I think we're going to be --

MR. TREGONING: And 3:00 is still -- that's the expire.

CHAIRMAN SHACK: That's -- that's -- yes.

MR. TREGONING: That's the expire.

CHAIRMAN SHACK: Be losing members here at that point. So.

MR. TREGONING: Yes. Yes.

CHAIRMAN SHACK: That -- that -- you know, otherwise, we'd just sort of run on today, but we can't do that because everybody's taking off.

So, I -- I guess 2:30 and we will finish at 3:00.

MR. SNODDERLY: And -- and I think what we'd like to hear about from Eileen is -- is the future actions and how you plan to -- to -- your approach for -- for responding to the SRM and then that way, we can gauge future interactions with you and you might -- well, we need to review and comment.

CHAIRMAN SHACK: So, we'll take a short break for lunch. 1:30 yes.

(Whereupon, the meeting was recessed at 1:02 p.m. to reconvene at 1:42 p.m. this same day.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

1:42 p.m.

MR. HARRIS: Okay. So, in the case of fatigue crack initiation in order to get probabilities -- the probabilities of the larger leak rates, we had to use an ad hoc procedure to make these estimates. Because if you just use the Monte Carlo simulation, the number of times it takes to do the trial, you'd still be doing it.

So, the ad hoc procedure uses pcPRAISE for the Monte Carlo simulation of failure. Just runs a regular old failure because the probability of a leak is fairly high.

So, you do your Monte Carlo simulation, but each time you get a leak which is a through-wall crack, you write down the length of that leak and the time at which it occurred and then from the -- and they're all fairly short cracks.

And you -- you get the distribution of those fairly short cracks and extrapolate it out to the longer cracks that are required for the larger leaks and get your failure -- your probability of the larger leaks that way and so, that was necessary in case of the components.

CHAIRMAN SHACK: Now, let me get this

straight, Dave. You get these things and then you fit it with a lognormal and then you follow out the tail of the lognormal to the big crack size?

MR. HARRIS: Yes, and I'm not sure with the lognormal, but something.

CHAIRMAN SHACK: Something like that.

MR. TREGONING: You're clearly extrapolating your distribution to get you out to the -- to the --

MR. WALLIS: How you extrapolate can make a big difference to the tail. It's a long way away.

MR. TREGONING: The distribution you use can --

MR. WALLIS: Right.

MR. TREGONING: -- get that --

CHAIRMAN SHACK: Well, hopefully, one checks the fit at least to the initial point of the distribution.

MR. HARRIS: Oh, we check the fit to the data that we do have and we're also able to do the problem both ways in some cases and we found that the extrapolation that I was doing gave you a higher -- higher estimated failure probability than if you could do the whole problem.

So, we were thinking we were getting --

getting upper bondage type numbers by this extrapolation procedure.

MR. TREGONING: But, if you go out to the tail you may not be -- if you've gone to a tail that's much longer times, you may not be able to make that same stipulation.

MR. HARRIS: We couldn't make that comparison.

MR. TREGONING: Yes. Yes.

MR. HARRIS: Right.

MR. TREGONING: Right.

MR. HARRIS: In some cases we could make the comparison and in those cases --

MR. TREGONING: Right.

MR. HARRIS: -- we erred on the conservative side.

CHAIRMAN SHACK: The statement was then that this, in fact, dominated the failure rather than the -- the weld flaws. The preexisting weld flaws.

MR. HARRIS: In some -- in some components.

CHAIRMAN SHACK: Some components.

MR. HARRIS: Some components.

CHAIRMAN SHACK: Not always.

MR. HARRIS: Not -- not always. In the

components that were dominated by --

CHAIRMAN SHACK: Okay.

MR. HARRIS: Okay. The next view graph. So, we do these analyses. We provide -- get the failure probability of the dominant joints as a function of time. We get the cumulative probability of flow exceeded the given rate as a function of time.

So, this is an example of an output. Sometimes these numbers are big. Sometimes they're small.

The next view graph.

MR. WALLIS: So, this thing has a 10 percent probability of given 100 gallons per minute in 60 years?

MR. HARRIS: Yes.

MR. WALLIS: At the end of 60 years.

MR. HARRIS: This particular problem. This is a 12 inch --

MR. TREGONING: Twelve inch with a weld overlay.

MR. WALLIS: With a weld overlay.

MR. HARRIS: And for the given stresses and everything else that was done for this particular one.

MR. WALLIS: Now, this is one place or

this is all the places where this occurs or --

MR. HARRIS: That's -- that's one place.

MR. WALLIS: One place and there are lots of these.

MR. HARRIS: There aren't -- there are not necessarily a lot of these places because this was probably the high stress point.

MR. WALLIS: The worse place. The worse place.

MR. HARRIS: So, there's only maybe a couple of those in the whole system.

MR. WALLIS: Okay.

MR. TREGONING: For a given -- you said this, but I'll just try to make it clearer. For a given system, he focuses in on the weakest link.

MR. WALLIS: That's what he means by the dominant joint? The weakest link.

MR. TREGONING: He -- he fixes the worse joint and when there's a number of joints, he --

MR. WALLIS: That's right.

MR. TREGONING: -- he has to make an assumption of how many joints are similar to this. Now, if there's 40 joints in the system, he wouldn't multiply these results by 40, but let's say, you know, there's four or five joints that are similar to this one and maybe would multiply these results by four or five. But, he has -- he makes that additional assessment off-line.

MR. HARRIS: Because in the end, what we're suppose to provide to the panel members is the system --

MR. TREGONING: System failure probabilities not failure probabilities of any one --

MR. WALLIS: That's right. You'll add them all up.

MR. HARRIS: This is the way I get to a system failure probability.

The next one says -- well, we concentrated on 25, 40, and 60 years that we talked about this morning.

Obtained the average LOCA frequency within a given time interval. We just used the cumulative at the end of each time interval and divided by the delta t to get frequency. So, it's just an average within that time interval.

CHAIRMAN SHACK: But, you really want to hazard rate, but if your cumulative probabilities are so low, it doesn't make any difference.

MR. HARRIS: Generally.

CHAIRMAN SHACK: Yes.

MR. HARRIS: That's true.

CHAIRMAN SHACK: Right. That's right.

MR. HARRIS: And then the system LOCA frequency is obtained by multiplying this number by the number of locations within that system that have the high stresses that we were looking at.

And we did a -- an extensive series of sensitivity calculations including the application of unexpected high -- high level stresses. Where I -- what I call and what some other people call a design limited stress. So, we'll put on a big stress and calculate the probability given the stress occurred and then put that in --

MR. WALLIS: How do you know how big that stress is?

MR. HARRIS: Well, that's up to somebody else to do.

MR. WALLIS: Up to somebody else?

MR. HARRIS: Oh, how big that stress is?

MR. WALLIS: Yes, that -- that unusual --

MR. HARRIS: No, we just -- we -- we chose a couple of representative -- well, we got with representative numbers, you know, yes.

MR. WALLIS: Pull them out of the air?

MR. HARRIS: Oh, yes, I'll give you 40

KSI, 60 KSI. Pull them out of the air. I'll give you 40 and 60 and then -- then if you want, you can use those numbers to try and estimate.

MR. WALLIS: How do I know what the loading function's going to be?

MR. HARRIS: I -- I don't say anything -- I don't say anything about the probability of that load occurring. That's part of the --

MR. WALLIS: Somebody else has to do that.

MR. HARRIS: Somebody else has to.

MR. TREGONING: Right. The -- the area where we're looking at rare loadings, we're doing exactly that. We're -- we're -- we're asking the experts to apply a specified stress level and say what's the conditional failure probability due to the stress level.

Now, we fixed those at magnitudes defined by the ASME codes. They're very well defined. So that all the experts know what they're doing in that case.

Now, you still have to ask the -- the million dollar question. What's the frequency of that occurring?

I'll go into a little bit of that if we have time at the end.

MR. HARRIS: The hot leg to pressure vessel joint was chosen as the dominant length for the large pipe. It has the highest stresses and the highest temperature.

The sensitivity studies for the hot leg and pressure vessel joint included these -- included this design limiting stresses and seismic stresses.

We also looked at PWSCC growth from initial defect with -- with proof testing -- proof testing and aging, residual stresses and so forth.

So, the -- the -- what I call a reference case. We do all these sensitivity studies on all of these locations and the -- and then --

MR. WALLIS: Did you go back and predict the DC Summer in some sort of way?

MR. HARRIS: Was that a CRDM?

MR. TREGONING: No, that was the DC Summer. We didn't attempt --

MR. HARRIS: we didn't attempt that. No.

MR. WALLIS: We have an event where there's --

MR. SIEBER: But, that was an anomaly.

MR. TREGONING: We had one event.

MR. WALLIS: It was a strange method of construction was it or something.

MR. TREGONING: A lot of repair wells. So, it was very -- somewhat atypical in that sense, but it's -- it's one of that --

CHAIRMAN SHACK: That's the wishful thinking part.

MR. TREGONING: Yes. Right. Well, right.

CHAIRMAN SHACK: Bad heat, bad well.

MR. TREGONING: That's right. I think the number of repair wells I think we could say that that was probably atypical. Now, I don't know that I'd say the residual stresses that evolved from those was necessarily atypical, but it's a different issue.

MR. HARRIS: So, for each component, we did -- we did several runs. In some cases, many runs and these -- the de-sensitivity studies and then at the end, I -- I selected what I call a reference case as the -- as the one I would highlight to the rest of the panel as the one that they should focus on during their elicitations and if they want to use that, they can and if they don't want to, they have a whole bunch of other information available to them or they might not even use any resource. I'm sure a lot of them didn't use it at all.

To the surge line elbow, we got some refined stresses so we could do better than we obtained from the -- that NUREG report that provided these summaries.

The HPI makeup nozzle was analyzed with failed thermal sleeve and with immediate fatigue crack initiation and then the stresses as -- as before. So, we had a set of stresses that we applied.

The 12-inch recirculation line bench mark with reported leaks and observations of cracks. So, this was an example where we could bench mark against some predictions made by Bengt Lydell based on his models in --

MR. TREGONING: We bench marked all of them, but this was the one case where the service experience was most directly applicable to what we tried to analyze. This is the one base case where we had the easiest way to make a comparison. That's slide 23 that we're going to get to when he's done.

MR. HARRIS: Next slide. Well, this is Bengt Lydell's results where he has the failures per -- failure frequency for weld year as a function of age for different diameters.

And I look at that and I say that's 10^{-4} to 10^{-3} per year, maybe a little more.

MR. TREGONING: And this has got a mishmash of old and new materials, various mitigation techniques. So, it's -- you know, this is all the data. It hasn't been screen using --

MR. HARRIS: I look at that and I just see it. They're all the same.

MR. TREGONING: Well, again, this is years of operation. It's not calendar years either. So, you have to be careful. Because if -- if you look at calendar years and you look at the effect of IGSCC, come up with a slightly different picture there.

I think the only point to be made is this is everything. This is a mishmash of different conditions, when the plants actually started, what their materials were, what their water chemistry --

MR. WALLIS: But, some are -- some are higher than others.

MR. TREGONING: Some are higher.

MR. HARRIS: This -- this green one to me kind of stands out. This is a 12 to 22 incher.

MR. WALLIS: Yes, it's the biggest one. Isn't it? Well, not quite.

MR. HARRIS: You would have thought it would have been the three to six. I mean from what I hear the four-inch line is one of the bad actors. So, you think the small lines would stand out, but they don't.

MR. WALLIS: So, six to 12 is the best.

MR. HARRIS: Six to 12 is good. Yes. But, see it's -- but it -- I mean this is just bouncing up and down by factors of three.

MR. WALLIS: It doesn't go anywhere near as high as the others do.

MR. HARRIS: Yes, it doesn't -- yes, but the -- the worse -- this -- this is the three-inch line and this is as big as 22-inch line. So -- so, I said well, let's just -- they're 10^{-4} to 10^{-3} per weld year and if I generate results and I fall in that bin, I -- I call that -- I'd ream it.

So, the next view graph is the results of some PRAISE calculations. We had a 12-inch line. The leak frequencies -- any -- any leak frequency. Run it -- it says three or four stainless. We run it for 20 years and then we do a weld overlay and --

CHAIRMAN SHACK: But, your failure mechanism here is SCC rather than fatigue. Right? Or is it --

MR. HARRIS: Yes.

CHAIRMAN SHACK: Yes.

MR. HARRIS: Yes. Yes. And that was the mechanism for the previous slide, too.

So, we then looked at the -- the mean

normal operating stress. First off, I used 20 psi and because this should be -- I -- this I figured was -- the dominant joint would have a stress on it like that. Based on -- on rolled stress analysis --

MR. WALLIS: You've done some real -- now, see work here. You're multiplying by 49 then dividing by 49 and getting the same answer.

MR. HARRIS: Where is this?

MR. WALLIS: In the first column. You start with per weld joint. You multiply to the 49. You divide by 49. You get the same answer.

MR. HARRIS: Oh, yes. Yes.

MR. WALLIS: That's so --

MR. HARRIS: Because here assuming we'd had --

MR. TREGONING: Redundant information obviously.

MR. HARRIS: Yes. Because in the end we want to do this per joint. This -- this average per joint. Okay. And they're all -- I say they're all 10^{-4}. This is 25 -- 0-25, 25-40, 40-60. I'm getting numbers on a per joint -- average per joint basis that are pretty much, you know, agreeing with what Bengt Lydell was doing actually.

MR. TREGONING: But, just to make it

clear, at the smaller stresses, you're assuming that -- these smaller stresses are more applicable to all the joints.

MR. HARRIS: You got 49 joints.

MR. TREGONING: The bigger stresses are only applicable to two joints. So, that's -- that's the distinction.

MR. HARRIS: Oh, here's the big differences. The big differences are here aren't they? The per joint -- where's my per joint.

MR. TREGONING: Yes, there's the big difference.

MR. HARRIS: Per weld joint when you look at all of these joints or whether you look at the dominant ones here's the big difference, but when you get all done factoring in the -- the number -- the number of joints that this number's applicable to and the total number of joints come up with the system-wide average per joint, they ended up about the same.

We ended up within the band that I -- that I wanted to end up in. So, that -- that makes me feel more comfortable about what we're getting.

And this -- this is a real important joint for the estimate for BWRs.

MR. FORD: Dave, why doesn't the

probability go up with the age? Yes, like this one, it's actually going down.

MR. HARRIS: Well, for one thing from 0-20 years there was -- we were just running three or four stainless and at 20 years, then we get the weld overlays.

MR. TREGONING: This is the effect of the weld overlays. So, the weld overlay in this case caused it to go down.

MR. FORD: Oh. Okay. Yes.

MR. TREGONING: Decrease in failure probability.

MR. HARRIS: So, after you do the -- and -- and this 25 -- oh, yes, okay. This -- this has spent 20 years without a weld overlay and five years with and this, it was all weld overlay and here it's all weld overlay and it's still going down.

MR. FORD: But, why should it go down?

MR. HARRIS: Well, why shouldn't it go down?

MR. FORD: Well, it's a time-dependent phenomena. Surely as the --

MR. HARRIS: The failure rate -- to my way of thinking, the failure rates don't necessarily have to go up with time. The one thing you can talk about infant mortalities and bathtub curves and --

MR. FORD: But, -- is going at the same rate. You wait another ten years and it'll have grown ten years multiplied by the inches per year.

MR. HARRIS: I don't think --

MR. FORD: And -- and, therefore, the likelihood of a -- a leak will have gone up correspondingly.

MR. TREGONING: Well, what he's saying here is -- is that -- is that again 0-25 years, the bulk of that history was without a weld overlay.

MR. HARRIS: Yes.

MR. TREGONING: I think what the model is saying before you put the weld overlay on, you had a fairly significant chance of having a leak and once you put the weld overlay on, your -- you've affected that in a positive sense and it's continuing, you know, it's continuing to be positive. I guess, you know, there's some cases where --

MR. HARRIS: Oh, it's still a positive --

MR. TREGONING: It's always a positive, but there -- but there's some cases that might be bigger flaws when you put this weld overlay on that still may grow through and lead to failure between 25 and 40. So, I think that's why it's continuing to decrease because you're shaking out all these things that occur.

MR. HARRIS: Yes.

MR. TREGONING: And if the assumption is if it hasn't failed by 40-60 years, it would have been a small flaw when you put the weld overlay on and the weld overlay's having a much bigger affect on that smaller flaw than that -- than the larger flaw. Is that a good interpretation?

MR. HARRIS: I think that's better than I could have explained it. Yes.

MR. FORD: Now, you have these quoted to two decimal places. What sort of uncertainties are on this?

MR. HARRIS: Oh, well, we don't --

MR. FORD: Should I take much benefit the fact that --

MR. HARRIS: Okay.

MR. FORD: -- it was done off the first 20 cycles of the overlay, but then is there much of a difference between 5x10 -- 10^{-3} and $2x10^{-3}$.

MR. HARRIS: I wouldn't attach much significance to it at the end of the day.

MR. FORD: Okay. Because if you look at the data --

MR. HARRIS: Yes.

MR. FORD: -- that's fudging around, too.

MR. HARRIS: Yes. No. No.

MR. TREGONING: We're -- we're shooting for one significant digit in these final results. If you tell me that we got these -- we get our results within an order of magnitude, hey, I won't believe you number one or (b) I would ecstatic with that.

MR. WALLIS: What order of magnitude?

MR. TREGONING: Huh? Order of -- I would ecstatic if we were able -- if we knew what the true value was and we were really within an order of magnitude, I would -- that would be quite an accomplishment.

MR. SIEBER: Yes, it would.

MR. TREGONING: And again, I'm not trying to be, you know --

MR. WALLIS: So, we -- of course, as regulators, we'd have two orders of magnitude and then --

MR. TREGONING: I -- what I think we're going to see and if we don't see this, it will -- it will lead me to -- an -- an indication that there's something about our process that's not right. What I would expect is we're going to have fairly large uncertainty bands over whatever numbers we come up with. If we don't have large uncertainty bands, that's going to cause me to question various aspects of this process.

Because of the difficulty of what we're asking people to do, because of the number of variables that are involved, there are certain things about the results that -- because of the rarity of the events, there's certain things that we would anticipate going into. If we don't see those in the final result, it's going to bring into question the validity of the process that we've applied.

I don't think that's going to be an issue, but if it -- if it is that we get very, you know, within -- even if we get less than within an order of magnitude uncertainty, I -- my expectation would be that's too small.

MR. HARRIS: The next slide. We also did a comparison of the observed and predicted cracks and the PRAISE results are for an overlay at 20 years and this is the cracks greater than a certain size per weld year. The data points are from Bengt Lydell and the line is -- is a result of the PRAISE calculations. His prior and post I believe have to do with -- with and without a weld overlay.

MR. TREGONING: Now, what -- let me clear because my base case definitions that I gave earlier weren't clear.

Earlier for the recirc, we didn't have any mitigation, but we thought we at least wanted to put one mitigation procedure in there. Not all of them. We didn't look at the effect of water chemistry, but we at least wanted to add one in there and what we added in there was the effect of overlay.

What you see in the distributions is when we calculated from the database leak frequencies, what they did is they used a database prior to 1983 essentially. So, events prior to 1983 was there prior distribution.

MR. HARRIS: Oh. Oh.

MR. TREGONING: Posterior distribution was impacted by the events since then. So, that's where the pre -- the prior and post comes from.

MR. HARRIS: I think -- I see prior and post and I associate it with Bengt Lydell, I think Baeysian something or other.

MR. TREGONING: It is. It's a Bazian update of that prior distribution. So, the -- the distribution they used was essentially the distribution prior to 1983 which was a lot of normal water chemistry, nominal 304 stainless types of materials and then that was updated by things that happened after that.

MR. HARRIS: You could also think of that as with and without mitigation.

MR. TREGONING: Effectively, yes, although the post numbers consider all the different types of mitigation. Where your analysis only considers one weld overlay.

So, in the post you've got -- again, you've got effective water chemistry. You've got effective material substitution. You've got weld overlay and I guess in some cases, some people did stress improvement also.

MR. HARRIS: Right.

MR. TREGONING: Mechanical stress improvement.

So, you've got three or four different things that -- and some plants --

CHAIRMAN SHACK: Well, you did that as an alternative to the overlay. I mean I don't think anybody ever did both.

MR. TREGONING: Well, we required people to do two I thought. Wasn't that the requirement? Had to do two different techniques?

MR. FORD: Well, that was GE approach. There's Belton Suspenders.

MR. TREGONING: Right. Belton Suspenders.

MR. FORD: Did use two. I don't know that it was ever demanded by anybody.

CHAIRMAN SHACK: Well --

MR. TREGONING: Inspection 0313 was -- was relative how many -- how many you had applied.

CHAIRMAN SHACK: Right. That's right. That's right.

MR. HARRIS: So, this was another bench mark that we did. I was pleased with this outcome. The number -- and this observed cracks. So, we have to put -- in order to get the PRAISE results you have to put in the detection probability and I had to use an outstanding what -- what -- outstanding detection probability in order to -- to get something that fell in between here. But, I -- I was pleased with this. I'd be in the same ballpark.

MR. FORD: Is it a big effort on your part to just rerun these things with just plugging into the crack growth model? Connectivity of .1 for instance and about .3 which I guess is what we have done so far.

MR. HARRIS: Yes, connectivity is just an input and that's real easy --

MR. TREGONING: That's just specific variables.

MR. FORD: The reason I am saying this is this will be used in the future and there are no BWR plants operating or pretty well none operating at that .1.

MR. HARRIS: They do weld overlay and the reduced --

MR. FORD: Well, they don't always do weld -- weld overlays.

CHAIRMAN SHACK: They almost all -- they all run with better water chemistry.

MR. HARRIS: They all run with better water.

MR. RANSOM: Or less.

MR. TREGONING: We could have, but we didn't. We could have tried to do sensitivity analysis and -- and I would have done this in -- each variable at the time to look at the effect. We didn't do that per se just because --

MR. FORD: Because I wouldn't -- wouldn't mind betting on this thing here. If you did that line, the .1, it would be on top of this post 1983 --

MR. HARRIS: Well, remember that we didn't do anything for the first 20 years. So, a lot of what we're seeing here might not have anything to do with mitigation.

MR. FORD: Okay.

MR. TREGONING: Well, certainly the prior -- the post distribution does have something to do with -- with mitigation.

MR. HARRIS: Well, but the -- the PRAISE result is pretty much -- might be dominated by what happened that first 20 years.

MR. TREGONING: That's -- that's entirely possible.

MR. HARRIS: But, then we can start changing the 20 years, too.

CHAIRMAN SHACK: Could you adjust your mike a little bit?

MR. TREGONING: You ready to move on?

MR. HARRIS: Yes.

CHAIRMAN SHACK: Well, you might just check to see if you got that one turned on. There's two switches.

MR. TREGONING: I looked at it before I gave it to you. I thought it was turned on.

MR. HARRIS: Why don't we just use the --

the table mike?

MR. WALLIS: The failure probability's fine.

MR. TREGONING: Okay. So, the --

MR. WALLIS: Also --

MR. TREGONING: So, the failure probability was one.

MR. HARRIS: I'd like to --

MR. TREGONING: You'd like to keep that.

MR. HARRIS: Yes, I'd like to -- I'd like to see what I'm -- okay. Is that okay?

The feedwater elbow was selected as the dominant joint for the feedwater system. That was -- that was the expectant dominant degradation mechanism, but I didn't have a probabilistic model available. So, I didn't -- wasn't able to consider it.

The results of the sensitivity studies and bench marking were all provided to the panel and I -- also I had a recommended reference case for each of these base cases and so, we had -- wholly cow, what happened to that thing? You wouldn't be able to see it anyway.

MR. TREGONING: It's not -- it's not readable unless you look at --

MR. WALLIS: Well, an interesting number

that comes to mind is 74.

MR. HARRIS: Yes, there's a 10^{-74} in there and that's -- that's from this ad hoc model where you do this extrapolation.

MR. WALLIS: The age of the universe?

MR. HARRIS: In microseconds and then some. Yes.

CHAIRMAN SHACK: So, you beat Pete Ricardella who only managed to come in with 10^{-32}. So.

MR. HARRIS: Ah. Okay.

MR. TREGONING: What was that for CRDM?

CHAIRMAN SHACK: No, that was for a vessel failure.

MR. HARRIS: Ah. Hum. That's a low number. But, you see just about -- if I didn't use my ad hoc procedure, all those grayed out areas, I'd say unknown. So, in order to just come up with some numbers to provide, we use this ad hoc procedure and I don't -- you know, 10^{-74}, I don't believe it. That's a number -- and some of those, I don't have any entries. Those are the 10^{-125} and things like that. But --

MR. TREGONING: You've got a low threshold for what you would include.

MR. HARRIS: I -- I have a low threshold.

Yes, but yes, I have a low threshold for that.

So, this was -- even though you can't see it here, hopefully, it turned out okay on your hard copy and that was --

MR. SIEBER: Here. You can take a look at it.

MR. HARRIS: That's kind of what --

MR. TREGONING: Yes, I can blow it up. That's all I can --

MR. HARRIS: So, that's -- and that also gives you the dominant joint frequency and then the system frequencies and so, that's a summary of the results and each one of these columns has -- has several tables associated with it to give the results of the sensitivity studies and the recirc line, we looked at the 12 and 28-inch joints.

So, that -- and that's what it all boils down to. What -- what my contribution boils down --

MR. WALLIS: This -- this is unusual events in that, too? This --

MR. HARRIS: No. No. No.

MR. TREGONING: Well, again, normal -- normal --

MR. HARRIS: This are just normal -- these are expected of him. This is the normal operation.

MR. TREGONING: Yes.

MR. HARRIS: And -- and then behind, you know, some of the -- some of the tables that give more details on each of these components have results with and without unexpected events. So, you -- this isn't the only thing that was provided. This is just a particular summary that -- that I thought would be most useful.

I like to get things all down onto one page.

And then that might be the very last one or do I have a concluding.

MR. TREGONING: That's the last one.

MR. HARRIS: That's the very last one.

MR. TREGONING: That is the last.

MR. HARRIS: So, that's what I came up with at the end of the day and then the next step for me was to go into the elicitation process and one thing I did was throw a bunch of that away and do something else. So, that's just something provided to people if they thought it would be useful. I found it useful, but there's a lot of it that I -- that I didn't even consider and in -- and in the end of the day, in fact, and for the feedwater elbow, you have to make some judgment as to what it's going to be because we don't address here.

MR. TREGONING: Okay. Okay.

MR. HARRIS: That's concludes my presentation. Thank you for the opportunity to come and talk to you.

MR. SIEBER: Thank you for being here.

CHAIRMAN SHACK: You must have computed a leak frequency and that's the greater than 0?

MR. HARRIS: Yes, I have it greater than 0. Is it in that table?

CHAIRMAN SHACK: Yes, I mean --

MR. HARRIS: That's a leak frequency.

CHAIRMAN SHACK: That's a leak frequency.

MR. HARRIS: Yes.

CHAIRMAN SHACK: So, you're -- you're -- how come you don't have a leak frequency for the hot leg?

MR. HARRIS: Well, good question. Because I selected as my base case the PWSCC and the predicted leak frequency was really off and I didn't believe that number and I didn't even want to talk about it.

CHAIRMAN SHACK: Oh, because you had -- you had an initial defeat and so, if you let that sucker grow, you're going to get a leak. Bingo.

MR. HARRIS: Bingo. You get a leak right

away, but the good news is it's a small leak.

CHAIRMAN SHACK: Yes.

MR. HARRIS: Because you can see that the hot leg pressure vessel for the -- for the large leak rates the numbers are pretty small.

MR. TREGONING: But, that table wasn't complete because you went back. That wasn't your most updated table because we did go back and try to estimate more realistic leak rates for the hot leg and that's how we got this 1.1. Was this your number that was in this -- 1.1 -- to the minus 1 and that's PWR1 is the hot leg.

MR. HARRIS: That's probably -- yes, that's probably it. I don't believe it's .1.

MR. TREGONING: Well --

MR. HARRIS: Yes.

MR. TREGONING: -- that would be high.

MR. HARRIS: And -- and you -- that would be high.

MR. TREGONING: You didn't put it in the table, but we did --

MR. HARRIS: I didn't even put it in that table. Yes. And then you did put it in the table, but --

MR. WALLIS: Well, if I see two experts

with such vastly different numbers, what shall I think?

MR. HARRIS: Well, you mean -- you mean comparing -- comparing this and this?

CHAIRMAN SHACK: Now, is one of you -- one of them a PFM and the other an experienced based?

MR. TREGONING: Yes. Yes, let me go into this now.

So, one of the things we did is -- this is a summary of the frequency of leak. So, not a LOCA. A frequency of a leak. So, this would be somewhere on the order of a one gpm or less leak and we had two people, two experts A and B which you -- serve as history data. They agreed that expert B had a better database. So, that expert B should be the one that obtained this information. Because again, even obtaining this from the database is a non-trivial exercise because of the mishmash of conditions that are inherent in all these databases.

So, we did one for expert B which was operating experience and one for the PFM to see how they compared. The BWR case, one is the IGSCC case and again, this was considering one sort of -- this was considering one sort of mitigation. This was considering -- this was the posterior essentially after considering all the effects of the mitigation.

If you look at these two guys, I'd say pretty good agreement. Now, again, this is the one where you -- this was the one where the comparison was the most straightforward because we had the most data and we also felt like we had -- all other things being equal, the most realistic model.

So, a little bit more background. These are for average of 25 years of service history. Expert B again was the service history experience, but again, what he tried to do was break them down for the various systems and degradation mechanisms that we identified, but these calculations again, even -- even thought they seemed like they're easier, they're really not just due to the state of the databases.

Expert C if you look here really for the BWR1 case, pretty good agreement and for this other case, which was the HPCI makeup line which was another area that we had quite a bit of pretty detailed service history data, these comparisons are actually pretty good.

Now, when we looked at the hotline case, these numbers for expert C were really sensitive to specific input.

I think these varied depending on how you defined your model between maybe e^{-1} to e minus I don't five/six something like that. So these were very sensitive.

The final LOCA frequencies weren't that sensitive, but these leak rate frequencies were very sensitive. So, given that, we decided there was probably no other warranted -- no really -- no really more effort warranted to try to get these numbers to be closer together. Because again, these were sensitive here, but the final results weren't nearly as sensitive.

We'd like to -- if -- if we can, we'd like to be able to go back and to a little bit more bench marking here to see if we can get these closer, but even for the surge, these aren't too bad.

Now, BWR2 is the feedwater and this is only for thermal fatigue and this is included in FAC. So, we'll never get these guys to match up just because he's not looking -- not looking at the same thing.

CHAIRMAN SHACK: And you wouldn't expect them to match. Yes.

MR. TREGONING: You wouldn't expect them to match. So -- so -- so, this difference is probably indicative of the -- of the relative weight of thermal fatigue versus FAC for that system and how important one is.

So, this difference is not unexpected. This one is relative big, but again, this number was very sensitive. This is maybe the only one --

CHAIRMAN SHACK: Again, as I understand, I mean he really has no initiation. So, I mean you're probability is really the probability that the residual stresses will let the initial crack grow through the wall.

MR. TREGONING: Right. For --

MR. HARRIS: Yes, the stresses that are there.

CHAIRMAN SHACK: Yes.

MR. HARRIS: Initiate it and that's just going to growth.

CHAIRMAN SHACK: Yes.

MR. TREGONING: Right.

MR. HARRIS: And they grow for a FAC.

MR. TREGONING: Right. So, for PWSCC, he did model initiations. Exactly right.

CHAIRMAN SHACK: So, I mean if you multiplied by any initiation probability that seemed halfway plausible, all of a sudden those numbers would look a lot closer.

MR. TREGONING: Yes, practically yes. If -- if -- if you had -- again, if we had that understanding.

Anymore discussion on this one before we move on?

MR. WALLIS: Well, I don't know. When you have a table like this, you -- you have so many excuses for why it's not so serious when it definitely looks as if one has trouble believing these guys are experts.

MR. TREGONING: No. No. No, we're not making excuses. What we're trying -- and what we -- this is what we tried to do for the panel. We provide them with the results and then provide them with reasons potentially why these numbers might be different from these numbers.

MR. LEITCH: What about A and D? Are they still pending or -- or -- no they're not?

MR. TREGONING: Expert -- expert D models weren't rigorous enough to come to this level of detail and expert A had a less precise database for expert B. So, we really only focused on bench marking between these --

MR. WALLIS: They're still going to be asked to give an end result. Aren't they? Well, they're experts and --

MR. TREGONING: Again, these are -- these are results for precursor events, lead frequency events.

So, this -- this information was provided for the rest of the panel for exactly the information that -- that you've noted. Hey, there's a lot of difference within these results. Why is that? Which one of these do we believe and want?

MR. WALLIS: And aren't the other guys all suppose to do it independently?

MR. TREGONING: Yes.

CHAIRMAN SHACK: This is just the base case analysis.

MR. TREGONING: It's just the base case analysis. Yes.

MR. WALLIS: So, they can't agree on that either.

MR. TREGONING: They -- they agree with -- within this level of uncertainty.

MR. WALLIS: Only two of them. So, I assume if you give A and D if they really would do their homework, we got another set of numbers.

MR. TREGONING: Oh, yes. Yes. Yes.

CHAIRMAN SHACK: But, then they would

agree that these are the two best numbers.

MR. TREGONING: We agreed as a panel that these would be the two best numbers. Yes.

CHAIRMAN SHACK: All numbers are not equal.

MR. TREGONING: Again, let's --

MR. WALLIS: That bothers me. Because suppose to have all these independent -- independent estimates and then they defer to some one person.

MR. TREGONING: Again, what we did for the experts, we tried to make it very clear how the calculations were done.

MR. WALLIS: Yes.

MR. TREGONING: And what's -- what problem they solved.

Again, I don't -- I don't want to trivialize this exercise. When -- when you see LOCAs calculated, they're generally only calculated one way or the other. There's only a very relatively few number of instances where any sort of bench marking is done at all and usually, like they've done here, they're under a pretty well defined sets of conditions and this sort of variability when you look at bench marking, I hate to say it, but it's not unusual for this type of problem.

Yes, this is big variability which is -- but, again, I don't think it's unexpected variability given the nature of what we're asking and the maturity level of some of these analyses. These are very difficult things to estimate.

Okay. Now, what I'm showing here these aren't the leak frequencies anymore. These are actually the results we get as a function of LOCA category. You're going to see here you were concerned about the variability of the leaking frequency, but we've got much bigger, much more tremendous variability in these LOCA frequencies results.

So, let me just set this up a little bit. What I've done is given you two different plots here. One for the BWR base cases, one for the PWR base cases for each LOCA frequency or for each LOCA --

MR. WALLIS: How can it go up? How can it go up with LOCA category? You told me it was cumulative.

MR. TREGONING: Well, they -- all of these trend downward. Maybe -- for the most part.

MR. WALLIS: Don't. Don't. And the second thing they don't --

MR. TREGONING: Which -- which --

MR. HARRIS: The bottom one.

MR. WALLIS: The bottom ones don't. That -- that Red Diamond doesn't

MR. TREGONING: You have to be careful. These aren't necessarily --

MR. WALLIS: I'm not. I am being careful. Aren't I? Are they a range or something? Maybe they're a range.

MR. HARRIS: Any one person's is going down.

MR. TREGONING: Well, no, some -- some -- well, they -- you're right. LOCA category -- I'll have to look at this. Maybe -- this is so close. I'm wondering if I'm hitting round off there because it --

MR. WALLIS: Well, that looks to me as if there were too many. There all large LOCAs. It can't be.

CHAIRMAN SHACK: 10^{-12}.

MR. WALLIS: Yes, but the same thing is for the one. Category 1 and 6 are the same. You can't have that. You can't have 100 gpm and 500,000.

CHAIRMAN SHACK: The same frequency.

MR. TREGONING: You're right. What I need to do is I -- let me check this because I may have plotted these incorrect. I may be plotting ranges instead of thresholds. It's possible that I -- that

I mis-plotted these. Because you're right. They should go down for each set.

MR. WALLIS: Yes.

MR. TREGONING: So, it's possible that I mis-plotted these. I'll have to go back and look at them to make sure I didn't.

But, really the reason for doing this was just to show the -- show the level of variabilities. So, for the BWRs and the PWRs, what you see here is each color type is a different base case. So, BWR1, base case one, and base case two and all I've done is provided the different estimates that were given by the experts. So, we only had three independent calculations for the BWRs. One of our experts didn't provide base case calculations there.

MR. WALLIS: I don't think we should look at this too long. It surely goes down very rapidly with LOCA size.

MR. TREGONING: We had four with the PWRs. Well --

MR. WALLIS: Yes, it must have.

MR. TREGONING: The way -- here's I guess one point I want to make. Certainly it goes down. The -- the level of magnitude at which it went down, because again, we had two different estimates, the PFM people because they had natural -- as a result of their methodology, they have a natural way to determine how these things are a function of LOCA size category. Operating experience people had to make assumptions on their end for taking leak data and postulating the trends with effective LOCA sizes.

Some of them did that in a very crude way where they essentially said these things would have half an order of magnitude continued degradation for each LOCA category, but it was no more a -- it was no -- no more rationale other than that.

But, you're right. I apologize. Some of these numbers just don't look correct. So, I need to -- what I'll do is I'll submit -- I'm going to go back and check these results and make sure that they're consistent and submit new figures here to make sure I'm plotting things correctly.

CHAIRMAN SHACK: Although at a certain extent, I mean if the only way you can get these things is somehow somebody missed the crack and somehow somebody misses -- I don't know. But, you always detect the leak. Don't you? That's the assumption.

MR. TREGONING: You always detect the leak if it's above tech spec.

CHAIRMAN SHACK: Above tech spec.

MR. TREGONING: It's above tech spec. You could miss it due to inspection. You could miss a smaller than tech spec leak.

Once they hit tech spec, the assumption is you've found it at that point.

Again, the one -- I guess the main reason for showing this is to look at some of the variability in the estimates. For instance, these numbers here for the BWR2 case, these aren't considering the effect of flow assisted corrosion where these service history estimates at least are trying to estimate that. So, you have some sense that -- that FAC here at least by these predictions is expected to be the dominant mechanism for the feedwater and that probably doesn't surprise too many people.

So, again, this variability is due to -- or these -- due to inconsistencies in the conditions evaluated and differences in the approaches.

Again, I mention this -- this base case participant their approach, warts and all and the results to the entire panel so that the panel could estimate which ones were better at doing certain things and this plot's for 25 years. There were other plots for 40 and 60 years.

And during the elicitation, the first question we asked each panel member to critique the approaches and the results of these base case analysis. So, that's the -- the first thing that they did.

And again, I apologize for -- I think you're right. There's definitely some things in this figure that need to be fixed. So, that -- make sure that we change that for the record.

Let me quickly go to the non-piping. We didn't do the same methodology in the non-piping. Why is that? Because the variety and the complexity of the non-piping failure mechanism would have made this assessment even more intractable. We had a lot of different ways that non-piping components could fail than piping components did.

So, what we've tried to do is we -- we've conducted database searches for each of the non-piping failure mechanisms that have been identified by the panel. We're trying to come up with estimates for component leak frequencies and also in some sense crack frequencies, but we realize these crack frequencies aren't going to be well represented by the database and we're asking the experts to use these precursor frequencies as the anchor for their responses for the non-piping.

And again, each expert has to determine the relationship between these leak and/or crack frequencies and the LOCA frequencies.

So, we spent a lot of time on the piping. How did we do the non-piping which again was fundamentally different? Again, we didn't have an operating experience database. The first methodology we did was to develop one.

So, we search the LER database for precursor events in the relevant P and BWR components that we looked at. What are events? Events are either leaks, through-wall cracks or partial through-wall cracks as long as they've been reported by the LER structure.

We did a very broad search initially back to about 1990 and by broad, any failure or any -- any -- any failure in any one of those LOCA sensitive components, we tended to pick up and then we went back and we screened them to insure they were relevant. So that they were relevant within the passive system degradation mechanisms that we were looking at within this exercise.

So, we -- we spent a good bit of time just developing the baseline data and then screen again to make sure the events were realistic.

Now, certainly we -- we know and we've already -- we've made sure the experts know that the information we've obtained on partial through-wall cracking is just not complete. We wouldn't expect it to be complete. There's two reasons for that.

One, the LER reporting requirements are a bit vague in that you'd only have to report serious degradation and what one particular plant considers to be serious degradation might vary. So, there's variability in -- in the understanding if you really have to report this as an LER or not.

Probably the bigger reason is you also -- you obviously don't report things you don't know about. So, lack of detection during ISI is also a factor that -- that we know we don't have very good completeness for this partial through-wall crack information.

The through-wall and the leaking information, we have much more confidence in the completeness of this database.

We developed an ACCESS database of events and we actually linked these to the LERs so that the panel members could go back and -- and look into the LERs or look at the genesis of these precursor failures.

This database was good for certain things, but for other things that we've -- that we spent a lot of time recently on and primarily steam generator tubes and control rod drive cracking, we have other databases that we're going to rely on for this precursor information. We feel that they're more complete and more rigorous than we've been able to develop in the short time using this LER information.

So, what kind of -- what kind of summary information did we give to the experts? Well, we -- we provided them a description of the approach used to develop this precursor database and then we provided -- and we gave them the access to all the events, but we also tried to do some crude summaries just so people had a sense for the types of things that were evident in the operating experience.

So, we plotted these summaries as a function of component which you see here. This is just one summary table of component versus degradation mechanism. Again, these are acronyms here and it shows the various totals that we had.

One of the things we did is this statistical measure. If we didn't see any failure within a degradation mechanism, went back and conservatively assumed that we had half a failure over that time period. Again, this is something that is done quite routinely to -- to give you data to analyze when you have none. So, this is sort of a -- a crude non-informative prior Baeysian update sort of approach.

So, we looked at specifying these versus degradation mechanism. We also looked as a function of the sub-component failure. So, RPV nozzles, penetrations. What -- what else?

MR. FORD: Just the RPV nozzles? Not the reactor pressure vessel?

MR. TREGONING: This -- this here is RPV. Anything associated with the RPV. When we broke them down by sub-components, they were RPV nozzle, RPV the vessel itself --

MR. FORD: It's just are you sure you --

MR. TREGONING: -- RPV penetration, RPV CRDM penetration. We were much more explicit when we broke these --

MR. FORD: It's just that we're shocked because you're showing nine instead of the stress corrosion cracking of the -- what I thought was the reactor pressure vessel.

MR. TREGONING: No, these are the -- yes, these are components and we -- we grouped a lot of -- we grouped nozzles and CRDMs and things like that within the pressure vessel itself. Sorry. Didn't mean to cause any alarm.

We also broke these down as a function of the flaw type whether they were a leak, a through-wall crack or a part through-wall crack and we also depicted failures as a function of calendar. So, if anybody wanted to infer trends from that realizing the trends from rare data is -- is a difficult proposition, but they had that information available to them.

All right. We're running -- I don't know. Keep going?

The next thing is the elicitation question development. I'll try to be as quick as possible here. We have six different topic areas within the elicitation questions.

The first one is the evaluation of the base case results. I've talked a little bit about this.

The next question is with respect to regulatory and utility safety culture, but again, it's safety culture as it pertains to LOCA frequencies. So, we're not talking about human factors and things per se, but just general organizational stresses and influence that could affect these LOCA frequencies in the future.

We -- we have categories on LOCA frequencies of piping, non-piping components and theses conditional failure probabilities under the emergency faulted loading.

I think I've covered the rest of this. Relative questions. We asked for mid, low, high values and we structured so that they could use the top-down or bottom-up approach.

I think we've covered most of this.

I said we'd give one question and this is probably the easiest question we have. This is a question that we have on safety culture. All these questions were multi-part for the most part. Required usually iterative solutions. So, this is the question on safety culture. This was exactly what we asked.

Said consider the current utility safety culture that exists after approximately 25 years of plant operation. So, that would be the safety culture today and how it influences Category 1 LOCAs which are our smallest LOCA size and we say express the relative change or ratio in the utility safety culture's effect on LOCA frequencies after 15 additional years compared to its current day. Next express the ratio in 35 years compared to its current day effect.

So, you could see we tried to be pretty prescriptive and clear in the language that we use in the questions so that what we were asking was clear to all the experts.

Now, during the technical development, we spent a lot of time defining what was going to be considered as part of the safety culture for this exercise. So, that's not in here, but that's part of the background effort.

MR. SIEBER: Were there any utility experts?

MR. TREGONING: I -- I wouldn't -- we didn't have any experts that I would say were experts in safety culture per se. So, they weren't people that were either expert in human factors. They weren't experts in I'll say organizational and psychological pressures.

MR. SIEBER: Or how about just plain old plant condition?

CHAIRMAN SHACK: You mean there were no utility plant people on the --

MR. SIEBER: That's right.

MR. TREGONING: Yes, and there were no

utility plant people. There were -- right. We had -- we had people represented from Exelon and GE and Westinghouse, but we didn't have any particular plant people like for instance from South Texas on this.

The -- the one thing we did we asked -- this is a separate question. The panel themselves felt very strongly that we ask this question. Because all of them had worked in this area, in the nuclear area for 30 plus years. They all had opinions about the area and about safety culture in general and its effect on LOCAs. They wanted to make sure we asked about it and that's why we've separated it here or we've tried to separate it.

Now, how we factor this into the final results still remains to be seen. We have to look at -- at -- at the responses from the expert, but one of the things we've said that if safety culture is an area that while none of the experts are an expert in safety culture, they've -- they've at least been around the industry long enough to have perceptions as to are we safer now culturally than we were? Do I see the safety climate improving or degrading the future? Those are the types of things that we -- that we were really looking for here.

MR. SIEBER: Yes, I struggle a little bit when somebody who doesn't work in the plant and worked with the utility organization makes a judgment about what their culture is.

MR. TREGONING: A lot of these people --

MR. SIEBER: I -- I have a hard time.

MR. TREGONING: I --

CHAIRMAN SHACK: Well, here all their doing is sort of saying though is safety culture going to have an impact on LOCA frequency and that's --

MR. SIEBER: I think it does.

CHAIRMAN SHACK: That's -- well, that's -- you know.

MR. TREGONING: But -- but -- and not asking that. We're -- we're not even asking that. We're asking -- because it does have an impact, but we're saying how does that impact change versus time? That's what we're really asking.

We're asking for ratios to current day and while -- while we don't have any utility people and I would agree that if we really wanted to probe deeply the affect of safety culture, we'd probably need a separate effort just on this along. But, we certainly have a lot of people that have worked with the industry and they have worked -- we don't have regulators on the panel either, but they've all worked with the NRC. So, they certainly all have impressions of over the prior 25 years how the climate has changed within the NRC. So, people had opinions on this.

CHAIRMAN SHACK: You have a regulator. You don't have an NRC regulator.

MR. TREGONING: Yes, that's true. We have two regulators. That's correct.

The second question was exactly the same, but instead of looking at the utility safety culture, look at the effect of regulatory safety culture and we also said if you think these safety cultures effect our function of the leak rates, so do they proportionally effect either positively or negatively large LOCAs different from small LOCAs? You know, make some opinion as to the relative differences there.

And finally, we asked them -- although we asked them initially to consider regulatory safety and utility safety culture independently, we ask them if they thought that these were correlated in reality and if so, is that correlation high, medium or low. This is important obviously to determine how we factored in these results.

So, we plan on using these outside. This will be a separate piece of information that's reported along with the LOCA frequency information. I don't think we're planning on modifying the numbers in anyway by the results of this particular question, but what we want to do is -- is we'll provide this as -- we'll provide these results. Other people, utilities and others, could look at that and say these guys got this totally wrong and here's why or these guys got this, you know, pretty good and here's why.

I can tell you with this one I've got enough of a sense that -- because again, we've asked people for middle estimates and then the outer bounds. A lot of the feedback we've gotten is people feel like the median safety culture is fairly static and they think it will be fairly static over the future and what's really variable is the variability that you can get from, you know, between the best possible plants and the worse possible plants. So, that's where your variability is.

That doesn't show up in the average per se because the average is weighted by both of them. But, it shows up in your uncertainty distributions.

So, you know, this is something. I don't -- I don't -- I don't think this is going to have a big effect.

MR. SIEBER: Okay.

MR. TREGONING: Now, should it? I don't know.

Now, this was the actual -- actual question that we asked for safety culture. For the -- for the piping components, these questions are a little bit more convoluted. So, I'm just going to try to quickly take you through the flow charts for how we -- what the questions tried to get at and how we get at the final piping contributions.

Everything's anchored to these base case results. So, we asked them to compare these base case results to a set of reference cases. This is the bottom-up approach.

The reference cases are similar to the base cases in that they're a well-defined set of conditions, but we don't have actual numbers associated with them like we do to the base cases. Okay. And they have to quantify or give us ratios between the reference and the base case results. Then they have to come in and list their important variable contributions. So, those issues that they think are most likely to lead to a LOCA.

Compare those with either the base case or these reference conditions and when you sum them all up for all the different variable combinations and piping systems, you end up with your piping contribution.

The top-down approach is -- is conceptually different in that instead of looking at those combinations of variables which are important, we just say list the significant piping systems that you're -- that you think are important. Determine what you think the contribution of each of these systems are to the LOCA frequencies and then pick one of those systems and compare them with a base case evaluation.

Once you make that comparison, it's just a matter of summing up these contributions to get the piping contribution.

So, the top-down approach is not as rigorous as -- it's not a rigorous -- it's not as rigorous a way as coming -- for coming up with these numbers. It's trying to build them conceptually from the ground up. Of course --

CHAIRMAN SHACK: Did people do both or did people pick their preference?

MR. TREGONING: We asked people -- ideally, we wanted people to do both because we're looking for self-consistency, but for the purposes of the elicitation, we said at least do one. Some people did both. Some people only did one.

Some people just could not -- some people could not -- there was no way. They didn't have the expertise to do a bottom-up type approach. It just didn't make sense and they thought that there would be an inherent danger in doing that because whenever you try to add small pieces to get to the final, you -- you could be more likely into missing something that's really a significant contributor.

MR. SIEBER: Right.

MR. TREGONING: So -- so, there's inherent advantages and disadvantages to each approach. That's why I think it's valuable to have both approaches. Ideally, everyone would use both and you'd have a consistency check.

But, I think we'll be able to see in the final results -- we'll be able to see potential differences between those that do it one way and those that do it this way and that'll be something that -- that we certainly examine also.

Most people tended to follow something like this believe or not. There were only a few people out of the 12 that went the other approach and I'm not showing -- there really -- many people what they did and I'm showing the pure examples. Many people tried to combine aspects of both. Different elicitations. We truly had 12 different methodologies and we wanted to allow that flexibility because we didn't want to hinder the experts' way of thinking and -- and analyzing this problem. We wanted to have them tackle it in the -- in the best way that they could.

Same thing for piping and non-piping. We had a bottom-up and a top-down approach. I'm not going to show the bottom-up approach for non-piping, but it's -- it's really analogous.

We asked them to consider all the pipe -- all the possible non-piping component classes together. So, pumps, valves, pressurizer steam generators. Looked at all the component classes and list the significant failure mechanisms that you would expect to lead the non-piping LOCAs and from those failure mechanisms, determine how -- their total contributions to LOCAs, the individual contributions for each of these failure mechanisms. Again, compare it with a relevant base case and once you get that with the contributions, you had your non-piping contribution.

So, this is very analogous to the piping top-down approach except in -- in looking at piping systems, we're asking them to look at non-piping failure modes essentially which would be a specific non-piping location due to a specific degradation mechanism.

I don't know if we want to touch this or not.

CHAIRMAN SHACK: Can you just go back for a second?

MR. TREGONING: Sure.

CHAIRMAN SHACK: How do you determine the total LOCA contribution without going through the branch that takes you to the -- the comparison with the base case?

MR. TREGONING: Well, they have to determine -- what -- what we do we -- we ask them -- the way the question's structured it says list the significant failure mechanisms. What do we mean by significant? We're asking them in your opinion, list the ones that in total will give you at least 80 percent of the contributions of all the LOCAs that you would have in the system. Okay.

So, when they list them by definition they have to come up with at least 80 percent. They can't come up with only 10 percent because they haven't even gone over 50 percent of their, you know, of their dominant contributors.

All we ask them to do here is say okay, you've told us that they're at least 80 percent. Give us a number. Is it 80? Is it 85? Is it 90? This isn't that important. It's just a normalizing parameter at that point. It's the difference between normalizing by .8 or 1. So, it's really not that significant.

MR. SIEBER: You have to do them all in order to be able to know which ones were significant and the problem is as I see it is that you're never sure you get them all. You know what I mean?

MR. TREGONING: No, but again, we came up with these master tables that said these are all the LOCA sensitive systems.

MR. SIEBER: Right.

MR. TREGONING: Some people would look at those tables and say for a LOCA -- for a certain LOCA size, Category 1 let's say, a lot of people said small pipes are going to dominate that.

The only ones that are significant in my mind are the ones that have small pipes associated with them. So, those people went in and looked at the systems that had a lot of small pipes. They said these are going to be the dominant and then at the end of the day, they said I'm not going to worry for --

for Category 1 LOCAs about this bigger pipe stuff. Because they're going to be dominated by small pipe failures.

So, did they catch all the contribution to Category 1 LOCAs? No. But, in their mind, they got the things that are driving the Category 1 LOCA frequencies and when they get up to a higher LOCA size, let's say Category 6 which is essentially double-ended guillotine break of the plant, there's only a couple of systems that can give them that. So, when they listed their system, they likely had close to 100 percent contribution at that point.

So, we didn't want them -- the point here, we didn't want them to agonize about things that at the end of the day ended up not being important in their minds. So, if there was a system that they thought didn't lend itself to leading to a LOCA, why spend time analyzing it?

That doesn't mean initially -- you have to do some ranking in your mind as to which systems are important.

MR. SIEBER: Yes, and it's got to be more rigorous than just sitting around dreaming about it, too.

MR. TREGONING: That's -- no. Right. And

that's why again we had operating experience data --

MR. SIEBER: Yes.

MR. TREGONING: -- that -- that -- I think most of the people that did this approach fell back on at least for -- you know, you have to make the assumption that operating experience data lists precursor events. You make the implicit assumption that if it has a high likelihood of precursor events, it also has a high likelihood of failure.

MR. SIEBER: That's right.

MR. TREGONING: Of LOCA failure. So, there's some implicit assumptions there that people have to make, but a lot of them felt more comfortable doing that sort of analysis than this bottom-up analysis where you're trying to think of all the possible failures in areas.

MR. SIEBER: Make -- yes.

MR. TREGONING: Yes. Because there you're -- you're potentially much more likely to miss one of these things.

I don't know. We're running low on time.

MR. SIEBER: Yes, why don't you just move past that.

MR. TREGONING: I hadn't talked about conditional LOCAs due to emergency faulted loading much. So, I -- I thought we at least needed to have a couple of slides here.

Just -- just the point -- I'll make a couple of points. The frequency of emergency faulted loading is essentially what we want. So, this -- these are the LOCA frequencies. Now, that's a function of the frequency of event times the conditional probability failure.

We're arguing here that this event frequency for these rarer emergency faulted loads are so plant specific that it just doesn't make sense to do this generically.

So, what we're tying to do generically is develop these conditional LOCA probabilities given a known stress amplitude. So, there's a lot of other work that would have to be done on a plant specific basis to come up with this estimate. But, this is -- this is somewhat akin or analogous to what's been done in like seismic hazard analysis and things like that and that's what we're looking for.

We're looking for possibly using that analysis and saying well, there we know about conditional failure probabilities for undergraded pipes. So, there's been some testing and analysis and service history even with that, but we'd like to see the differences in this conditional failure probability if you consider degraded pipes.

MR. RANSOM: What are typical emergency followed events? I mean things like station blackout or --

MR. TREGONING: Now, we're -- we're thinking of the -- the ASME code definition of emergency faulted in the sense of the loading magnitude that's applied. So --

MR. RANSOM: But, they're not earthquakes or anything like that? Seismic?

MR. TREGONING: We did -- we -- what we did is we didn't -- we didn't -- we didn't specifically specify what they were. What we said or what we're saying in here is consider that you've got a loading event of a certain magnitude. Okay. And use the code stress levels of Category B or Category D loading. So, these are well defined.

The question that we asked them is we said okay, consider this what are some things -- what are some events that could lead you to these loads in these pipes and are these events load controlled or displacement controlled. Because that's an important consideration on the analysis that you're going to do.

MR. RANSOM: When are -- when are going to

I guess see that? You know, see what the experts -- what their evaluation of -- you know what are typical events? Their estimation of the frequencies. I'm a little lost on all this.

MR. TREGONING: Oh, yes, we're not -- again, we're not asking for frequencies for this one. Because again, we would --

MR. RANSOM: Yes.

MR. TREGONING: We're arguing that these frequencies can only be developed on a plant specific basis.

For instance, for seismic, individual plant design is such -- is such a strong role in --

MR. RANSOM: Well, is that something that comes out of the application of this methodology to defining the LOCA for a specific plant then?

MR. TREGONING: What we would intend here again we've been trying to develop these conditional failure probabilities generically.

What we would have along with these generic numbers would be for use, we'd have some methodology that would be recommended for taking these generic numbers and calculating these frequencies of -- due to emergency faulted loading on a plant specific basis. So, they would be generic calculations plus here's a methodology that we would recommend that you follow for doing that. Doesn't mean they couldn't deviate potentially from that methodology, but we -- we give one approach that would be available to do this.

Again, we could have spent a lot of time trying to determine these frequencies and again, I would argue that the expert panel is -- their expertise is not collectively in developing that sort of information. Their expertise is trying to get at this more, but even this is very difficult to get at and I'm not sure if -- I'm not sure how well we're going to do this either. Again, this is a secondary phase, secondary part of the elicitation.

CHAIRMAN SHACK: Well, do the PRA people think that they're including these now when they -- when they make their estimates of LOCA frequencies?

MR. TREGONING: Well, they would argue that the service history was.

CHAIRMAN SHACK: The service history. Yes.

MR. TREGONING: The service history was. So, you happened to have an event and it was within the event and you're naturally including -- it's naturally included. That would be their argument that the data is what the data is and you're looking back over what actually occurred. So, it's -- it's implicit in the database. However --

CHAIRMAN SHACK: But, then they -- they extrapolate to larger say diameter pipes where they have no data. Now, do they really believe it covers that or they're conservative enough or --

MR. TREGONING: Well, again, I -- if I, no events is not no data. So, the fact that you've had no events is --

CHAIRMAN SHACK: No.

MR. TREGONING: -- is data.

CHAIRMAN SHACK: That's -- that's certainly data. True.

MR. TREGONING: Now, many times that's not good enough because if you use that, the frequencies are still too high.

So, yes, the service history people -- and that's -- that's why you just can't use data here. They have to be able to -- you have to be able to have some methodology in taking that data which is largely precursor events or small diameter failures trying to extrapolate this up to larger diameter failures and each person did it in their own way. Some of the people did that in a -- in a very ad hoc manner.

MR. LEITCH: Now, if you were including my pet peeve of sabotage events, this is like -- a likely place for it to be included.

MR. TREGONING: Yes.

MR. LEITCH: Without prescribing the frequency.

MR. TREGONING: Right. This -- this frequency of -- this would be a frequency of event giving you a certain stress magnitude.

MR. LEITCH: Yes.

MR. TREGONING: If you knew that, you could use this information theoretically and come up with a LOCA frequency.

MR. LEITCH: Right.

MR. TREGONING: Yes. So, you could -- you could --

CHAIRMAN SHACK: Of course his saboteur could put in loads bigger than the ASME Level D.

MR. TREGONING: Yes, the saboteur could do that.

MR. LEITCH: And I'm picturing other things here. Might be things like rigging accidents. If we were moving something over piping and dropped it or --

MR. TREGONING: Yes. Yes, crane drops and things like -- there have been a few studies on crane drop frequencies and things like that and that would -- that would particularly apply here. Although a lot of times with those, with the crane drop, the drop frequency and then the probability of hitting one of these pipes --

MR. LEITCH: Right.

MR. TREGONING: -- is all you need to worry about usually because the loads are such that you usually have a failure at that point.

MR. LEITCH: Yes.

MR. TREGONING: So -- so, that would -- again, I would say that you would have a different exercise to build in pieces of that.

One -- one point I want to make. LOCAs can come from a lot of different sources. This exercise -- there's just no way we can be comprehensive that we're going to say at the end of this here's a LOCA frequency that covers all the possible things that could happen.

We're trying to grab out a manageable chunk that we think we can do within about a year given the expertise of the panel that we have.

What we'd like to say is that if there are other aspects that need to be added in, you need to do some sort of separate exercise. We -- we're hoping that our results are going to modular enough that we could combine them with these other exercises to come up with more complete numbers as people have interest.

We're getting short. So, I don't -- I don't -- we've essentially asked them two things, conditional failure probabilities and the likelihood of damage because you have to sum these curves up to get this final conditional failure probability of a LOCA given a certain stress magnitude.

So, again, it's a function of the amount of damage that's in the pipe -- a function of the amount of damage in the pipe and the likelihood of having that damage and because these curves are inversely related, we've asked them about three specific points here. We asked them to consider a tech spec lead, a perceptible leak, and a 50 percent through-wall crack.

These conditional failure probabilities curves continue to go up. As you have higher amounts of damage, you have more likelihood of failure. But, the likelihood of having those goes down precipitously. So, you have to multiple these curves together, summed them up to get this final conditional failure probability.

I think Lee covered all this. This is where we're at. We finished the individual elicitations. Initial interviews have been finished. We've had submitted updated responses, but we need to address and insure that the adequacy of these updated responses is appropriate and I think I've -- I covered most of this in the executive summary. I don't think we need to go through it again at this point.

Again, I apologize. We've run way over. I apologize to Eileen for that.

We -- we knew we were going to run long today, but we wanted -- we thought there was an interest in providing as much detail as possible in this exercise. So, we -- we had really tried to do that and we've provided hopefully sufficient information.

If -- if certainly more information is desired, we -- we would be more than happy to provide that either through another -- either through another session here or through some -- some more documentation.

CHAIRMAN SHACK: Well, I think we will want to meet again when you -- when you have your final package put together.

MR. TREGONING: Certainly. Yes, we're in

the middle. So, what we wanted to do was come and give you a sense -- as clear a sense as we could of what we're doing. Get some feedback if -- if there are any corrections that we should look at making now and if -- and if that's indeed the case, we're try to build that in as much as we can.

Certainly we'll be back again when it's time to present the results and how we analyze the results.

So, this next meeting will focus entirely on that for the most part. So, I wouldn't plan on going back into many of these approach details again because we're going to have enough to discuss with the results and given the people that weren't here, hopefully, that's going to be sufficient that we won't have to digress too much at that time.

CHAIRMAN SHACK: Eileen, we didn't leave you much time.

MS. MCKENNA: I know. I think that we'll -- I was talking with Mike. I think we will make plans for a future occasion.

CHAIRMAN SHACK: Can you -- can you begin to address -- this question that sort of came up here is that there's lots of LOCAs that aren't being considered here and yet in 50.46, you guys are going to have to consider all LOCAs, you know. We all can sort of say okay, that's somebody else's problem, but it -- it's all your problem.

MS. MCKENNA: Well, ultimately it will be when we get into -- into the rule making, I think we'll have more discussion on this in terms of what actually has changed in the regulations and what actually changes in the plant will obviously play into how that LOCA information and the frequency -- the -- the scope of it. Because right now, you know, in terms of 50.46 it looks at piping. So, look at the definition of LOCA in 50.46.

CHAIRMAN SHACK: Yes, it's a large diameter pipe. You're right.

MS. MCKENNA: Yes.

MR. TREGONING: Yes, so -- and again, in the past, we've never looked -- we've never said that the LOCA frequencies that we're using are all inclusive. They were defined over a fairly narrow set of conditions.

MS. MCKENNA: And the frequency -- I mean you have -- they have to show the results through the full spectrum regardless of what the frequencies are. So, it's really -- if there is perhaps this contribution from other things that are not encompassed by the break sizes within the -- up to the double-ended and that might be, you know, where you're -- where you're going.

MR. TREGONING: And again, these will be for design basis changes first. One of the things that you'll talk about when you come back is we're looking at having other criteria in there to develop -- to -- to demonstrate some sort of mitigation capabilities beyond design basis. Now, there's been a --

MS. MCKENNA: Intended to be a risk informed change. We have to somehow bridge between what remains in the design basis and is treated this -- the way it's historically been treated and what do you do with beyond design basis things which is what Rob was alluding to.

MR. TREGONING: Yes, we're walking a bit of a tightrope. Because the design basis you don't want to over impose conditions that don't make sense within the design basis. So, we're -- we're trying to -- that's one of the reasons we're trying to be somewhat historically consistent with -- with the types of things we're considering as -- as being part of these LOCA frequencies.

MR. SNODDERLY: Eileen, as far as the

upcoming schedule, if I understand it correctly, you -- between now and -- and the end of December, you plan on issuing a -- a SECY to the Commission that would just --

MS. MCKENNA: It will be some communication to the Commission. Whether it's a memo or paper is part of our discussions. But, we do plan to go back to the Commission with summarizing or pointing out some of the issues that we've included in the background information we provided to you a couple of weeks ago that we -- we feel have a major impact on any direction of the rule making and make a proposal to the Commission as to how we -- we're going to proceed to try to get to resolution on those -- those issues.

We're still having some internal debates on what's the best way to do that, but we're hoping in that kind of time frame by the end of December that we will have some piece of paper in front of the Commission which then the committee can -- can see and what can be the -- form some of the basis for our future discussions, but it's -- we've had some challenges in that area to get agreement on exactly what message to deliver.

MR. SNODDERLY: And then you also plan on then delivering a -- a SECY in March.

MS. MCKENNA: Right. The -- you know, the SRM had a deliverable within the March '04 time frame and we are still looking to try to provide a deliverable. Again, I -- I won't speculate on exactly what the product is going to look like at this point. The Commission had asked for a proposed rule and I -- we think that's not likely to be the product because of some of the issues that we noted, but -- but we are going to try to respond in that time frame with whatever we can.

MR. SNODDERLY: Okay.

CHAIRMAN SHACK: Anybody have any final comments they want to make before we adjourn? Any -- any problems or questions, messages we want to give?

MR. RANSOM: Is this going to be presented at the December meeting?

CHAIRMAN SHACK: No.

MR. RANSOM: I mean directions came out and said the expected subcommittee action was to anticipate that the full committee will write a report in December.

MR. SNODDERLY: That's -- that's right, Vic. What -- the reason I -- I wrote that was because I was anticipating that -- that the -- the first paper that Eileen talked about would have been issued by now and then -- then what I thought was that we would review that document, that communication, and provide feedback to the Commission on that at the December meeting.

Now, that we know that that's not going to be issued until probably --

MS. MCKENNA: When we have time for that kind of deliberation.

MR. SNODDERLY: Right.

MS. MCKENNA: Yes.

MR. SNODDERLY: So, then our next meeting would be the February meeting and I think that's what I'm -- I'm going to discuss with Dr. Shack and -- and the other folks is that we'll -- we should probably at the December meeting I believe discuss this subcommittee meeting and then also talk about maybe at the February meeting it might be appropriate for the staff to brief us on that status communication and also by that time they should have a -- probably a pretty -- that the SECY -- the March SECY should be at a form that maybe we could --

MS. MCKENNA: Right.

MR. SNODDERLY: -- be -- be --

MS. MCKENNA: Looking ahead. Right.

MR. SNODDERLY: So, either February or March I would anticipate would be the next full committee meeting and correspondence.

CHAIRMAN SHACK: So, at the December meeting, we'll basically have a subcommittee report. I would suspect it be basically what we -- what we heard here, the summary form.

If there are not further comments, let me thank Rob and I guess Dave Harris has already split. Was a -- for that impressive presentation.

MR. SNODDERLY: And also Eileen. I -- I think that the paper that -- that she provided to us in support of this meeting was very concise and -- and really laid out the issues that they're struggling with. We appreciate that and I think we'll -- we'll be able to provide some feedback in the future.

MS. MCKENNA: Okay. That'll be great. Thanks.

MR. SIEBER: I -- I point out there's nothing on the December agenda about this --

MR. SNODDERLY: Right.

CHAIRMAN SHACK: Adjourned.

(Whereupon, the meeting was concluded at 3:03 p.m.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards Regulatory Policies and Practices Subcommittee

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Jennifer Rosario
Official Reporter
Neal R. Gross & Co., Inc.

Estimation of LOCA Frequencies for Expert Panel by Use of Probabilistic Mechanics Models

Presented to ACRS
Rockville, Maryland
November 21, 2003

D.O. Harris
Engineering Mechanics Technology, Inc.
San Jose, California

- LOCA frequencies (as a function of flow rate) for base case systems estimated by probabilistic models for crack initiation and growth

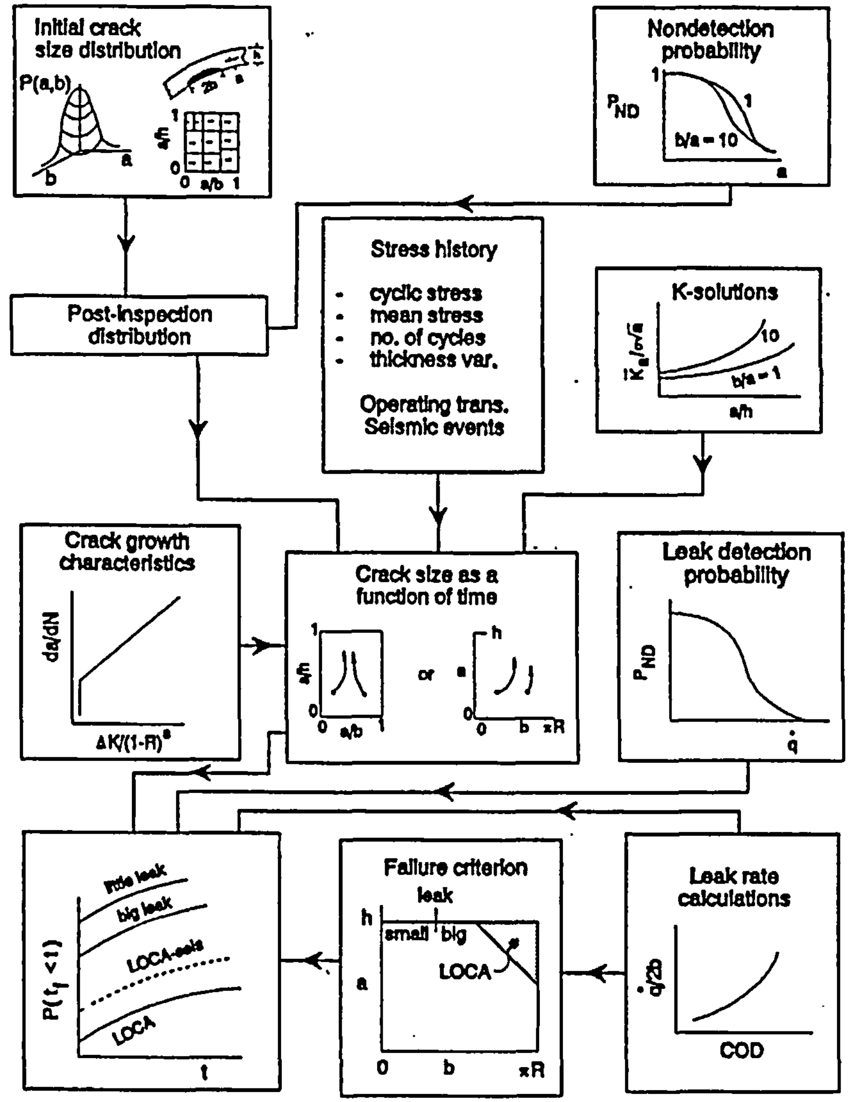
- Base case systems selected by expert panel based on estimated contribution to overall LOCA frequencies
  - PWR main coolant system
  - PWR surge line
  - PWR HPI make-up nozzle
  - BWR recirculation line
  - BWR feedwater

- LOCA frequencies estimated for expected dominant degradation mechanism
  - IGSCC
  - PWSCC
  - fatigue
- Initiation and growth can be considered for each of these mechanisms
- Material aging and overload events considered
- Some of the inputs to the mechanics-based models of crack initiation and growth are considered to be random variables

- Monte Carlo simulation used to generate results
- Computations performed using PRAISE software
  - originally developed in 1980 with NRC support for probabilistic analysis of fatigue crack growth from pre-existing weld defects (NUREG/CR-2189, Vol. 5)
  - IGSCC initiation and growth models developed in mid 1980s (NUREG/CR-4792, Vol. 3)
  - Fatigue crack initiation capability developed in 1999 (NUREG/CR-6674) using probabilistic strain-life correlations developed by Argonne National Lab

Overview of PRAISE methodology for fatigue crack growth

{similar modules available for
- initiation (fatigue and SCC)
- SCC growth }



- Random variables – fatigue crack growth
  - Initial crack depth
  - Initial aspect ratio
  - Fatigue crack growth rate (da/dN) for a given cyclic stress intensity factor (ΔK)
  - Critical net section stress (σ_{flo})
  - Probability of detection during an inspection [P_{ND}]

- Additional random variables – SCC
  - Time to initiation for a given set of conditions (stress, temperature, sensitization, dissolved oxygen and coolant conductivity)
  - Residual stress distribution (also useable for fatigue)
  - Crack growth rate

- Additional random variables – fatigue crack initiation
  - Cycles-to-initiation for a given cyclic stress
  - Aspect ratio of initiated cracks (depth set at 0.3 inches per ANL)

- Stratified sampling of crack sizes (*a* and *a/b*) employed to allow evaluation of extremely small probabilities

- Note that operating conditions are considered as deterministic (stresses and frequency of loading, temperatures and pressures)

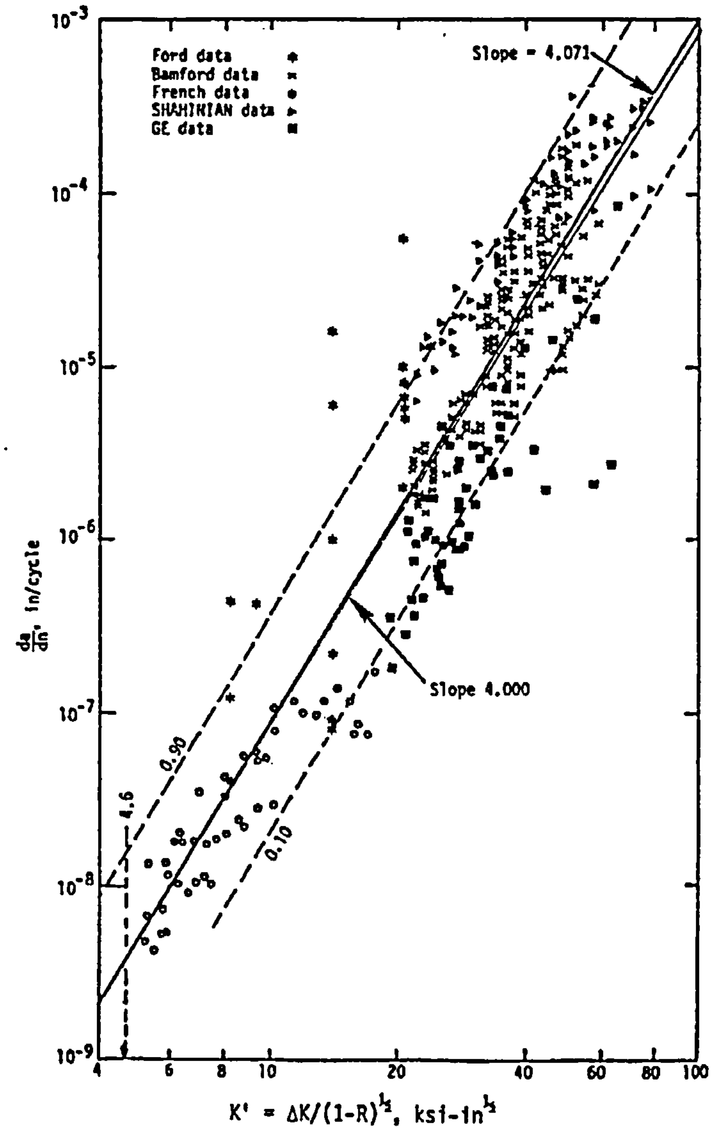
- Characterization of random variables key to model

- Initial crack depth distribution is probably the most important single variable, and is based on PRODIGAL runs performed by Vic Chapman for PNNL (Monte Carlo simulation of weld defects in multi-pass welds)

Example of characterization of scatter in fatigue crack growth characteristics (based on test data 1980 austenitic stainless steel)

$da/dN = C[\Delta K/(1-R)]^m$

m=4
lognormal C
median = 9.14×10^{-12}
$\mu = 1.042$



- Calculations are performed for most likely failure location within a system, then extended to system by number of locations with similar dominant LOCA frequency

- Calculations performed as a function of flow rate (probability of a through-wall crack of length exceeding that required for flow rate)

- Flow rates calculated using SQUIRT (developed by Battelle with NRC support).

- Credit taken for leak detection (>5 gpm immediately detected).

- Stresses and frequency of occurrence required for the dominant location in the system

- The stresses were drawn from a variety of sources

hot leg/PV	NUREG/CR-2189, vol 5	includes var EQ
surge line	NUREG/CR-6674	with and without EQ
HPI	NUREG/CR-6674	
recirculation	an old analysis (DOH)	includes seismic
feedwater	NUREG/CR-6674	

(NUREG/CR-6674, “Fatigue Life Analysis of Components for 60-year Plant Life”, PNNL, June 2000)

- The stresses and operating conditions drawn from NUREG/CR-6674 were modified in some instances based on more complete information

Example of Stresses: Surge Line Elbow with no Seismic Stresses

LOAD PAIR	AMP(KSI)	NUM/40 YR
HYDRO-EXTREME	190.17	6
9B-HYDRO	149.86	4
8A-UPSET 4	140.42	14
9B-UPSET4	139.43	10
8B-UPSET4	105.89	14
9A-UPSET4	105.13	2
9A-LEAK	103.86	12
8F-18	63.40	68
9C-11	63.38	68
9F-LEAK	63.37	68
8C-LEAK	63.37	35
2A-8C	62.30	33
8G-18	52.38	22
8G-17	52.35	90
9D-11	52.35	22
2A-8D	51.20	72
8H-9G	51.18	400
8G-UPSET3	51.00	30
9D-12	50.96	50
8G-12	50.96	40
8G-16	50.93	90
8G-9H	50.92	128
2A-8E	40.10	90
8H-9H	40.09	100
9H-10A	40.09	272
9E-13	39.82	90
3A-10A	33.10	4120
6-10A	33.10	200
3B-10A	33.10	4120
7-10A	33.10	4580
2B-SLUG1	32.87	100
2B-SLUG2	32.87	500
5-10A	29.90	9400
4A-10A	29.90	17040
4B-10A	29.90	17040
2B-10A	20.60	14400
2A-10A	20.60	14805
10A-UPSET1	20.59	70
10A-UPSET5	20.59	30
10A-UPSET6	20.59	5
10A-UPSET2	20.59	95
1B-10A	20.59	1533
1B-10B	20.00	87710

- These are the surface stresses that govern crack initiation

- These stresses will generally have a steep radial gradient which will not grow cracks as rapidly as a uniform stress

- The relative amounts of uniform and radial gradient defined by procedures in NUREG/CR-6674, unless additional information allowed refinement (details in reference)

- The stresses in some cases were very large

- The calculation procedure employed depended on the degradation mechanism

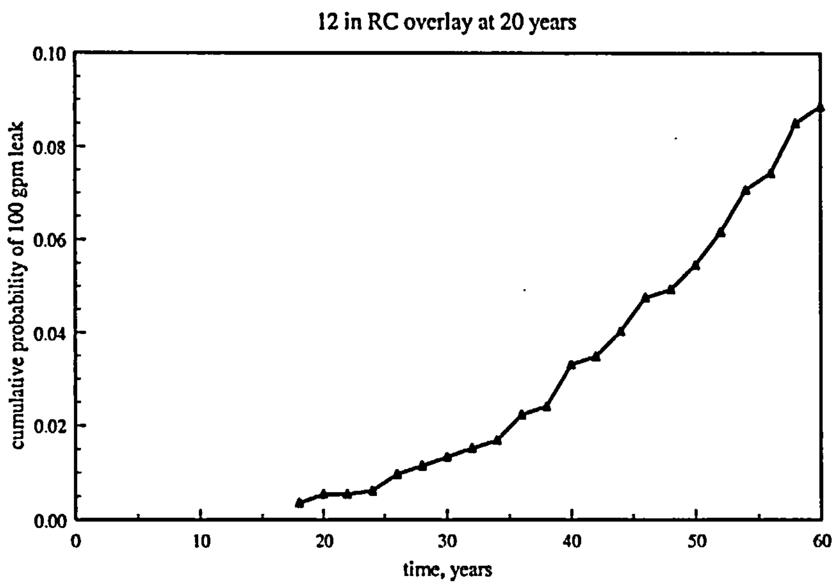
HL/PV	fatigue crack growth (PWSCC initiation & growth)	WinPRAISE (modified WinPRAISE)
surge line	fatigue initiation & growth	pcPRAISE & ad hoc
HPI	fatigue initiation & growth	pcPRAISE & ad hoc
recirc	SCC initiation & growth	WinPRAISE
feedwater	fatigue initiation & growth	pcPRAISE & ad hoc

  - WinPRAISE is a windows version of pcPRAISE that is much easier to use, and provides same result as pcPRAISE for the same problem analyzed in the same manner

- An ad hoc procedure was used with pcPRAISE in order to obtain results for larger flow rates with reasonable computer time (the stratified sampling that is available for fatigue crack growth is not available for initiation)
  - The ad hoc procedure uses pcPRAISE for Monte Carlo simulation of failures (through-wall crack), with the length of any through-wall crack and the time that it first becomes through-wall printed out
  - The statistical distribution of through-wall cracks within a given time is analyzed and extrapolated to crack lengths corresponding to a given flow rate (which is a standard result from pcPRAISE)

- These analyses provide the failure probability of the dominant joint (highest failure probability)

- The cumulative probability of flow exceeding a given rate is obtained as a function of time



- Times of 25 years (now), 40 and 60 years are concentrated upon

- The average LOCA frequency within a given time interval is computed from the cumulative results

$$p(t_2) = \frac{P(t_2) - P(t_1)}{t_2 - t_1}$$

- The system LOCA frequency is obtained by multiplying by the number of locations within the system that have the high stresses of the dominant location

- Sensitivity calculations performed for each component

- One case for each component selected for system

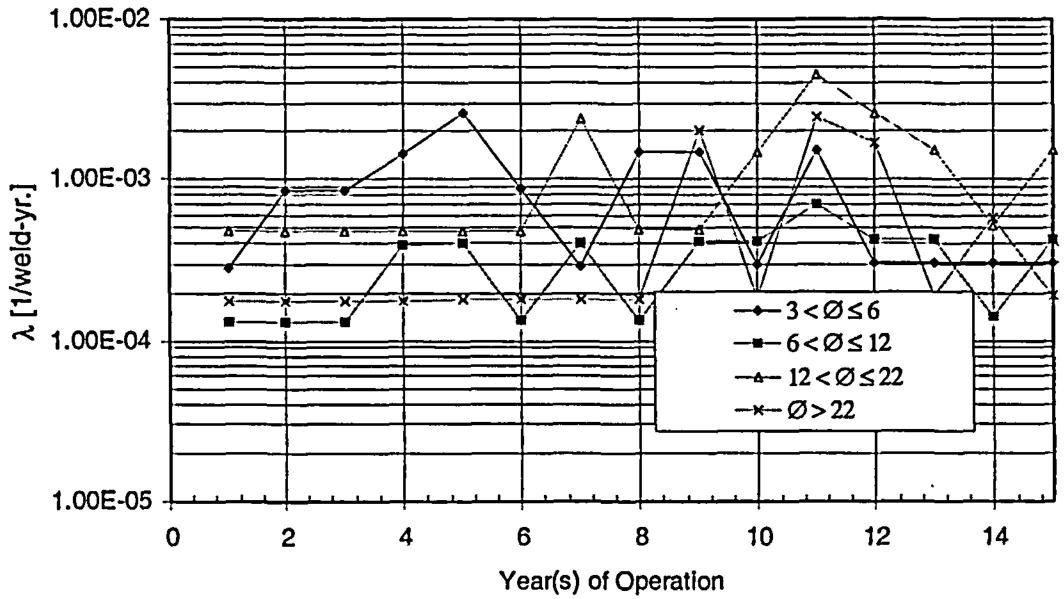
- Hot leg/pressure vessel joint dominant for large piping in main coolant piping (highest stresses and temp)

- Sensitivity studies for HL/PV
  - fatigue crack growth relation (ASME code vs original PRAISE)
  - design limiting stresses (seismic)
  - PWSCC (initiation and growth)
  - material aging (reduced toughness with time)
  - proof test

- PWSCC growth from initial defect with proof, no aging, residual stresses or seismic events selected as reference case

- Refined stresses used in surge line elbow analysis
- HPI/makeup nozzle analyzed with failed thermal sleeve (which has been observed in service), with immediate fatigue crack initiation and stresses as before.
- 12 inch recirculation line benchmarked with reported leaks and observations of cracks

- Leak observations in recirculation lines



from B. Lydell

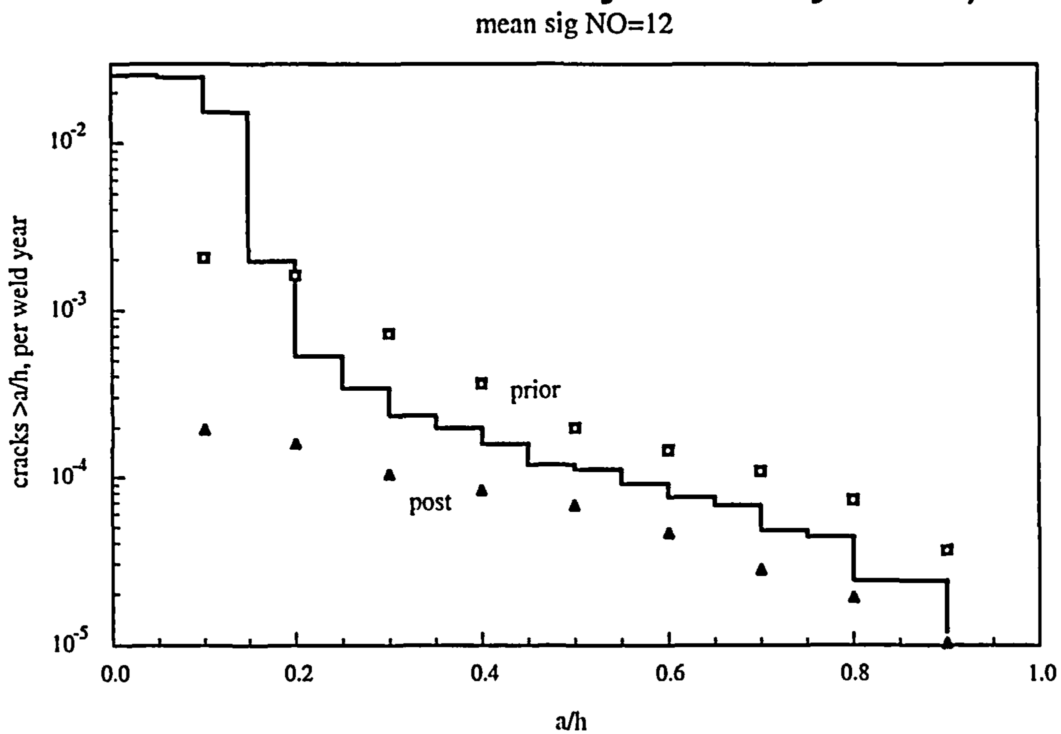
$10^{-4} - 10^{-3}$ per weld-year

- Results of PRAISE calculations

(12 in, leak frequencies, overlay at 20 years)

mean σ_{NO}	12	20
mean σ_{te}	5.32	13.32
cov	0.3	0
stdev of σ_{te}	1.6	0
	per weld joint	
0-25	$6.15x10^{-4}$	$1.19x10^{-2}$
25-40	$2.36x10^{-4}$	$5.57x10^{-3}$
40-60	$9.25x10^{-4}$	$2.19x10^{-3}$
no. dom. joints	49	2
no. in system	49	49
	system(x no. dom. joints)	
0-25	$3.01x10^{-2}$	$2.38x10^{-2}$
25-40	$1.16x10^{-2}$	$1.11x10^{-2}$
40-60	$4.53x10^{-3}$	$4.38x10^{-3}$
	ave per joint(÷49)	
0-25	$6.15x10^{-4}$	$4.86x10^{-4}$
25-40	$2.36x10^{-4}$	$2.24x10^{-4}$
40-60	$9.25x10^{-4}$	$8.94x10^{-5}$

- Similar results for dominant joints vs all joints
- Comparison of observed and predicted cracks (PRAISE results for overlay at 20 years)



PRAISE results – lines. B. Lydell prior and post for with and without overlay. (outstanding P_{ND})

- Feedwater elbow selected as dominant joint. FAC is expected dominant degradation mechanism, but no probabilistic model available

- Results of sensitivity studies and benchmarking provided to panel

- Reference case for each base case recommended and summary of results provided to panel

Summary of Results for Reference Systems (July 2003)

			hot leg	surge	HPI	recirculation 12	recirculation 28	feedwater
		OD, in	34	14	3.44	12.75	28	12.75
		h, in	2.5	1.406	0.4375	0.687	1.201	0.687
		A, in^2	661	98.3	5.167	102	515	102
		Q_{max}	423	63	3.6	38	193	38
		matl	cast SS	SS	SS	SS	SS	CS
		degr mech	PWSCC growth	fatigue init&gro	fatigue init&gro	SCC init&gro	SCC init&gro	fatigue init&gro
		σ	Table 1	refined	Table 4	Table 5	Table 5	Table 6
		case	base no EQ	no EQ, no DL		overlay		σ_{flo}
		insp	0,20,40	none	none	0,20,40	0,20,40	none
dominant joint freq	>0	0-25	--	--	$1.48x10^{-4}$	$1.19x10^{-2}$	$3.1x10^{-4}$	$<4x10^{-10}$
		25-40	--	$5.8x10^{-3}$	$5.94x10^{-4}$	$5.57x10^{-3}$	$2.6x10^{-4}$	$3.8x10^{-7}$
		40-60	--	$1.6x10^{-6}$	$8.60x10^{-4}$	$2.19x10^{-3}$	$2.2x10^{-4}$	$1.3x10^{-5}$
	>0.1	0-25	$1.33x10^{-8}$		$2.60x10^{-5}$	$5.71x10^{-3}$	$3.0x10^{-5}$	
		25-40	$1.33x10^{-8}$	10^{-32}	$1.35x10^{-4}$	$1.30x10^{-3}$	$1.0x10^{-5}$	[illegible]
		40-60	$1.33x10^{-8}$	$<5x10^{-9}$	$1.32x10^{-4}$	$3.55x10^{-4}$	$<5x10^{-7}$	[illegible]
	>1.5	0-25	$1.6x10^{-11}$		$2.60x10^{-5}$	$4.26x10^{-3}$	$2.7x10^{-6}$	
		25-40	$1.6x10^{-11}$	$4.4x10^{-74}$	$1.35x10^{-4}$	$1.23x10^{-3}$	--	[illegible]
		40-60	$1.6x10^{-11}$	$5.0x10^{-12}$	$1.32x10^{-4}$	$3.10x10^{-4}$	$3.0x10^{-6}$	[illegible]
	>5	0-25	$4.6x10^{-13}$			$3x10^{-3}$	$2.4x10^{-6}$	
		25-40	$4.6x10^{-13}$			$1.23x10^{-3}$	$5.8x10^{-7}$	[illegible]
		40-60	$4.6x10^{-13}$	$1.6x10^{-13}$		$3.10x10^{-4}$	$1.5x10^{-6}$	[illegible]
	>25	0-25	$4.6x10^{-13}$			$1.96x10^{-3}$	$1.6x10^{-6}$	
		25-40	$4.6x10^{-13}$			$1.23x10^{-3}$	$\sim2x10^{-6}$	[illegible]
		40-60	$4.6x10^{-13}$	$9.8x10^{-15}$		$3.10x10^{-4}$	$1.7x10^{-6}$	[illegible]
	>100 **	0-25	$3.6x10^{-14}$				$1.6x10^{-6}$	
		25-40	$3.6x10^{-14}$				$\sim2x10^{-6}$	
		40-60	$3.6x10^{-14}$				$1.7x10^{-6}$	
	field		22	3		20	22	29
	shop		12	9		20	30	22
	safe end		16	1		9	3	12
	dominant		3	2	3	2	2	4
system frequencies	>0	0-25	--	--	$4.44x10^{-4}$	$2.38x10^{-2}$		$<1.6x10^{-9}$
		25-40	--	$1.06x10^{-7}$	$1.78x10^{-3}$	$1.17x10^{-2}$		$1.5x10^{-6}$
		40-60	--	$3.2x10^{-6}$	$2.58x10^{-3}$	$4.82x10^{-3}$		$5.2x10^{-5}$
	>0.1	0-25	$4.0x10^{-8}$		$7.80x10^{-5}$	$1.15x10^{-2}$		
		25-40	$4.0x10^{-8}$	$2x10^{-32}$	$4.05x10^{-4}$	$2.62x10^{-3}$		[illegible]
		40-60	$4.0x10^{-8}$	$<10^{-8}$	$3.96x10^{-4}$	$7.10x10^{-4}$		[illegible]
	>1.5	0-25	$4.8x10^{-11}$		$7.80x10^{-5}$	$8.52x10^{-3}$		
		25-40	$4.8x10^{-11}$	$8.8x10^{-74}$	$4.05x10^{-4}$	$2.46x10^{-3}$		[illegible]
		40-60	$4.8x10^{-11}$	$1.0x10^{-11}$	$3.96x10^{-4}$	$6.20x10^{-3}$		[illegible]
	>5	0-25	$1.4x10^{-12}$			$6x10^{-3}$		
		25-40	$1.4x10^{-12}$			$2.46x10^{-3}$		[illegible]
		40-60	$1.4x10^{-12}$	$3.2x10^{-13}$		$6.20x10^{-4}$		[illegible]
	>25	0-25	$1.4x10^{-12}$			$3.92x10^{-3}$		
		25-40	$1.4x10^{-12}$			$2.46x10^{-3}$		[illegible]
		40-60	$1.4x10^{-12}$	$2.0x10^{-14}$		$6.20x10^{-4}$		[illegible]
	>100 **	0-25	$1.1x10^{-13}$			$3.2x10^{-6}$		
		25-40	$1.1x10^{-13}$			$4x10^{-6}$		
		40-60	$1.1x10^{-13}$			$3.7x10^{-6}$		

shaded areas are estimates based on alternative procedure
flow rates in thousands of gallons per minute
cross-hatched cells are beyond maximum leak capability for that pipe size
** also applicable to >500kgpm if hot leg is of sufficient diameter

Expert Elicitation in Support of Risk-Informing 10 CFR 50.46

Robert L. Tregoning
Lee Abramson
US Nuclear Regulatory Commission

David Harris
Engineering Mechanics Technology, Inc.

ACRS Subcommittee on Regulatory Policies and Practices
November 21, 2003

Meeting Agenda: Expert Elicitation Presentation

■ Overview	Tregoning, NRC
■ Expert Elicitation Process	Abramson, NRC
■ Technical Issue & Piping Base Case Development	Tregoning, NRC
■ Piping Base Case Development: One Approach	Harris, EMT Inc.
■ Base Case Summary, Elicitation Questions, & Status	Tregoning, NRC

Previous ACRS Briefings and Program Milestones Since Last Briefing

- Previous ACRS briefings
  - July, 2003: ACRS main committee on the status and approach of expert elicitation.
  - May, 2002: Combined M&M, THP, R&PRA Subcommittee briefing on interim LOCA frequency elicitation and LOCA break size redefinition plans.
  - June, July, November, 2001: Overviews of LOCA frequency and break size redefinition effort provided to outline its importance within 10 CFR 50.46 revision framework.
  - March, 2001: Technical issues necessitating LOCA reevaluation.
- Program milestones since Jan 2003
  - Conducted kick-off meeting: February.
  - SRM Issued on SECY-02-0057 (Option III plan for risk-informing 10 CFR 50.46, Appendix K and GDC-35): March.
  - Conducted base case review meeting: June.
  - Public Meetings to discuss 10 CFR 50.46 effort: February, June, July, September.
  - Participated in CSNI/CNRA-sponsored international workshop on LB LOCA redefinition: June.
  - Completed individual elicitations: October.

Expert Elicitation: Executive Summary

- Elicitation objective and approach are consistent with SRM guidance for development of near-term LOCA frequencies.
- Elicitation process will develop LOCA frequencies as a function of flow rate and operating time considering both piping and non-piping contributions.
- The conditional LOCA probabilities of larger, "emergency faulted" loadings are being estimated.
- Elicitation process combines aspects of group and individual elicitation approaches as appropriate to achieve objectives.
- Approach is based on quantitative base case frequency estimates. Elicitation responses are provided relative to the base case frequencies.
- Plans are in place to provide alternative estimates of the elicitation frequencies and to develop a methodology for continually assessing LOCA challenges.

Elicitation Scope and Objectives

- Develop piping and non-piping passive system LOCA frequencies as a function of flow rate and operating time up to the end of the license extension period.
- Estimate LOCA frequency distributions for generic plant operational cycle and history.
- Estimate conditional LOCA probability distributions for rare, emergency-faulted load conditions.
  - Seismic loading.
  - Other large, unexpected internal and external loads.

LOCA Frequency Reevaluation: General Approach

1. **Operating Experience Assessment**
2. **Expert Elicitation.**
   - Develop relationship between flow rate/break size and LOCA frequency.
   - Provide input to probabilistic LOCA computer code development.
3. **Probabilistic LOCA Code Development**
   - More rigorously combine operating experience and PFM insights.
   - Explicitly consider contributions from piping and non-piping components, and the evolution of new degradation mechanisms.
4. **Continuous LOCA Assessment.**
   - Develop and maintain LOCA precursor database through expansion of existing pipe failure database.
   - Identify emerging degradation mechanisms and conduct anticipatory research to assess LOCA significance.

EXPERT ELICITATION PROCESS

LEE ABRAMSON
OFFICE OF NUCLEAR REGULATORY RESEARCH
U. S. NUCLEAR REGULATORY COMMISSION

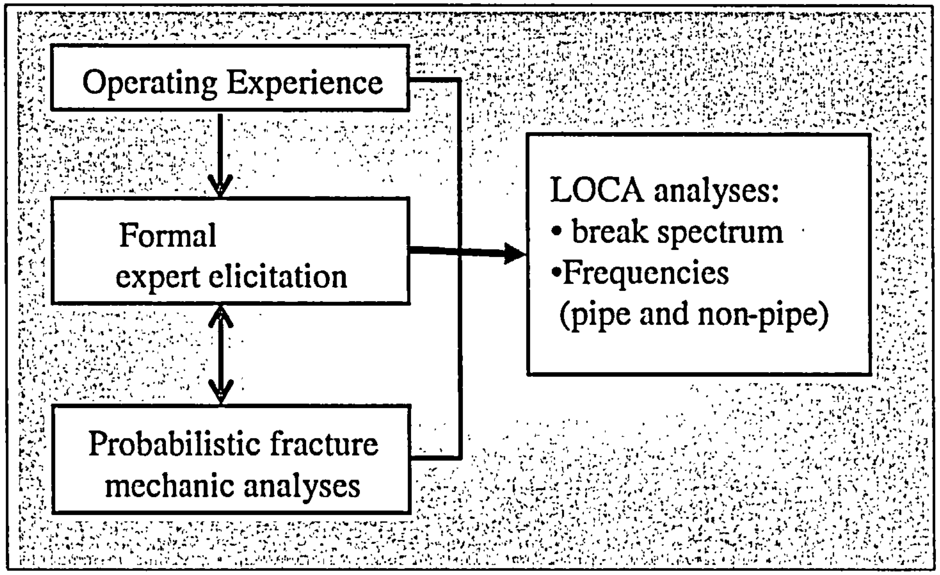
ACRS SUBCOMMITTEE ON REGULATORY POLICIES AND PRACTICES

ROCKVILLE, MARYLAND

NOVEMBER 21, 2003

LB-LOCA Frequency Reevaluation

"The staff should conduct ... expert elicitation to converge the results"



Formal Elicitation Approach

- **Conduct preliminary elicitation**
- Select panel and facilitation team.
- Develop technical issues.
  - Construct approach for estimating LOCA frequencies.
  - Determine significant issues affecting LOCA frequencies.
- Quantify base case frequencies.
  - Develop estimates for well-defined piping conditions.
  - Two estimates used PFM analysis and two estimates used operating experience analysis.
- Formulate elicitation questions.
- Conduct individual elicitations.
- Analyze quantitative results and qualitative rationale.
- Summarize and document results.

Preliminary Elicitation

- Conducted last year using 11 internal (NRC) experts with broad knowledge.
- Discussed during May 2002 ACRS meeting on 10 CFR 50.46 revision status.
- Provided interim LOCA frequency results for use in 10 CFR 50.46 re-evaluation effort.
- Developed possible framework for subsequent elicitation and identified strengths and weaknesses to address in formal elicitation.
- Identified some technical issues for consideration within formal elicitation.
- Results predicted a modest increase (factor of 2) in NUREG/CR-5750 LOCA estimates for internal events.

Formal Elicitation Approach

- Conduct preliminary elicitation
- Select panel and facilitation team.
- **Develop technical issues.**
  - **Construct approach for estimating LOCA frequencies.**
  - **Determine significant issues affecting LOCA frequencies.**
- Quantify base case frequencies.
  - Develop estimates for well-defined piping conditions.
  - Two estimates used PFM analysis and two estimates used operating experience analysis.
- Formulate elicitation questions.
- Conduct individual elicitations.
- Analyze quantitative results and qualitative rationale.
- Summarize and document results.

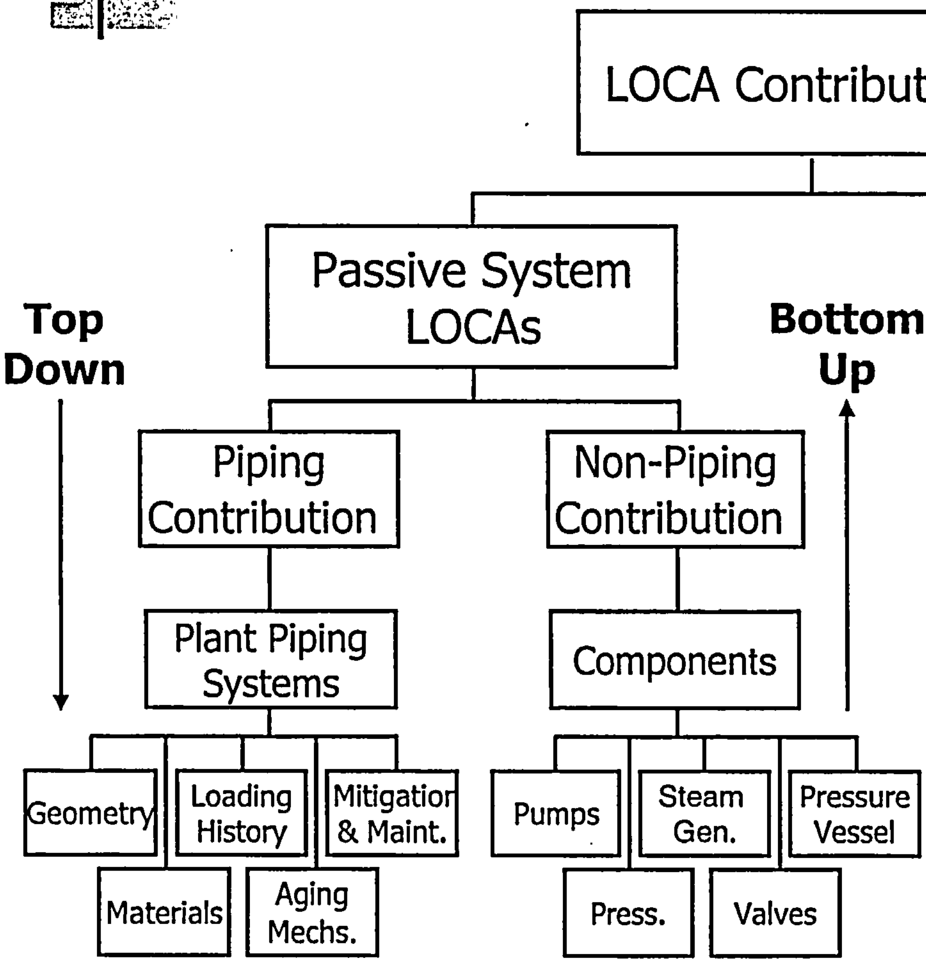
LOCA Sizes and Operating Time Periods Evaluated

- LOCA sizes based on flow rate required for mitigating system equipment.
- First three categories encompassed traditional definitions utilized in NUREG-1150 and NUREG/CR-5750.
- Three more LBLOCA categories added to evaluate larger break sizes.
- Correlation between leak rate and break size developed for relevant BWR and PWR systems.

Category	Flow Rate Threshold (gpm)	LOCA Size
1	> 100	SB
2	> 1500	MB
3	> 5000	LB
4	> 25,000	LB a
5	> 100,000	LB b
6	> 500,000	LB c

- Three time periods evaluated.
  - Current (industry average of 25 years of operation).
  - End of design life (40 years of operation).
  - End of life extension (60 years of operation).

General Issue Structure



- Elicitation focuses on passive system LOCAs.
- Important piping and non-piping variables identified.
- Elicitation questionnaire supports top down and bottom up analysis.
- Relevant active system LOCAs will be included.

Piping Issue Classification

- Panel brainstormed variable categories which influence the LOCA frequencies: materials, geometry, loading, mitigation & maintenance, degradation mechanisms.
- Panel determined that variable categories and their effects are a function of the piping system.
- Panel developed applicable inputs for each variable category.
- Panel determined LOCA sensitive piping systems for BWR and PWR plants.
- Panel determined the individual variables that were relevant for each piping system considering existing plant variability.
- Panel developed master tables for BWR and PWR plants.

Piping Issue Classification

Loading Categories

Main Category	Sub-Category 1	Sub-Category 2	Sub-Category 3	Sub-Category 4	Sub-Category 5
Thermal	Differential Expansion	Restrained Expansion	Radial Gradient	Stratification	Cycling & Striping
Water Hammer	Steam Hammer				
Seismic	Inertial	Displacement			
Pressure	Normal	Transients			
Residual Stress	Design	Repair welds	Fabrication	Mitigation-Induced, eg. Weld overlay	
Dead Weight Loading					
SRV Loading					
Overload (Ext. and Int.)	Pipe Whip	Jet Impingement	Deflagration	External Weight Drops	
Support	Snubber malfunction	Hanger Misadjust.			
Vibration	Mechanical	Cavitation			

- Example classification table for loading variable.

Piping Issue Classification

- LOCA sensitive piping systems for BWR and PWR plants.
- Geometry, materials, degradation mechanisms, loading, and mitigation procedures applicable for each piping system.
- Master table for BWR & PWR plants for use during the elicitation process.

BWR: LOCA Sensitive Piping Systems

System	Piping Matls.	Piping Size (in)	Safe End Matls.	Welds	Sig. Degrad. Mechs.	Sig. Loads.	Mitigation /Maint.
RECIRC	304 SS, 316 SS, 347 SS	4, 10, 12, 20, 22, 28	304 SS, 316 SS, A600*	SS, NB	UA, FDR, SCC, LC, MA	RS, P, S, T, DW, SUP, SRV, O	ISI w TSL, REM
Feed Water	CS	10, 12 (typ), 12 - 24	304 SS, 316 SS*	CS, NB	UA, FDR, MF, TF, FS, LC, GC, MA	T, TFL, WH,P, S, SRV, RS, DW, O	ISI w TSL, REM
Steam Line	CS – SW	18, 24, 28	CS	CS	UA, FDR, FS, GC, LC, MA	WH, P, S, T, RS, DW, SRV, O	ISI w TSL, REM
HPCS, LPCI	CS (bulk), 304 SS, 316 SS	10, 12	304 SS, 316 SS, A600*	CS, SS, NB	UA, FDR, SCC, TF, LC, GC, MA	RS, T, P, S, DW, TS, WH, SUP, SRV, O	ISI w TSL, REM
RHR	CS, 304 SS, 316 SS	8 - 24	CS, 304 SS, 316 SS	CS, SS, NB	UA, FDR, SCC, TF, FS, LC, GC, MA	RS, T, P, S, DW, TS, O SUP, SRV	ISI w TSL, REM
RWCU	304 SS, 316 SS, CS	8 – 24	CS, 304 SS, 316 SS	CS, SS, NB	UA, FDR, SCC, TF, FS, LC, GC, MA	RS, TS, T, P, S, DW, SUP, SRV, O	ISI w TSL, REM
CRD piping	304 SS, 316 SS (low temp)	< 4	Stub tubes – A600 and SS*	Crevice A182 to head	UA, FDR, MF, SCC	RS, T, P, S, DW, V, O, SRV	ISI w TSL, REM
SLC	304 SS, 316 SS	< 4	304 SS, 316 SS	SS, NB	UA, FDR, MF, SCC	RS, T, P, S, DW, V, O, SRV	ISI w TSL, REM
INST	304 SS, 316 SS	< 4	304 SS, 316 SS	SS, NB	UA, FDR, MF, SCC, MA	RS, T, P, S, DW, V, O, SRV	ISI w TSL, REM
Drain lines	304 SS, 316 SS, CS	< 4	304 SS, 316 SS, CS	SS, NB	UA, FDR, MF, SCC, LC, GC	RS, T, P, S, DW, V, O, SRV	ISI w TSL, REM
Head spray	304 SS, 316 SS, CS	< 4	304 SS, 316 SS, CS	SS, NB	UA, FDR, SCC, TF, LC, GC	RS, P, S, T, DW, SRV, O	ISI w TSL, REM
SRV lines	CS	6, 8, 10, 28	CS	CS	UA, FDR, MF, FS, GC, LC, MA	RS, P, S, T, DW, SRV, O	ISI w TSL, REM
RCIC	304 SS, 316 SS, CS	6, 8	304 SS, 316 SS	SS NB	UA, FDR, SCC, LC, MA	RS, P, S, T, DW, SRV, O	ISI w TSL, REM

Non-Piping Issue Classification

- Panel identified approximately 25 different locations within primary components (i.e. pressurizer, reactor, steam generator, pumps, valves) where passive system failures could lead to a LOCA.
- Panel characterized failure mechanisms which could lead to LOCAs in these components.
- Panel identified components with possible existing failure data.
- Panel developed inputs for each of the five variable categories that were relevant for each non-piping system.
- Panel developed master tables for non-piping LOCA contributors for use during the elicitation.

Non-Piping Issue Classification

Pressurizer Failure Mechanisms

Failure Mechanism	Geometry	Material	Degradation Mechanisms	Loading	Mitigation/ Maintenance	Comment
Shell		A600C-LAS, SSC-LAS	GC, SCC, MF, FDR, UA			Boric acid wastage from OD
Manway		NB-LAS, SSC-LAS, LAS, HS-LAS (Bolts)	GC, SCC, MF, SR, FDR, UA			Bolt failures
Heater Sleeves	Small diam. (3/4 to 1 in)	A600, SS	TF, MF, SCC, FDR, UA			Req. multiple failures
Bolted relief valves		C-SS	MA, FDR, UA			
Nozzles		SSC-LAS C-SS	CD, TF, SCC, MA, FDR, UA, GC			Same as surge line

- Example of relevant failure mechanisms for pressurizer.
- Values for five variable categories included as appropriate.

Formal Elicitation Approach

- Conduct preliminary elicitation
- Select panel and facilitation team.
- Develop technical issues.
  - Construct approach for determining LOCA frequencies.
  - Determine significant issues affecting LOCA frequencies.
- **Quantify base case frequencies.**
  - **Develop estimates for well-defined piping conditions.**
  - **Two estimates used PFM analysis and two estimates used operating experience analysis.**
- Formulate elicitation questions.
- Conduct individual elicitations.
- Analyze quantitative results and qualitative rationale.
- Summarize and document results.

Piping Base Case Development

- The base cases anchor the elicitation responses.
- Base case conditions specify the piping system, piping size, material, loading, degradation mechanism(s), and mitigation procedures.
- Five Base Cases Defined.
  - BWR
    - Recirculation System (BWR-1)
    - Feedwater System (BWR-2)
  - PWR
    - Hot Leg (PWR-1)
    - Surge Line (PWR-2)
    - High Pressure Injection makeup (PWR-3)
- The LOCA frequency for each base case condition is calculated as a function of flow rate and operating time.
- Four panel members individually estimated frequencies: two using operating experience and two using probabilistic fracture mechanics.

Piping Base Case Approach

- Iterative process involved facilitation team and expert panel.
- Evaluated LOCA frequencies at 25 (current), 40 (end-of-license), and 60 years (end-of-license extension) after plant startup.
- Each base case participant attempted to benchmark results using service experience for leaking cracks.
- All base case calculations attempted to capture as closely as possible the conditions established by the expert panel.
- Sensitivity analyses of PFM results conducted to evaluate:
  - Effect of seismic loading
  - Effect of ISI
  - Loading history variability
  - Effectiveness of mitigation

Piping Base Case Conditions: Summary Table

Plant Type	System	Piping Size	Piping Material	Safe End Material	Weld Material	Degradation Mechanism	Loading	Mitigation/ Maint.
BWR-1	RECIRC	12 – 28	Original 304 SS	Non creviced A600	NB	IGSCC	Nominal Service Loading	NWC, leak detection, ISI (88-01), Stress improvement
BWR-2	Feed water	12	CS			FAC, TF	Nominal Service Loading	NWC, leak detection, ISI (88-01)
PWR-1	RCP – Hot Leg	30	304 SS	A600	NB	TF, PWSCC	Nominal Service Loading	ISI, leak detection
PWR-2	Surge Line	10	304 SS	A600	NB at Pressurizer	TF, PWSCC	Nominal Service Loading	ISI, leak detection
PWR-3	SIS: DVI HPI/makeup	4	SS/CS			TF	Nominal Service Loading	ISI, leak detection

Piping Base Case Summary Results: Leak Frequency Results (per Reactor year)

Base Case	Expert A	Expert B	Expert C	Expert D
BWR-1	NA	5.8 E-03	1.3 E-02	NA
BWR-2	NA	1.5 E-03	< 1.6 E-09	NA
PWR-1	NA	4.0 E-04	1.1 E-01	NA
PWR-2	NA	1.6 E-05	<1.1 E-07	NA
PWR-3	NA	1.4 E-03	3.7 E-04	NA

- Leak frequencies for average of 25 years of service.
- Expert B's results represent the service history experience for the base case systems and degradation mechanisms. These calculations are not trivial.
- Expert C's results require no additional benchmarking for BWR-1, PWR-1, and PWR-3 base cases.
- Sensitivity analyses evaluated to examine effect of benchmarking Expert C's BWR-2 and PWR-2 base case leak rates to the service history.

Estimation of LOCA Frequencies for Expert Panel by Use of Probabilistic Mechanics Models

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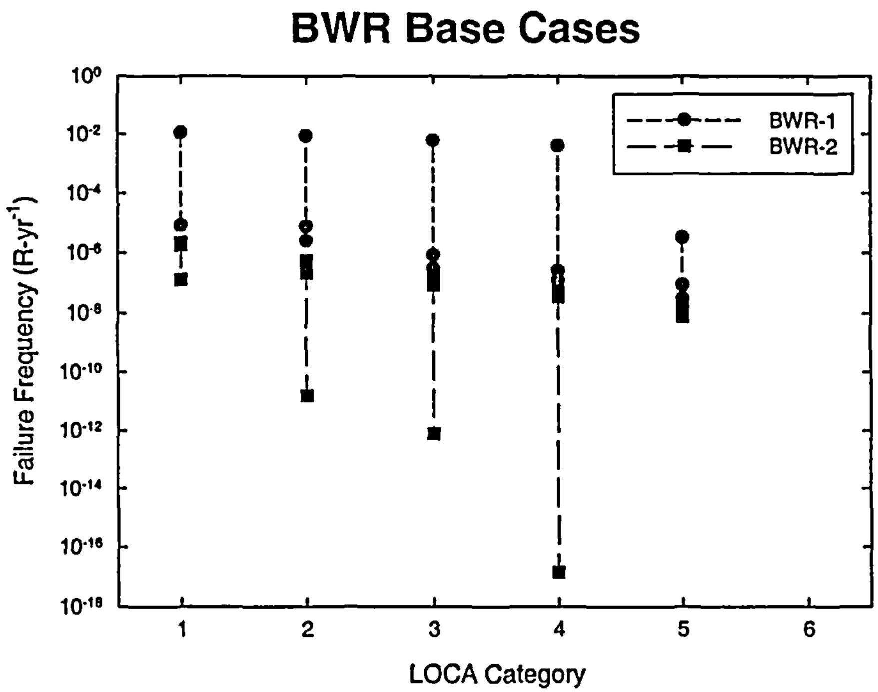
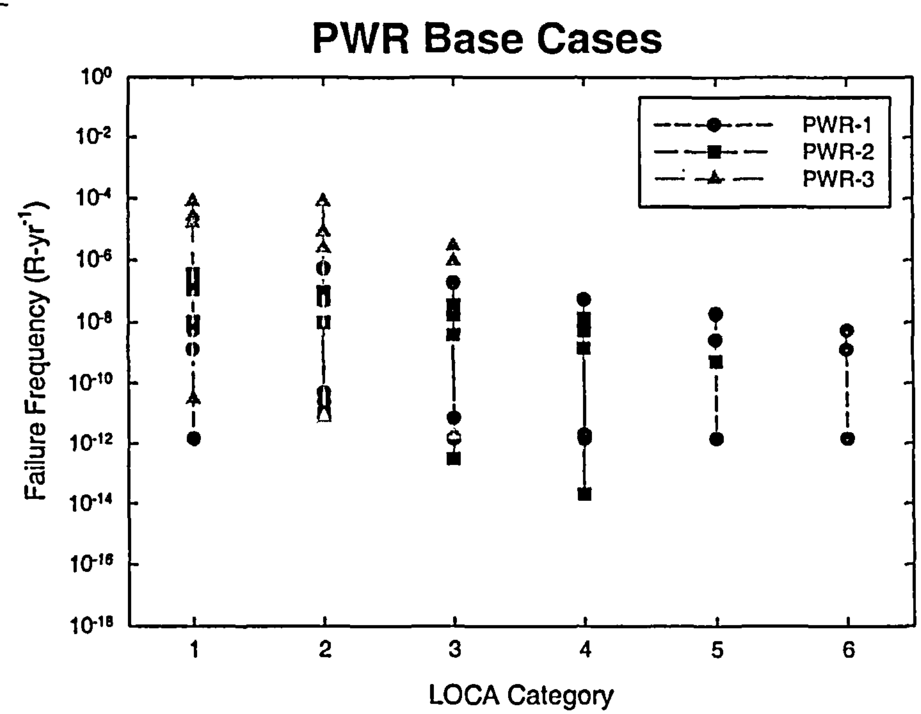
ROCKVILLE, MARYLAND

NOVEMBER 21, 2003

Piping Base Case Summary Results: 25 Year Operating Period





- Large variability due to inconsistencies in both the conditions evaluated and differences in approaches.
- Each base case participant presented their approach and results to entire panel.
- Each panel member was asked to critique approaches & results during their elicitation session.

Non-Piping Base Case Development

- The non-piping base cases could have been developed in a similar manner to the piping base cases.
  - Choose several representative systems.
  - Examine and extrapolate operating experience through modeling
- However, the variety and complexity of the non-piping failure mechanisms makes this assessment intractable.
- Approach adopted conducts database searches for each non-piping failure mechanism identified to estimate component leak and crack frequencies.
- These frequencies are used to anchor the non-piping responses for each expert.
- Each expert determines the relationship between leak and crack frequencies and LOCA frequencies.

Non-Piping Base Case Approach

- Searched LER database for precursor events in relevant PWR and BWR components.
  - Events are leaks, through-wall cracks, and partial through-wall cracks.
  - Broad search initially conducted back to 1990.
  - Events screened to ensure relevance to LOCA-sensitive components.
- The partial through-wall crack information is not complete.
  - Variable interpretation of LER reporting requirements for serious degradation.
  - Lack of detection during ISI.
- MS ACCESS database of events was linked to LERs and available to the panel.
- Other databases are being used to develop separate frequency estimates for steam generator tube and control rod drive mechanism cracking.

Non-Piping Base Case Summary Results

Event Summary

- Function of subcomponent failure.
- Function of flaw type (leak, etc.)
- Failures as a function of calendar year also determined.

Event Summary by Degradation Mechanism

Plant Type	Component		Degradation Mechanism (see legend)							
			MA	FDR	SCC	LC	MF	TF	FS	UNK
BWR	RPV	10		1	9					
		100%	0%	10%	90%	0%	0%	0%	0%	0%
	Valve	1					1			
		100%	0%	0%	0%	0%	100%	0%	0%	0%
	Pump	2		2						
		100%	0%	100%	0%	0%	0%	0%	0%	0%
	Totals	13	0	3	9	0	1	0	0	0
	Adjusted*	17	0.5	3.5	9.5	0.5	1.5	0.5	0.5	0.5
		100%	3%	21%	56%	3%	9%	3%	3%	3%
			MA	FDR	SCC	LC	MF	TF	FS	UNK
PWR	Pzr	28	1	3	23	1				
		100%	4%	11%	82%	4%	0%	0%	0%	0%
	RPV	42		5	27	5				5
		100%	0%	12%	64%	12%	0%	0%	0%	12%
	Valve	3	1		1	1				
		100%	33%	0%	33%	33%	0%	0%	0%	0%
	SG	124	2	29	85				3	5
		100%	2%	23%	69%	0%	0%	0%	2%	4%
	Pump	2		2						
		100%	0%	100%	0%	0%	0%	0%	0%	0%
	Instr nozzles	4			4					
		100%	0%	0%	100%	0%	0%	0%	0%	0%
	Totals	203	4	39	140	7	0	0	3	10
	Adjusted*	207	4.5	39.5	140.5	7.5	0.5	0.5	3.5	10.5
		100%	2%	19%	68%	4%	0%	0%	2%	5%

Formal Elicitation Approach

- Conduct preliminary elicitation
- Select panel and facilitation team.
- Develop technical issues.
  - Construct approach for determining LOCA frequencies.
  - Determine significant issues affecting LOCA frequencies.

Quantify base case frequencies.
  - Develop estimates for well-defined piping conditions.
  - Two estimates used PFM analysis and two estimates used service history analysis.
- **Formulate elicitation questions.**
- Conduct individual elicitations.
- Analyze quantitative results and qualitative rationale.
- Summarize and document results.

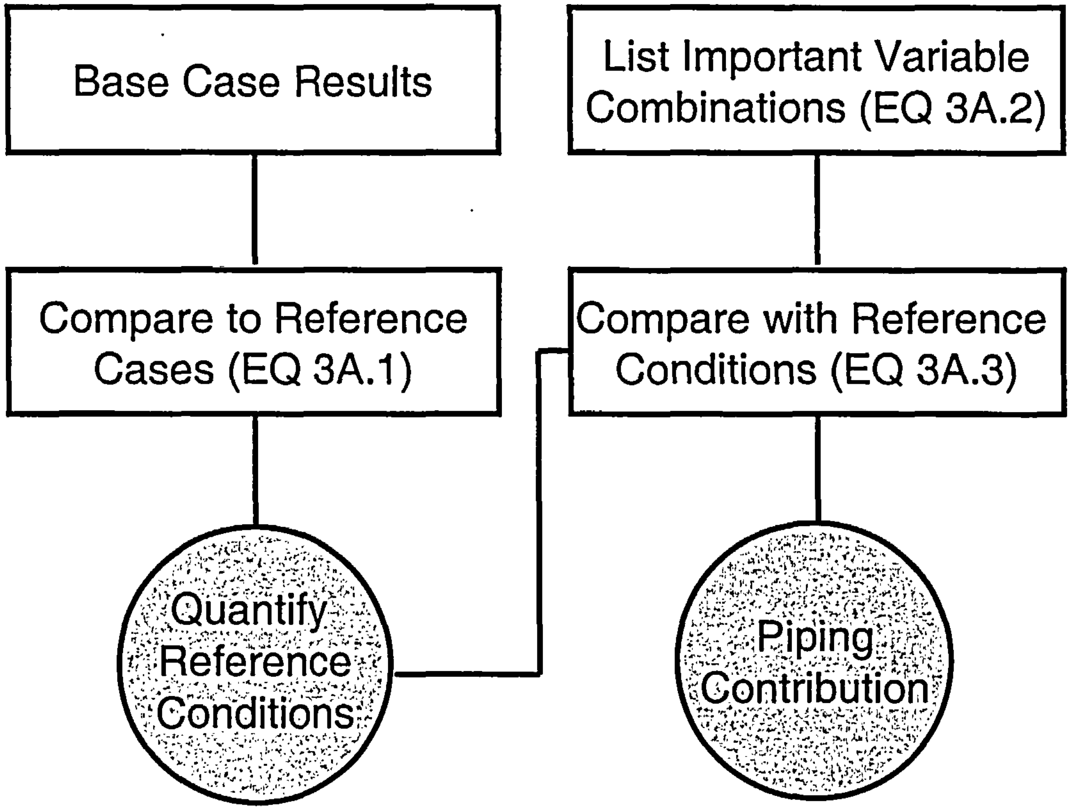
Elicitation Question Development

- Questions focus on the following topic areas.
  - Base Case Evaluation.
  - Regulatory and Utility Safety Culture pertaining to LOCA frequencies.
  - LOCA frequencies of Piping Components.
  - LOCA frequencies of Non-Piping Components.
  - Conditional piping failure under Emergency Faulted Loading.
  - Conditional non-piping failure under Emergency Faulted Loading.
- Questions are asked relative to a set of conditions and quantitatively linked to the base case results.
- Each question asks for mid, low, and high values as well as appropriate rationale or comments.
- Questions can be answered using a top-down or bottom-up approach.
- Possible inconsistencies between answers and rationales discussed for important technical issues.

Elicitation Questions: Safety Culture

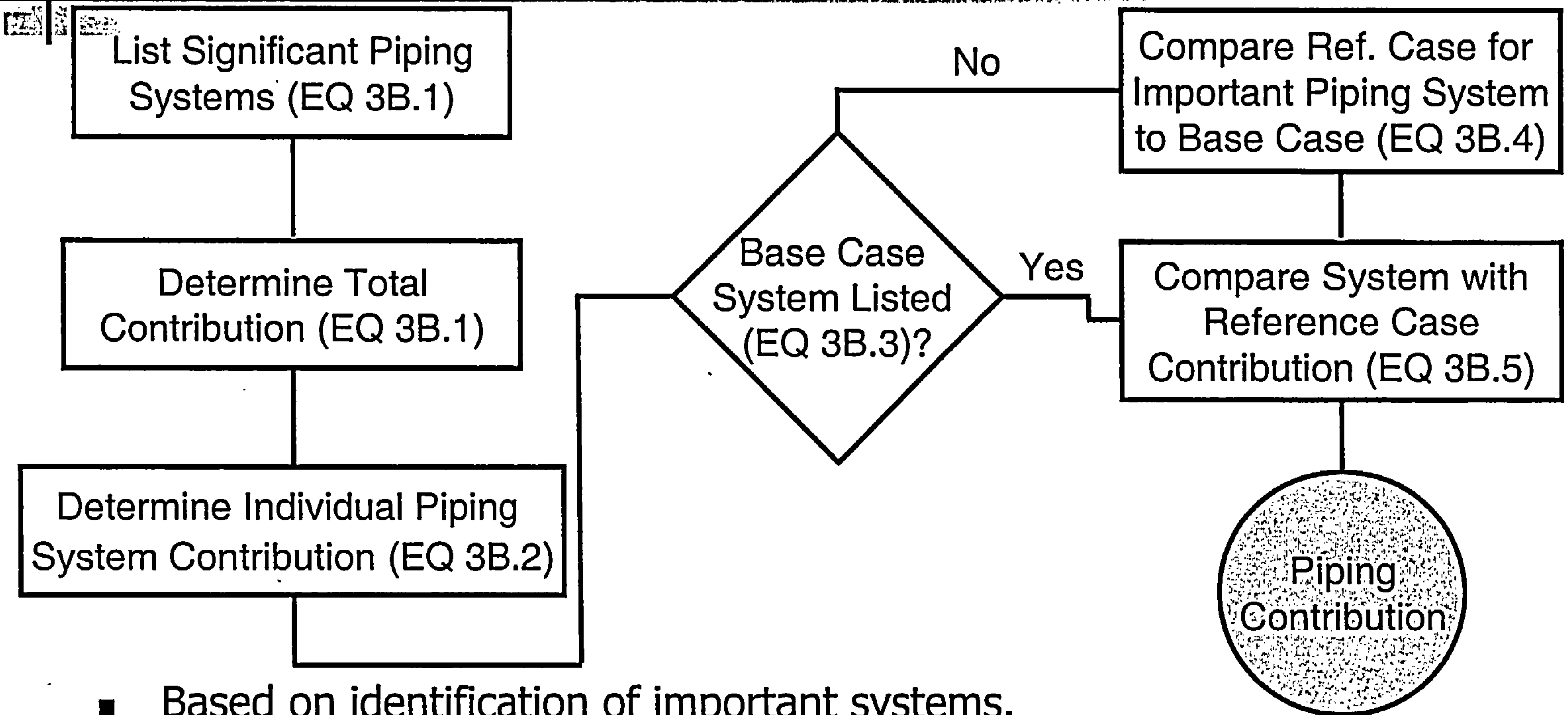
- **EQ 2: Safety Culture**
  - Consider the current utility safety culture that exists after approximately 25 years (current day) of plant operation and how it influences Category 1 LOCAs. Express the relative change, or ratio, in the utility safety culture's effect on LOCA frequencies after 15 additional years (40 years of operation) compared to its current day effect. Next, express the ratio of the utility safety culture's effect on LOCA frequencies ratio in 35 years (60 years of plant operation) to its current day effect. Include the 90% coverage interval for all estimates.
  - Repeat 2A.1 but now considering the effect of the regulatory safety culture on LOCA frequencies.
  - If you believe that safety culture effects are a function of leak rate category, repeat 2A.1 and 2A.2 for Category 2 through Category 6 LOCA frequencies.
  - Do you believe that the utility safety culture and regulatory safety culture are correlated? If so, is the correlation high, medium, or low?

Piping Components: Bottom-Up Approach (EQ 3A)



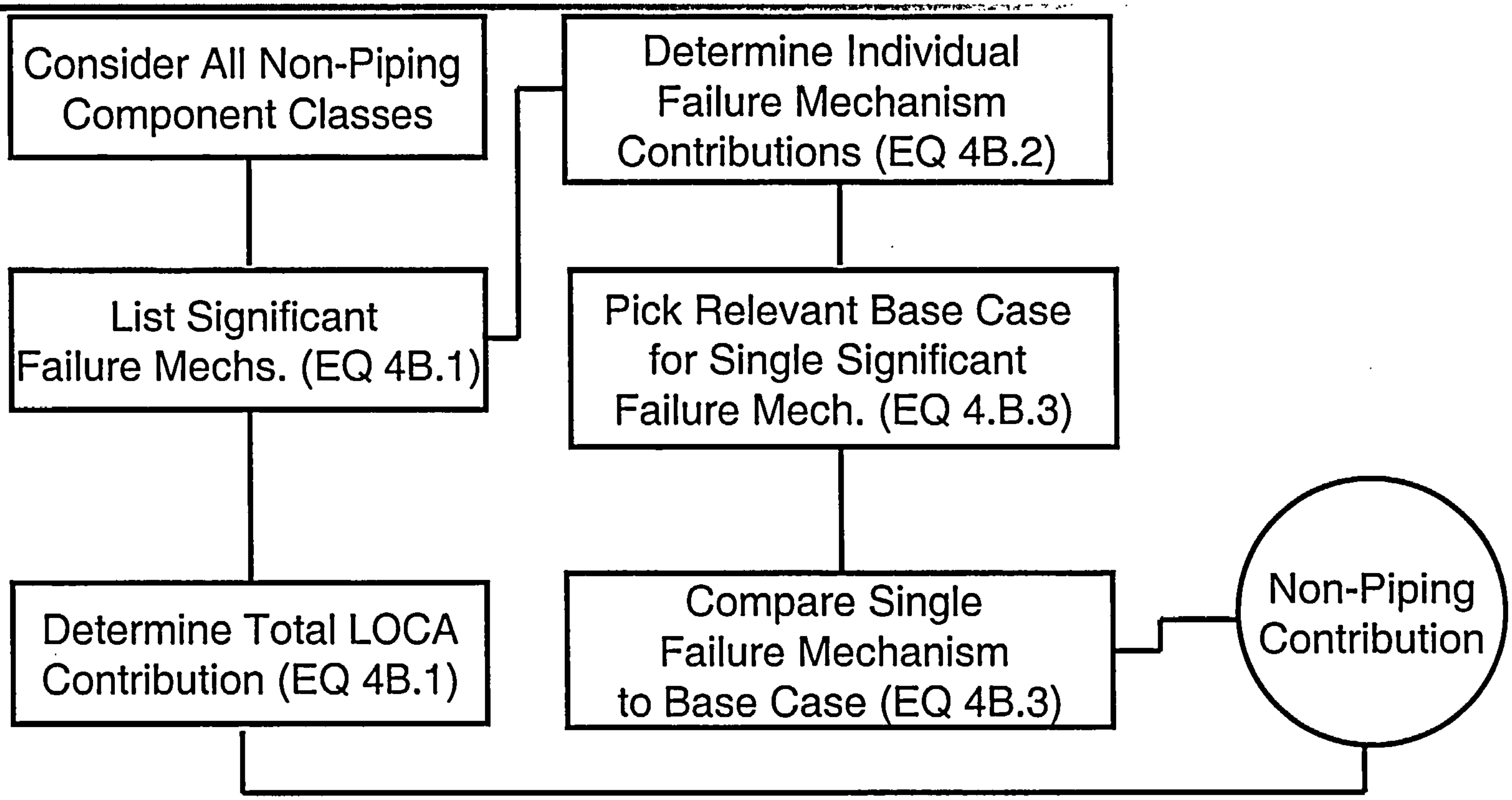
- Requires assessment of all significant variable combinations for each piping system.
- Contribution of significant variable combinations are added.
- All system contributions are then summed to determine the LOCA frequency.

Piping Components: Top-Down Approach (EQ 3B)



- Based on identification of important systems.
- Only relates one system to the base case results.
- Must still determine base case contribution to the total system performance.

Non-Piping Components: Top-Down Approach (EQ 4B)



- Considers independent failure mechanism contributions regardless of component type.
- Only comparison of a single failure mechanism to base case results is required.

Conditional LOCAs Due to Emergency Faulted Loading

$$f_{EFL} = \sum_i f_{Si} P_{L|Si}$$

where

f_{EFL} = frequency of emergency faulted LOCA

f_{Si} = frequency of stress with magnitude i

$P_{L|Si}$ = Conditional failure probability given S_i

$$f_{Si} = \sum_j f_{ej} g_{pj}$$

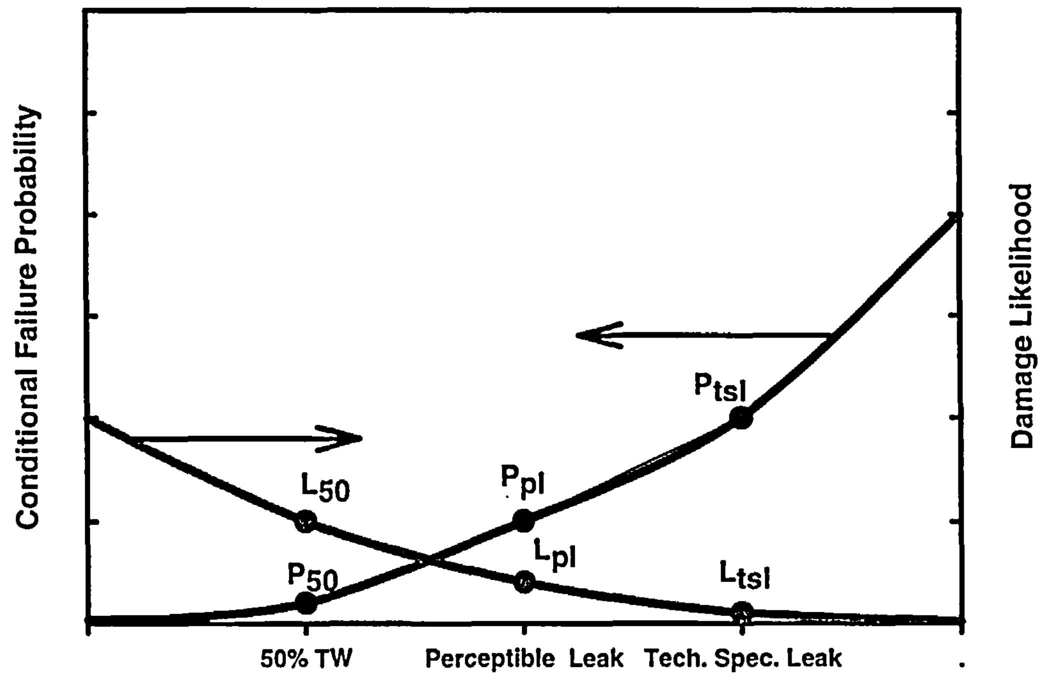
f_{ej} = frequency of event j

g_{pj} = plant response characteristics for event j

- Plant Specific Estimation: (f_{Si})
  - Determine event frequencies
  - Determine component stress distribution for each event
- Generic Estimation: ($P_{L|Si}$)
  - Elicitation question.

Conditional LOCAs Due to Emergency Faulted Loading

- Elicitation requirements.
  - Determine systems/components most susceptible to LOCAs for a prescribed stress amplitude (Cat. B & D loading).
  - Determine most likely failure mechanisms.
  - For each system and failure mechanism develop relative ratios between damage states
- Emergency faulted base case developed for P_{tsl} assuming idealized damage.
- Damage likelihood referenced to likelihood of perceptible leak using operating experience data.



$$P_{L|Si} = \sum_k L_{Dk} P_{L|Dk}$$

Ongoing and Future Elicitation Work

- Complete individual elicitations.
  - Initial interviews finished.
  - Most panel members have submitted updated responses.
  - Adequacy of updated responses needs to be determined.
- Analyze quantitative results and summarize rationales.
  - Calculate results for each expert if appropriate.
  - Combine answers for individual questions and calculate results.
  - Characterize uncertainties.
- Conduct wrap-up meeting.
  - Summarize quantitative and qualitative results.
  - Summarize analysis methodology and LOCA results.
  - Obtain feedback from the expert panel.
- Document results.

Summary

- NRC is using expert elicitation process to estimate LOCA frequencies as a function of break size.
- Elicitation process will develop LOCA frequencies as a function of flow rate and operating time considering both piping and non-piping contributions.
- The conditional LOCA probabilities of larger, "emergency faulted" loadings are being estimated.
- Elicitation process is designed to capture uncertainties expressed by wide-ranging technical opinions for a complex topic area where the underlying data is sparse.
- The process has developed quantitative estimates for base cases which are simplified conditions used to anchor subsequent elicitation responses. The base cases are extrapolations of operating experience.
- Experts determine relevant issues/parameters which govern LOCA frequencies and provide the relationships between these issues/parameters and the base cases.

EXPERT ELICITATION PROCESS

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NOVEMBER 21, 2003

FORMAL USE OF EXPERT JUDGMENT

- **APPLICATIONS**
  - SCENARIO DEVELOPMENT
  - MODEL DEVELOPMENT
  - DISTRIBUTION ESTIMATION
  - PARAMETER ESTIMATION

- **PREDETERMINED STRUCTURE**
  - COLLECTION
  - PROCESSING
  - DOCUMENTATION

- **INDICATORS FOR USE**
  - LACK OF DATA
  - COMPLEX ISSUES
  - EXTENSIVE REVIEW EXPECTED

FORMAL VS. INFORMAL USE

- ADVANTAGES
  - IMPROVED ACCURACY AND CREDIBILITY
  - REDUCED LIKELIHOOD OF BIAS
  - ENHANCED CONSISTENCY
  - IMPROVED SCRUTABILITY AND DOCUMENTATION

- DRAWBACKS
  - INCREASED TIME AND RESOURCES
  - REDUCED FLEXIBILITY
  - ENHANCED VULNERABILITY TO CRITICISM

- USE EXPERIENCED PRACTIONERS
  - SAVE TIME AND RESOURCES
  - AVOID POTENTIAL PITFALLS

ELICITATION OF LOCA FREQUENCIES

- DELAY QUANTITATIVE ASSESSMENTS UNTIL AFTER PANEL DISCUSSIONS AND ISSUE ANALYSES

- DEVELOP BASE CASES

- ALL QUANTITIES RELATIVE TO BASE CASES OR OTHER QUANTITIES

- QUANTITATIVE ASSESSMENT

  X = Quantity to be assessed

  X_M = Mid value
  X_L = Low value
  X_H = High value

  Chance $\{ X < X_M \} \approx$ Chance $\{ X > X_M \} \approx 50\%$
  Chance $\{ X < X_L \} \approx 5\%$
  Chance $\{ X > X_H \} \approx 5\%$

  (X_L , X_H) is an approximate 90% coverage interval for X

EXPERT ELICITATION PROCESS

1. **SELECTION OF EXPERT PANEL**
   - FULL RANGE OF DISCIPLINES
   - VARIETY OF APPROACHES

2. **TECHNICAL BACKGROUND DEVELOPMENT**
   - PROJECT STAFF
   - INDIVIDUAL PANEL MEMBERS
   - FILL IN KNOWLEDGE GAPS AND AUGMENT INDIVIDUAL EXPERTISE

3. **FORMULATION OF ISSUES**
   - PROJECT STAFF
   - INITIAL DECOMPOSITIONS

EXPERT ELICITATION PROCESS (CONT'D)

4. **PANEL DISCUSSIONS**
   - FINAL FORMULATION AND DECOMPOSITIONS
   - ELICITATION QUESTIONS

5. **ELICITATION TRAINING**
   - IDENTIFY BIASES
   - ELICITATION EXERCISES

6. **ELICITATION QUESTIONNAIRE**
   - MANY ITERATIONS BETWEEN PROJECT STAFF AND EXPERT PANEL

7. **TWO PILOT ELICITATION SESSIONS**
   - REVISED QUESTIONNAIRE
   - NEW APPROACH TO EMERGENCY FAULTED LOADING

EXPERT ELICITATION PROCESS (CONT'D)

8. TWELVE INDIVIDUAL ELICITATION SESSIONS
   - PREPARATION BY EXPERT
     - ➢ COMPLETE QUESTIONNAIRE
     - ➢ STATE RATIONALES
   - ELICITATION TEAM
     - ➢ NORMATIVE EXPERT
     - ➢ SUBSTANTIVE EXPERT
     - ➢ RECORDER
   - PURPOSES
     - ➢ CLARIFY QUESTIONS AND ISSUES
     - ➢ REVIEW RESPONSES FOR COMPLETENESS AND CONSISTENCY
     - ➢ FEEDBACK ON ELICITATION PROCESS
   - FOLLOW-UP
     - ➢ COMPLETE QUESTIONNAIRE
     - ➢ COMPLETE RATIONALE DEVELOPMENT

9. RECOMPOSITION AND AGGREGATION
   - INDIVIDUAL LOCA FREQUENCIES
   - PANEL LOCA FREQUENCIES
   - SUMMARY OF RATIONALES

EXPERT ELICITATION PROCESS (CONT'D)

10. WRAP-UP MEETING
    - PRESENTATION OF RESULTS AND RATIONALES
    - PANEL RESPONSE AND DISCUSSION
        - OPPORTUNITY TO REVISE RESPONSES
    - FINAL FEEDBACK

11. DOCUMENTATION

SOURCES OF BIAS

1. **MOTIVATIONAL BIASES**
   - SOCIAL PRESSURE
   - MISINTERPRETATION
   - MISREPRESENTATION
   - WISHFUL THINKING

2. **COGNITIVE BIASES**
   - INCONSISTENCY
   - ANCHORING
   - AVAILABILITY
   - UNDERESTIMATION OF UNCERTAINTY

ELICITATION EXERCISE

1. According to the 2000 census, how many men 65 or over were there in the U.S.?

Low Value	Mid Value	High Value
5th Percentile	Median	95th Percentile

- Coverage by (LV, HV) intervals: 15/17 = 88%

2. Consider the following chronic conditions: Arthritis, Cataracts, Diabetes, Hearing Loss, Heart Disease, Prostate Disease

- How many American men age 65 or older suffered from these chronic conditions in 1995?
  - Coverage by (LV, HV) intervals: 55/90 = 61%

3. What is the <u>ratio</u> of the rate for men 45- 64 years old to the rate for men 65 and older for each of the conditions listed?
   - Coverage by (LV, HV) intervals: 69/96 = 72%

4. What is the <u>ratio</u> of the rate for men under 45 years old to the rate for men 45 - 64 years old for each of the conditions listed?
   - Coverage by (LV, HV) intervals: 68/96 = 71%