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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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RELIABILITY AND PRA SUBCOMMITTEE

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TUESDAY

MARCH 1, 2016

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., John Stetkar, Chairman, presiding.

COMMITTEE MEMBERS:

JOHN W. STETKAR, Chairman

DENNIS C. BLEY, Member

RONALD G. BALLINGER, Member

MICHAEL L. CORRADINI, Member

DANA A. POWERS, Member

DESIGNATED FEDERAL OFFICIAL:

JOHN LAI

ALSO PRESENT:

KEVIN ANDERSON, PNNL

KEITH COMPTON, RES

KEVIN COYNE, RES

STACEY HENDRICKSON, SNL *

ALAN KURITZKY, RES

JOHN SCHROEDER, INL

STEVE SHORT, PNNL

JACK VECCHIARELLI, Ontario Power Generation *

*Present via telephone

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Ontario Power

Adjourn

P R O C E E D I N G S

8:33 a.m.

CHAIR STETKAR: The meeting will now come to order. This is a meeting of the Reliability and PRA Subcommittee. I'm John Stetkar, Chairman of the Subcommittee meeting.

ACRS members in attendance are Ron Ballinger, Dana Powers, and Dennis Bley. John Lai of the ACRS staff is the Designated Federal Official for this meeting.

The Subcommittee will hear the staff's presentation on the progress of the Level 3 PRA project in the morning, and Dr. Jack Vecchiarelli of Ontario Power Generation will discuss nuclear plant site risk assessment and safety goals in this afternoon's session.

There will be a phone bridgeline. To preclude interruption of the meeting, the phone will be placed in a listen-in mode during the presentations and Committee discussions. A portion of the meeting may be closed in order to discuss and protect information designated as proprietary by the NRC pursuant to 5 USC 552(B)(c)(4), in case anybody wanted to look it up.

MEMBER POWERS: Could I get those numbers again?

CHAIR STETKAR: Yes, yes, you can. It's 5

USC 552(B)(c)(4).

MEMBER POWERS: Not three?

CHAIR STETKAR: No, no, it says four right here. We received no written comments or requests for time to make oral statements from members of the public regarding today's meeting. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full Committee.

The rules for participation in today's meeting have been announced as part of the notice of the meeting previously published in the Federal Register. A transcript is being kept and will be made available, as stated in the Federal Register notice. Therefore, we request that participants in the meeting use the microphones located throughout the meeting room when addressing the Subcommittee. The participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

I know that we have material for, I think, open and closed sessions. If, in the open session, we stray too far toward proprietary information, just alert us to that and we'll hold off on questions until we get to the closed session.

I'm a bit unprepared, so I have to look at the agenda here. What we'll try to do is open the bridgeline and ask for public comments at a convenient time after the open session, the first part of the morning, just in case there are any public comments and then try to keep most of the closed session material consolidated.

With that, I also remind everyone to check your little electronic communication doodads and turn them off, please, so they don't bother us. And we'll now proceed with the meeting, and I'll ask Kevin Coyne, Kevin, do you have opening remarks?

MR. COYNE: Yes, thank you. Kevin Coyne from the Office of Nuclear Regulatory Research. Thank you again to the Subcommittee for making time for us today in the agenda. Our last meeting was about a year ago, but since that time we've continued to benefit from ACRS fact-finding activities, which have provided us extremely valuable feedback on the Level 3 PRA project. As a result of this feedback and other quality activities, such as PWR Owners Group-led peer reviews and other internal review processes, we have made significant updates to our PRA model that have served to improve the technical basis, consistency, and overall quality of our model.

We have also completed an expert elicitation process on interfacing system LOCA, which piloted our expert elicitation guidance developed pursuant to SRM/SECY-11-0172. You'll hear more about that this morning.

Alan will provide a more complete status update, but 2016 is expected to be a very busy year for us. We hope to complete revisions to the at-power internal event Level 2 and 3 analyses, in addition to completing other modules for fire, seismic, and shutdown risk.

There are many challenges that remain, but we continue to focus on pulling together a quality product that will provide meaningful and useful insights. We also continue to enjoy strong support for the project from Southern Nuclear, the PWR Owners Group, EPRI, and Westinghouse, and their substantial contributions have made many of our accomplishments possible.

With that, I'll look forward to today's discussion, and we'll turn things over to Alan.

CHAIR STETKAR: If the green light is not on, you're not on. Push right at the base of the -- keep them off unless you're speaking because --

MR. SHORT: Too much noise?

CHAIR STETKAR: Yes, and it bothers transcripts.

MR. KURITZKY: Okay. As Kevin said, I'm Alan Kuritzky with the Division of Risk Analysis in the Office of Research, and I echo his sentiments. I appreciate the time and the expertise of the Subcommittee. I look forward to the opportunity to talk to you about what we've accomplished in the last year and what we hope to accomplish in the next year on this project. And as Kevin also said, we've benefitted greatly from our interactions to date with the Subcommittee on this project and expect to continue to do so.

With me also up here today is Steve Short and Kevin Anderson from Pacific Northwest National Labs. They were instrumental in running our expert elicitation for ISLOCA, which will be the subject of the presentation after mine. And there will be some other people that will be coming up for the closed session on the Level 1 results.

Okay. Just to go over what we're going to cover today. I'll start off with the overview, general overview of the project status, what we've accomplished, what we're planning to accomplish in the near future. As I mentioned, we'll have the ISLOCA expert elicitation

also in the open session. There might be some information associated with the ISLOCA presentation that will require discussion in the closed session.

Originally, I thought we would have presentations both for the open and closed, but, after looking at the presentation, we were able to check to make sure it had no proprietary information. So we'll make the whole presentation in the open session and only if questions from the members lead us into a closed area where we have to continue in the closed session. We may be able to wrap it up in the open session.

Okay. And in the closed session, we'll wrap up anything else on ISLOCA and then move on to our Level 1 internal results. We'll go into the major update that's occurred since the one that we briefed you on probably a year and a half or so ago or two years ago. And as Kevin mentioned, there was a lot of changes based on feedback we got from the ACRS, as well as others.

CHAIR STETKAR: The ACRS Subcommittee.

MR. KURITZKY: Subcommittee.

CHAIR STETKAR: In all of these discussions, remember you haven't received any formal feedback from the ACRS here. It's only individual subcommittee members.

MR. KURITZKY: Thank you for the

clarification. Okay. The status of the project right now will go over the different areas of the scope elements. This is the general order that we'll follow, going first with the reactor at-power Level 1 for the various hazards, and then we'll move on to Level 2 and 3. We'll talk a little bit about the low-power shutdown work we're doing and then move on to the spent fuel in the pool and in dry cask storage. We'll wrap up integrated site risk and the path forward.

I'm going to skip over this slide because it really only applies to the path forward slides, and it will be a little confusing to talk about now. So we'll come back to those definitions later.

Okay. So the crux of our model, the core, is the internal event and flood reactor at-power Level 1 model. And that one we initially completed and had peer reviewed back in the summer of 2014. However, we had substantial feedback from the PWR Owners Group on that. We had a lot of feedback from members of the ACRS Subcommittee on that model, as well as internal and Technical Advisory Group feedback, etcetera. And so we ended up having to do substantial changes to the Level 1 internal event and flood model or models.

We refer to them as the, that was the R01 model originally. We refer to it as the R02 model now,

which is essentially complete. In the next couple of days, we'll probably wrap that up.

We made substantial changes to the event trees, a lot of changes to improve the accuracy and the consistency to the event trees. We had to modify quite a bit of the fault trees. The human reliability analysis, we re-quantified quite a few human error probabilities, as well as identified and incorporated a few new human failure events into the models.

The dependency analysis, we've had to re-do the human dependency analysis. And that actually is the one thing that we're still wrapping up. Once that's wrapped up in the next couple of days, we hopefully can put a bow on what we call the R02 version of the internal event model.

We've also made some substantial changes to the internal flooding models. Based on a feedback from the peer review, we've kind of re-interpreted, we have a new interpretation of the requirements in the standard for what flood scenarios should be considered significant and, therefore, we've upped the number of internal flood scenarios in the model from 10 to 23. We also have adjusted our initiating event frequencies for the floods to be more consistent with the EPRI approach.

We are currently revising those reports, and they should be completed in the next couple of months. But as I said, the actual model itself should be done in the next couple of days.

MEMBER POWERS: I think there are double the number of flooding scenarios. Why?

MR. KURITZKY: Not to get into the technical jargon, but there's a definition in the standard about what qualifies as a significant flood scenario and we had a different interpretation of that requirement, which led us to just retain 10 scenarios. But when we had the peer review, they explained what that really was intended to cover, and, using that interpretation, another 13 scenarios met the definition, even though they weren't big contributors. But we now retain them also in the model.

MEMBER POWERS: So it didn't change your flooding risk very much, but it made it a more robust analysis?

MR. KURITZKY: Right. And the flooding risk did change. I don't know specifically the breakdown how many of those 13 scenarios added versus the change in initiating event frequencies or changes in the internal event model itself that it's based on. But the risk from internal flood was low and it remains

very low. So from an overall risk profile point of view, it's not --

MEMBER POWERS: But that's just your idea of the plant as you've got it configured?

MR. KURITZKY: Well, that internal flood doesn't add much to the overall risk you mean?

MEMBER POWERS: Yes.

MR. KURITZKY: Yes, yes, it's just, it's robust against internal flooding.

MEMBER POWERS: Yes. I mean, if it was, I've had, like, Catawba units, one didn't have much of a flood risk and one does. I mean --

MR. KURITZKY: Right.

MEMBER POWERS: -- subtle, subtle things can get you into a lot of trouble with internal flooding.

MR. KURITZKY: Right.

MEMBER POWERS: So you really want a fairly robust analysis there just because you're looking for peculiarities in plants that might escape people's attention.

MR. KURITZKY: Exactly.

MEMBER POWERS: Okay. I understand.

MR. KURITZKY: And Vogtle doesn't seem to have those vulnerabilities.

MEMBER POWERS: Okay.

MR. KURITZKY: Okay. And the last thing we completed on the internal event model was the ISLOCA expert elicitation, which will be the subject of the next presentation.

Moving on to internal fires, this is an area where, again, the whole premise of the project was to leverage the peer-reviewed licensee models, like we did with the internal event model. Internal fire, we also had, Southern had prepared or had completed a fire PRA that was peer reviewed, and we were able to make use of it and mapping over their scenarios into our fire event trees.

However, after we completed our new fire model based on theirs, Southern had submitted, they had gone through and re-did a lot of their fire model because of feedback they had received on some of the approaches and assumptions in their fire model, particularly dealing with electrical cabinets. A lot of it came out of the NFPA 805 reviews. And even though Vogtle wasn't an NFPA 805 plant, they use a lot of the same techniques. And so they had gone --

MEMBER BLEY: Their fire PRA pre-dated the 805, right? Or not?

MR. KURITZKY: It was the same, it was that generation. Right. So it used those same, it had a lot

of the same issues. So they had gone back, we were not aware, but they had gone back and re-did their fire PRA to get rid of that information. We were struggling with how to adjust our model because we really didn't have the access to the plant or the capability to do a fire PRA from scratch. We were relying on theirs, and theirs had relied on these suspect assumptions and modeling techniques. But in the meantime, they went and re-did it. They resubmitted to us after we had completed our model, and that kind of left us in an uncomfortable position of either going forward with the suspect modeling assumptions and techniques on our own without even the plant having that in theirs or re-doing our whole fire PRA. So we've bitten the bullet, and we're going to re-do the fire PRA to take advantage of the changes that Southern has done in their Vogtle fire PRA. As such, there's going to be a lot of changes, dealing particularly with the electrical cabinet fires in terms of fire growth and spread assumptions and whether or not the fire gets out of the cabinet, how much of the equipment in the room can be damaged, etcetera.

We actually went back to the plant in November and had a walk down specifically to look at some of these changes or how they would impact the model, focusing again on the electrical cabinet fire scenarios.

And so we'll determine whether or not we agree with the changes they've made and then go ahead with the remapping of all their fire scenarios into fire event trees in our model.

We hope to have that updated fire model completed by the end of the calendar year. That's kind of the longest item that we have for the at-power, the reactor at-power models.

For seismic events, we're kind of in a similar situation there, too. When we started this project, we did not have a seismic PRA from Vogtle, from the licensee. They had not completed one yet, though they were working on one. So while we got some information from them on the seismic PRA, we didn't actually have a completed model or documentation from them.

So we initially built all of our seismic PRA akin to what we do for the SPAR all-hazard models. And so we used that. We incorporated the seismic fragility and hazard information that we got from Southern Nuclear into our model. However, again, once we completed our initial model but before we had the peer review, Southern had their fire PRA, their seismic PRA peer reviewed, and then submitted us, the results -- well, first, they submitted the full model

documentation that they went for peer review, so we got that. So we already knew we wanted to update our model to account for that new information. But since we were waiting for our internal event model to be revised, we were holding off on that. And in the meantime, that was in December '14 they gave us the information they sent for peer review. Then in October of '15 they sent us new information because now they have incorporated all the peer review comments that they received on their seismic PRA and, again, updated the seismic hazard, updated the fragilities, so there was a lot of changes again that they made. They submitted that to us this past October, and that's going to be the basis of what we're going to include in our revised seismic PRA model.

MEMBER BLEY: Can you give us a few hints of that? Did they do some plant-specific fragility analysis?

MR. KURITZKY: Yes, yes, they definitely did a lot of that. In fact, we just got a new plant-specific fragility notebook from them yesterday actually, Federal Express yesterday. And that will form the basis for what we're going to incorporate into our model.

The one thing also, besides the new hazard information and the new fragility information is,

because we based ours initially on our SPAR all-hazard models, a more simplified seismic model. Now that we have their PRA, we see there's a number of things that they've addressed that we did not include in our initial model that we may want to add in. So we're going to look into those to see what else we might want to incorporate in our model. One example will be seismically-induced flooding. The new PRA from Southern includes that, and our initial model did not, so we'll look into whether we can add stuff into our model to incorporate seismically-induced flooding.

MEMBER BLEY: Did you or they look at seismically-induced fires?

MR. KURITZKY: I don't think that's included in there. I know in our project we ruled that out as scope, and it's being done --

MEMBER BLEY: Okay. So you didn't look at all?

MEMBER POWERS: Why was it ruled out of scope? I don't understand that.

MR. KURITZKY: Because the seismically-induced fire, both seismically-induced fire and flooding were things that were called out to be in the project as active topics for consideration. But because we're doing a state of practice PRA and we

did not have a solid handle in how that should be incorporated into the model, we put that out of scope. And a separate project was started in research to address seismically-induced fires and floods, so there's a parallel effort that's looking specifically into those issues. And we did not to include seismically-induced floods in our model for the same reason, but since the new seismic PRA from Southern has seismically-induced floods included in it, we felt, well, if we can see what they did and we understand it and agree with it, then we would be comfortable putting that into our model also.

MEMBER BLEY: Will the seismically-induced fires be an update on this PRA, or is it just a completely separate project?

MR. KURITZKY: Not as part of this project. This project is going to have a laundry list --

MEMBER BLEY: So that other project is not going to look at this plan?

MR. KURITZKY: What's that?

MEMBER BLEY: The other project on seismically-induced --

MR. KURITZKY: No, no, no, it's not looking at this --

MEMBER BLEY: Not looking at this plan. Okay. So this will be a whole . . .

MR. COYNE: Just to clarify, so under NTTF Recommendation 3, research had a task to look at seismically-induced fires and floods. That was binned as a Tier 3 item to look at what enhancements licensees could make to make their plants more robust. I'm sorry. Kevin Coyne, research staff.

We also had a Tier 1 portion of that item to develop a PRA methodology. So the Commission directed us to have a Tier 1 portion of NTTF Recommendation 3. We had spent several years working on developing a PRA method. Brookhaven National Lab assisted us in that. We had gotten as far, in December, as completing a fairly robust feasibility study to lay out what a method would look like and what some of the gaps remaining are.

That particular issue got caught up in the NRR JLD's effort to sunset many of the Tier 2 and 3 items so that Tier 3 portion was closed with Commission approval without further action. So we've issued the feasibility report, but we don't intend to do any further research activities on seismically-induced fires and floods.

CHAIR STETKAR: As a member of the subcommittee, I'm going to say we're going to follow that. Be prepared. We're going to plan to have, we'd

like to have a subcommittee meeting that addresses the issue of seismically-induced fires and floods. We haven't seen the Brookhaven study. We thought that, we held off because we thought that the staff was going to prepare a review and a path forward on that. Apparently, that's not going to happen.

We know also that EPRI is doing work in this area for the industry. So I think the subcommittee is pretty interested in hearing about that topic. We can talk offline in terms of arranging a date for a subcommittee meeting.

MR. COYNE: Yes, and we'd be happy to share. We'll get that to John Lai, the result of the Brookhaven study. But right now we have no resources or direction to continue work in that area.

CHAIR STETKAR: Okay. We'll have to work that out.

MEMBER POWERS: That seems a problem if they don't have resources or charter. Maybe we should make that fairly explicit in our research report. I mean, it's an issue. If I didn't have pictures of the seismically-induced fire in Japan, I could say, okay, well, maybe they don't occur. But now I explicitly know they do, in fact, occur.

CHAIR STETKAR: I'd be interested to see

what Brookhaven did because, as I said, the subcommittee hasn't received that report yet. Particularly, I have a copy of it, but I haven't read it yet because I'm pressed for time typically. But I think it would be very worthwhile to see what Brookhaven concluded in terms of -- I don't even know what they addressed, methods or data. I have no idea. I --

MEMBER POWERS: It would be interesting to see what the database is.

CHAIR STETKAR: Well, yes. And it's also, as I said, I know that EPRI has produced a report on seismically-induced fires and floods also. That is a proprietary report. It's not available publicly. And they have -- I'll be careful here because we're in open session. They've tried to address the issue; let me just say that.

So I think it would be useful for the subcommittee if we could hear from the staff. And I realize resources are a concern, even to support a subcommittee meeting, but hear from the staff and Brookhaven on what they've done and, if possible, from EPRI on what they've done, what their path forward might be.

MEMBER POWERS: Well, I think we ought to make our interest known to those that control resources

and direction. We can't create bodies. I mean, you can have an infinite amount of resources. If you don't have bodies to carry it out, they won't be any good. But this is an issue that's been sitting around for a long, long time. I mean, I can remember not too much anymore or less and less, but I can definitely remember people asking about seismically-induced fires 20 years ago.

CHAIR STETKAR: Anyway, that's, as Alan correctly stated on the record, that's out of the scope of the current study and, because of resources, there's absolutely no plans to address it even in an update.

MEMBER POWERS: So do you intend to change the title of the view graphs to say full scope except for it's not?

MR. KURITZKY: No, I don't. Actually, if you look at the project plan, we do call out a number of areas that were not addressed, and we have an initial project plan that does call out things. Offline, as Dr. Powers and I were discussing earlier, digital I&C was one that is out of scope, as well as seismically-induced fires.

MEMBER POWERS: Well, the digital I&C is going to cause undue amounts of --

MR. KURITZKY: Headaches.

MEMBER POWERS: -- headaches because, I

mean, it's a fictitious plant about digital I&C.

MR. KURITZKY: Right. Okay. Moving on, the seismic events, going back to what I was mentioning about the information we got from the licensee, so we got a full report and model in December. We got an updated -- in December '14. We got an updated model in October of '15. The updated model is the one we're basing it on, but we don't have an updated report that goes with that model. That is not going to be prepared by SNC until probably closer to early 2017 in response to one of the NTTF recommendations.

So we're kind of flying blind a little bit. We can pull information out of the model, but we don't often have the basis or justification for why things are treated a certain way. So in some cases, if we can't understand why something is a certain way, we may have to make simplifying assumptions in our model because we have to be able to defend whatever is in our model. So if we can't feel comfortable defending what they have in their model, we may have to change it to something that we can be more comfortable with.

One example is the relay chatter issue. They're re-looking at the relay chatter. We do not have the resources to do a full relay chatter analysis, so we're going to have to figure something out on how to

address that in our model. The final revised seismic model we hope to have ready in the late summertime.

Moving on to the IPEEE language was the HFOs, the high winds, floods, and other hazards. Here we've kind of broken out high winds from the other hazards because we actually have the PRA model for high winds. We do not have a PRA model for the other hazards. Those all have been screened out through a qualitative analysis or semi-quantitative semi-qualitative analysis.

We did complete the peer review, had an ASME/ANS PRA standards-based review led by the PWR Owners Group completed in November of 2014 on both the high wind PRA we had, as well as our other hazards screening analysis. We're currently in the process of updating those analyses based on the feedback from the PWR Owners Group-led peer review from ACRS, the Technical Advisory Group and external and internal feedback.

One of the comments we did get back on the high wind PRA was that we didn't appear to have a very strong walk down focused on high winds because we had a seismic team just take a look at them. So since that time, we actually contracted out with Applied Research Associates, which is one of the preeminent high wind

PRA companies in the country, and they actually went down in November of this past year and did a walk down focused on high winds for us. We're currently reviewing their trip report and recommendation to determine what, if any, additional analysis we may want to pursue.

And so, in general, we hope that by fall, September 2016, we'll have the revised documentation, as well as any additional analyses that are needed for the high wind PRA model and the screening analyses for the other hazards. A couple of the other hazards that we're still --

MEMBER BLEY: Before you go on, you're looking at both tornados and hurricane?

MR. KURITZKY: Tornados, hurricanes, and straight-line high winds, thunderstorm winds. And a couple of things in the other hazards that are getting some focus from us right now particularly are external flooding. We're looking at the external flooding, particularly the probable maximum precipitation issue, and also the accidental aircraft crash. We're re-looking at some of the aircraft crash screening numbers because, based on some new information, we're not sure that they screen out as easily as we felt initially, and so we may have to sharpen the pencil a little bit in terms of size of aircraft and speeds,

etcetera, to see if that will still screen out appropriately.

Moving on to Level 2, we completed the standards-based peer review for that in December of 2014 and we're working on incorporating the feedback from that peer review, as well as, again, from the ACRS, TAG, external and internal feedback.

There are a number of things that are going to change significantly in that Level 2 external and internal flood model, particularly the overhaul of the plant damage state binning, primarily because we've changed so much in the Level 1 model, so that is affecting the plant damage state binning that we had done originally.

We also had made a lot of changes to the MELCOR model and also some of the boundary conditions for some of the calculations. So we've re-run all the MELCOR analyses, and, because of all those re-run MELCOR analyses and other internal and external feedback, we're going to have to do a re-scrub of the containment event tree and a lot of the issues therein to see whether or not things have to change. And we hope to have that updated model completed in the summertime.

MEMBER BLEY: We'll be hearing about that?

MR. KURITZKY: You'll hear about

everything you'd like to hear about.

MEMBER BLEY: Okay. I assume that would be more toward the fall then?

MR. KURITZKY: Yes. We'll generally be coming to see the subcommittee a couple of times a year. This last year, because of schedule --

MEMBER BLEY: I understand.

MR. KURITZKY: -- snafus -- so we'll probably be back in the fall, you know, late fall time frame. So whatever we have at that time we usually pass to you and then we'll discuss it. In fact, depending on what we have, it will probably be a full day meeting. If you have enough topics, generally, we have a full-day meeting. So, certainly, you'll hear about it.

Moving on to Level 3, that peer review was just completed in October of this past year. And there, again, we have feedback that we are going to incorporate from that peer review, as well as others. We're kind of moving on that slowly, primarily because we are waiting for the updated results from the Level 2. So we at least have to have interim results on an updated Level 2 before you dive into the Level 3 update.

But there are some things we already know that we're going to be changing. One thing is, in the initial model, we had a cohort for the Unit 3 and Unit

4 construction workers. One of our going-in conditions for this study was that Units 3 and 4 don't exist, and so we kind of feel that, well, if Units 3 and 4 don't exist, those construction workers don't exist either, so we're going to actually take that cohort out of the analysis for the next go-around.

Also, based on the peer review feedback, we're going to make some changes to our protective action models. And also there are some newer decontamination parameters that we're going to use in the new version.

So, anyway, all that will get wrapped up into the new Level 3 internal and external flood model that we hope to complete and be ready to share in November of this year.

Moving from at-power to low-power and shutdown. For low-power and shutdown, the licensee did not have a model, so we are building our low-power shutdown model from scratch. Southern Nuclear did start a model some years back with a contractor before they aborted it, and they were able to provide us the information that the contractor had completed up to that time, which was primarily plant operating state definitions and initiating event listings. That information was very valuable to us, and it gave us a good starting point.

We have now completed our identification of plant operating states and initiating events that we're going to consider in our model. Our main focus is going to be on loss of RHR, loss of inventory, and loss of off-site power. Those are the main three categories we're looking at, at least initially.

We've already completed several of the event trees. We're in the process of completing the rest of them. There's a number of them because you have different initiating events and the different operator states, so you have quite a number of event trees to look at.

We are doing kind of a prioritized, you know, experientially judgmental scheme to pick which ones to analyze because if you took all the possible initiating event possibilities and all the operating states, you would end up with a model that was just beyond our resources to deal with right now. So we're trying to be smart about what we're looking at.

CHAIR STETKAR: Trying to be smart based on what?

MR. KURITZKY: On previous low-power shutdown PRAs --

CHAIR STETKAR: That's interesting --

MR. KURITZKY: -- and what they do in their

operating, you know, their outages.

CHAIR STETKAR: The second would be more important than the first because the first, in my experience, everybody has become mid-LOOP-centric, and that's the only thing that's important. I don't know how Vogtle organizes their outages. A lot of plants try to stay away from mid-LOOP operation with fuel in the reactor. My experience from seeing other PRAs that have looked at all plant operating states, sometimes the risk is surprising because of the way, what they do during particular plant operating states and things that other people hadn't thought about might be important for a particular plant. So be careful about looking only at previous studies.

MR. KURITZKY: We appreciate the caution. In fact, at Vogtle, they do have, they look at operation with fuel. The time frame was not very large, but it's there. But we are looking well beyond that. Your caution is well noted. I mean, we are looking at past studies because there's information to glean from them, but that's not what we're focusing --

CHAIR STETKAR: Alan, I really do hate to throw monkey wrenches into this, so just maybe take it as a question. How are you addressing human-induced initiating events because of, for example, operational

or testing or maintenance activities that are done? At least operational and testing are typically orchestrated as part of the outage plan. Maintenance is more of amorphous type of activity, but operational and testing activities, you know, operators are supposed to line up a system by closing valve X and opening valve Y and, occasionally, they do it in reverse order and put water in places that it ought not to be. That's also a very, very plant-specific contribution to risk because it's part of that matrix of what's done as a function of where you are in the outage. Are you trying to address that at all?

MR. KURITZKY: Yes, I can't give you a lot of details. I can bring Jeff Wood up. But, basically, that's part of our initiating event database, looking at operator actions that lead to human-induced loss of inventory. That is definitely within scope, and we are addressing that.

CHAIR STETKAR: Not only inventory but also power things. I mean, I tell the sea stories. Every outage, we always lose power because, when they did a certain test, they always dropped a DC bus. Nobody could figure out why. It just always happened. You know, if you can't figure out why, at least do the test during plant configuration when dropping the DC bus

might be less important to risk than the more important to risk. So that type of thing is what I'm talking about.

MR. KURITZKY: Yes, I can't specifically to that issue. I've noted it and, again, you know, as part of our study, we'll be aware of --

CHAIR STETKAR: Okay, good.

MR. KURITZKY: Okay. So in addition to the event trees that we're working on, we also are having Idaho National Lab look at the failure events in the shutdown, you know, at shutdown conditions to help us come up with initiating event frequencies.

Also, because human reliability issues are so important for low-power shutdown PRAs, as you just mentioned, we are looking into how we're going to approach the HRA. I think right now our current thinking is to use SPAR-H to do an initial quantification of all the events because we have limited resources, we have limited access to the plant, so we use it as kind of like a screening approach. And in those events, those human failure events that look like they're important to the study will get a more rigorous analysis. So kind of a two-stage approach. We're hoping to have the initial model for low-power shutdown for internal events, internal events only, completed and documented by August of 2016.

Moving out of the reactor space into spent fuel, specifically spent fuel pool, unfortunately that's one area where we have not made a lot of progress since we briefed the subcommittee approximately a year ago, primarily because staff availability is very limited for that work. There have been competing priorities that have kept the key staff in that area of the study busy elsewhere. We have made some incremental progress. In particular, for seismic events, we've actually developed all the event trees for the seismic, essentially for all the seismic events we're going to consider, both seismic events and the various spent fuel pool operating states. That combination of event trees are complete.

We're also working on, actively working on the fault tree and system notebook for the spent fuel pool cooling and purification system. We've done some analysis to come up with the temperatures that the pool line and structure would see given a zirc fire. We're also working on the MELCOR model for the two pools simultaneously. If you recall from presentations we did in the past at Vogtle, the Unit 1 and Unit 2 pools are almost always thermohydraulically connected through the cask bin area, so we're modeling them as one big single pool.

In contrast to the spent fuel pool, the dry cask storage PRA, we actually have made substantial progress in the last year. We're getting very close to wrapping that analysis up. Through interviews with the operators at the site and review of procedures, we have used THERP to complete the human reliability analysis for the vertical cask transporter crane. We also did an analysis of the frequency of an earthquake causing a cask to get knocked over, which we have determined is not very significant.

We completed a hazard and operability study, a HAZOP analysis, for the site, and from that we identified one scenario that had not been previously identified that we're including. That's a situation where, in the cask wash-down area, where a cask would drop and then tip over in the wash-down area.

MEMBER BALLINGER: As a point of curiosity, when you did the earthquake analysis to see if it would knock over a cask, did you ever decide how big an earthquake it would take to knock over a cask?

MR. KURITZKY: Yes, that's, obviously -- we have a probability for it knocking over, so we have --

MEMBER BALLINGER: Okay.

MR. KURITZKY: -- earthquakes we looked at.

MEMBER BALLINGER: I didn't get that much

detail.

MR. KURITZKY: So some knock it over and some don't, and there's a frequency associated. The frequency associated with those big enough to knock it over is low enough that it doesn't make a large contribution.

MEMBER BALLINGER: I would hope so.

CHAIR STETKAR: I suspect the stuff inside the plant is probably not real happy at that frequency.

MR. KURITZKY: Yes, there's a lot of other concerns to be dealt with. That's right. Okay. There's a number of things on the list here that we're still working to wrap up. Many of them are very close to being done, if not essentially done already.

First, the structural performance. Pacific Northwest National Lab is doing the performance of the multi-purpose canister and the fuel. That's essentially done. The problem there is it's 95 percent of the way done, but we've run into a contract issue with the umbrella contract that this work is a piece of, and that, unfortunately, is probably going to be the critical path item for getting this work done because that's probably -- all the other work will be done long before that contract issue gets resolved for that last little piece. But it is what it is.

We're wrapping up our evaluation of the vent blockage scenario. We've also essentially completed our crane reliability analysis and the support systems analyses.

One thing we're re-evaluating, again, the aircraft impact analysis. Just like we are for the reactor, we're re-evaluating it for the dry cask storage. One of the main reasons is we've discovered that the physical location of the pads and the arrangement isn't quite what we thought originally. We actually saw in a Google Earth picture that the pads weren't exactly what we originally had thought, and so now we're having to -- the shielding is a little bit different in terms of aircraft pathways, etcetera. So we have to kind of re-look into that.

The source term analysis, we haven't really done much in that. But, actually, our thinking right now is we'll probably end up using the conservative source terms from NUREG-1864, the previous NRC's dry cask storage PRA, because I think we can use those source terms without taking much of a hit. And only if it becomes an issue would we re-consider doing anything different.

We hope to have all the, the Level 1, 2, and 3 dry cask storage all done completely -- yes?

MEMBER POWERS: How do you decide what a conservative source term is?

MR. KURITZKY: Well, I think, and I'm not expert on this, but in NUREG-1864 they did some analysis of the fuel, which I think is the same type of fuel that we have in our study. But then at the end, they decide to use a value that was well above some of the source terms that they calculated just for convenience. And so we'll be using those same --

MEMBER POWERS: I always get interested when somebody says calculated source terms because, typically, we can only calculate well those things that we measure. And the measurement data for pertinent source terms here strikes me as a bit thin.

MR. KURITZKY: I cannot speak to the robustness of the calculations that we've done in 1864. If we had our, that's something our consequence analysis individual or source term people or dry cask storage people might be able to offer more. Actually, one of them is about to walk to the microphone, Keith Compton?

MR. COMPTON: This is Keith Compton, Office of Research. Yes, one of the things in NUREG-1864 is that they calculate kind of a, they come up with a model for estimating the release from the cask. Is this -- can you hear me? They come up with a model for estimating

the release from the cask, but then the result that was actually used set a number of parameters kind of at their maximum value, such that it was trying to maximize the release fraction coming from the cask. And when you look at the numbers that actually come out of it and calculate the fraction of inventory that is in the cask, it was quite high. So that's the -- I'm generally cautious about the more conservative, but, in this case, it does seem to be a fairly --

MEMBER POWERS: I mean, it causes pause because my brethren who pray at the alter of PRA assure me in no uncertain terms that this is all realistic, and so here we do things very conservatively. We'll leave that one aside, and we'll come to, again, you can calculate only those things that we measure -- we can calculate well only those things that we've measured well. And so what you're putting into these event pathways for your release analysis is the question I have. The database available for pertinent source terms here strikes me as a bit thin, and so how do I do a calculation for the input that you give conservative release fractions of or escape fractions of? How do I do that well?

MR. COMPTON: Again, I don't want to speak for the people that will be generating the source term,

but I think it is fair that some of the information was not terribly, was somewhat thin to kind of validate and to test that kind of model. So we'd have to look at it and just try to get an understanding.

I know from the consequence side, I can speak more to the consequence side, we can get a sense of, you know, how would it change if you, you know, if the source term was kind of set as a very large value or if I dropped the release fraction by a factor of ten or a hundred or whatever it was and made some statement about, you know, where am I? So I might not be able to say this is what the risk is, but I might be able to make, have enough information to say, well, if I did do it better, I might be able to, you know, it might be done in this kind of range and then, given that, and in light of consideration of the reactor risk and other things, I can draw some insights. That's all I can really say --

MEMBER POWERS: I understand where you're coming from. Maybe I'll turn to John and ask him should I look at this 1764 for you?

CHAIR STETKAR: Yes, sure.

MEMBER POWERS: You want me to look at that?

CHAIR STETKAR: Yes, yes. Part of what we're doing here, as Alan mentioned, this project is

so big that several of us have sort of taken it upon ourselves to provide input to the subcommittee, as we do often. So I think that would be really useful.

MEMBER POWERS: Well, maybe I could look at that and try to generate something that would be useful to them.

CHAIR STETKAR: Yes.

MEMBER POWERS: I mean, at the very least, I pay attention to this kind of stuff for reasons that probably reflect a bad upbringing. But it might be of interest just to know where we stand in this area because these things are very difficult to do in this particular situation, once you're worried about them, is what the hell does the iodine do, what does the tellurium do, and what are the particle size distributions, and then you can put the escape fractions and things like that anyway you want to. But if you get the particle size distribution too big, it all falls out on the ground and kills firefighters. If it gets too fine, then it gets dispersed out and kills seagulls. In between, more hazardous things occur.

CHAIR STETKAR: Yes, I certainly would appreciate that.

MEMBER POWERS: But if you can get the NUREG, I'd look it over and at least --

CHAIR STETKAR: We've done it in other areas. Alan has mentioned it, and we've done it in other areas where individuals on a subcommittee have sort of looked in more depth at particular issues and written up a little bit of prepared information.

MEMBER BLEY: I think the other thing that you've talked about before, Dana, is what appears to be conservative, many of us, when you look at the detailed chemistry, it might not go that way or might, different reactions --

MEMBER POWERS: There is pertinent literature. It actually comes out of transportation cask kinds of things where they've done studies on leaks. Most of them were done back in the 80s, and there was some nice work done in Great Britain actually that's pertinent here. Unfortunately, the author of that work, apparently it was so difficult, it drove him over the wall and he escaped to Canada and is writing the great American novel or the great Canadian novel or something like that. And then Canada squared off the part he was living in, and so he's living like an Eskimo or something like that.

CHAIR STETKAR: Risk assessment will do that to people. I need to be a little bit more cognizant of time, so let's let Alan see if he can --

MEMBER POWERS: It is Alan's fault. It is not yours.

CHAIR STETKAR: Somebody has got to be responsible.

MR. KURITZKY: Okay. The last item we're going to cover is the integrated site PRA. We've made some headway on that. In the last year or so, we've developed an integrated site operating configuration matrix, SOC. That's actually not much different than what we presented to the subcommittee a couple of years, what we called then the joint plant operating state matrix. Now it's site operating configuration matrix. The only real difference between that version and I think the version that we have now is the durations of the SOCs have changed based on newer information, but, essentially, it's a similar type of thing.

One of the big things we have completed, though, in the meantime is the integrated site dependency matrix. That's a crucial item because it's really the dependencies between the various radiological sources that are going to drive the multi-source issues, and so we have combined and consolidated dependency analysis frameworks from various sources together to come up with this matrix. We've looked at stuff that's in the PRA procedures guide,

that's in, for instance, the Seabrook multi-unit PRA, emerging peer-reviewed literature, also draft and trial use standards that address multi-unit issues. So all that information we've used to come up with this.

MEMBER BLEY: I don't think we've seen that, right?

MR. KURITZKY: No, that was just something that we've just been working on.

MEMBER BLEY: Okay. That would be very interesting. Okay.

MR. KURITZKY: Yes. And the next time we come to you, that should be more baked and we might be able to give -- in fact, I'll make a note of that. Okay. And so that's one thing we've done.

Another thing, we've started taking a look at the single-source PRA models, particularly the updated Level 1 external and internal flood model that we've just recently completed. So our contractor and our lead there is taking a look at the insights from that, identify what are the dominant contributors, what are the dependencies that are driving things in that model.

From a Level 2 and Level 3 side right now, we're kind of looking at them qualitatively because we haven't updated those models yet. But we're using

consideration to those aspects also to try and, at least from the initial point of view, focus down a lot on the most important things. We're never going to be able to do a soup to nuts integrated site risk model, so we have to kind of focus on what things we think are going to be the most important, primarily looking at the single-source results and looking at the dependency matrix and things like that. So that's where we're going with the integrated site PRA.

So that brings us to the path forward. Now I'm going to go back and talk to you about the slide I skipped over before because the terminology in that slide only applies to this slide and is opposite to terminology elsewhere.

What I tried to do in that slide was I refer to the models in three different ways. I talk about initial models, updated models, and revised models on this slide. And so what I wanted just for clarification, the initial model we talk about, when I refer to that, it's the model that we first do that's going to get peer reviewed. It's the initial model, the first one we do, and it goes under peer review.

Once we get the peer review comments and the comments from the ACRS and TAG, etcetera, we do an updated model. So it's really the initial model and the

updated model. However, as I discussed earlier, there are a couple of cases, particularly the fire and seismic, where we did the initial model before we had it peer reviewed. We got a huge amount of new information that totally changes the model, so we have to revise that model before we can even do the peer review. So that's why I talk about revised model.

So I have the three different terms in this slide. Just to differentiate between them, I use those definitions.

So in terms of revised models, like I said, the seismic and the fire, we hope to have the revised seismic model done August - September 2016, the revised fire by the end of the calendar year. We hope to have the updated Level 2 and Level 3 models for internal floods completed in July and in November respectively, and we hope to have the initial dry cask storage model and the low-power shutdown Level 1 model for internal events completed both around the August time frame.

So those are the things that we're looking forward to getting accomplished today. And so that goes back to what Kevin said that we expect 2016 to be a big production year, and we're hoping to have all of these things accomplished before the end of the year.

Moving forward, we also continue to work

with the PWR Owners Group to have standards-based peer reviews. And so there's several that we hope to have held this calendar year: the dry cask storage model in September, the low-power shutdown Level 1 internal event model in October, and then the seismic PRA model in December. The fire model will be the following year.

And I would be remiss if I didn't mention again the various challenges that we've run across in this project that are putting pressure on our schedule. The diversion of key staff has been one. Since the beginning of the project, that's always been an issue. I mean, obviously, there's a limited number of PRA staff here. There's a lot of high-priority work that has to be addressed, and so staff has to balance all these things. We don't have a dedicated staff just to this project, so they're going to have to split their time and essentially get what we can. So that's obviously a major issue on the schedule.

The other thing, conversion and ownership of the licensee's models. The conversion was a thing that took more effort than we thought, more time than we thought, switching from CAPTA to SAPHIRE. But really the biggest issue has been the ownership issue. You know, we realized initially going in that we thought we'd be able to leverage the licensee's peer-reviewed

models with doing some minor work, and they'd become our models. Then we realized that we really have to defend everything in there, and the more we got comments on things and looked into the models, the more we found things that we didn't understand, we couldn't defend, and we felt we needed a change. And so more and more of the models have been changing and changing, and they say --

MEMBER POWERS: Other people's models you just don't mess with.

MR. KURITZKY: That's obviously a lessons learned. It's a real big issue if you're going to try to take over someone else's models.

CHAIR STETKAR: That's an important lesson, though, an important message also to other people, not so much in the United States, but I've seen a lot of people around the world saying I'm going to take the, pick the plant, you know, design model or the Surry model and fluff it up a little bit because I have a PWR and, yes, mine looks a little different, but this is my risk assessment. And your experience says that, even if you're looking at the same facility, you have to own your own model of that facility.

MR. KURITZKY: And I think that's an important point. Any time that an agent is going to rely

on models that they didn't develop themselves, they have to keep that in mind because it's not a slam dunk. There's a lot of work involved, and there's a lot of things that we're not going to understand unless we really dig into those models.

As we saw, Southern Nuclear, which I was going to get to in the acknowledgments, I mean, they have been a tremendous support to us on this project. They have put huge resources in supporting us. They've provided us tremendous amount of information, tremendous access to the site, probably terabytes of information on our SharePoint site that they've provided us for us to go through with this model, and still we have this problem. So, you know, if you're going to use a licensee's model, it's a major undertaking.

So that's one thing. And the last one I just wanted to mention under the challenges was the Southern's active PRA program for Vogtle, which actually is a good thing. The updates of their internal event and their fire, the seismic, this is a very good thing for them and their plant, and it's a good thing for us. We get newer information. So for the realism and the accuracy of our models, that's good. But from a project management and schedule point of view, it's a real headache because there's only so much we can keep chasing

our tail and re-doing things. So we kind of have to draw a line, which we have in many cases, but, as I discussed in the fire and seismic, the changes were so major that we really had to go ahead and make corresponding changes.

CHAIR STETKAR: But that's all. And I think we raised that two or three years ago that, regardless of the project or who's doing the risk assessment, of necessity, you have to set a freeze date. You have to, at this moment in time, our models are based on the following information, and there's engineers and it's always tempting to say, well, yes, but I just learned something and I need to go perturb something. And that has a, as you know, a terrible compound effect down the road.

MR. KURITZKY: Yes, it does.

CHAIR STETKAR: Yes, it does. So it's time to draw the line in the sand, Alan, because next week when they change the fire model a little bit more, you know, it's --

MR. KURITZKY: Right. So I think, as a point I was making, that, from a physical point of view, there's physical things at the plant, we've kind of drawn a line, a freeze date. And so if they make changes to RCP seals or other things, they're just not going to be part of this model.

In the case of this where it's more of a knowledge thing, there's nothing I really change in the plant. It's how something is analyzed or what our knowledge of what the plant was that has changed. Again, if the change is not major, we just put it on a list and say this is something that, for an update -- or keep in mind this is no longer accurate. But if the change is major enough that it would totally re-do or invalidate the work we've done, then it's a tougher decision just to hang it up on the wall.

MEMBER POWERS: Alan, you've experienced a variety of perturbations that have caused you, the cascade. Nothing in the PRA gets completely compartmentalized. Have you identified aspects of this effort that would be very useful to have automated so that when you have one of these perturbations occur over here the cascading effect can all be done automatically?

MR. KURITZKY: I mean, it would obviously make things easier to be able to do that. Remember, PRAs, it's somewhat of an automated process. It's a computerized model, so if we maintain just to a basic event in one place, it's reflected anywhere else that basic event is in the model. If you make changes, for instance, to the Level 1 model, you can't really automate the Level 2 model. There's a lot of manual analysis that

gets done on these --

MEMBER POWERS: What I'm asking is, you don't have to do it, but if you had your druthers or your wishes or prayers answered, what kinds of things would you ask to be automated so that when these perturbations occur, and they occur all the time and they always will occur, that it is not such a herculean task to go back and fix everything that got affected because -- I mean, there are two things. First of all, that's a lot of work; and, second of all, your potential for error, leaving something out, in that correction process is very high. And, you know, it seems to me you guys are in a wonderful position to say, you know, if IBM's Watson really is good, here's what it would do in PRA land to automate things just because, you know, people are always looking for these. I mean, he has thousands of graduate students clamoring for theses to write. I mean, those people are looking for things, and if you could suggest to them here's a list of things that, if we could automate, we could do these things because we know we're going to get perturbations a hundred years from now when we do PRA. We're still going to get these perturbations that propagate through the whole system. It's just the way PRA is.

MR. KURITZKY: It's an interesting

question, something we can think about.

MEMBER POWERS: Yes.

MR. KURITZKY: I don't have an answer right now for you.

MEMBER POWERS: Talk to the boss man and tell him you want to go to the ANS meeting and give a paper on that subject. I think it would be fascinating.

CHAIR STETKAR: I have to try to keep us on a little bit of schedule here, but backing off a little bit from the sense of knowledge management, automated knowledge management if you will, but looking at more pragmatic realtime issues is, my experience has been that, if you lay out the scope of the information that you're working with initially, try to look at a complete scope -- and give you an example. We talked a little bit earlier about which plant operating states you're going to focus on during low-power shutdown PRA. Well, many, many people, when they develop a low-power shutdown PRA, will develop a very large matrix of possible plant operating states, perhaps hundreds I've seen, and coalesce them into a subset and then maybe focus on yet a further subset of that coalesced subset.

If you learn something that suddenly makes preliminary plant operating state 97 potentially important, having that information available that there

is even a preliminary plant operating state 97 can be important. So too quickly making assumptions about what's going to be important and what subset of things are we going to look at is where you run into the danger of new information making you unravel all of that stuff to create something that perhaps existed at one time but was lost. That isn't necessarily an automated process, but it's something that -- we were talking earlier about inter-unit dependencies. If you had a complete inter-unit dependency matrix, rather than focusing only on dependent, and I don't know how it's laid out yet because we haven't seen it, but rather than focusing only on dependencies that you thought today might be important to today's model for today's risk from those units, that would help, you know, if additional information becomes available.

Anyway, as I said, I'm now not being the adult in the room anymore, so let's see if we can get through your last, this is your last slide.

MR. KURITZKY: Again, I wanted to express my sincere appreciation to Southern Nuclear for their support; as I mentioned, the PWR Owners Group, Westinghouse, EPRI, as Kevin mentioned before, for the peer reviews and for Westinghouse and EPRI for giving us a person on the Technical Advisory Group. So that

continued support has been greatly appreciated, and that's essentially all I have for this presentation.

CHAIR STETKAR: Good. Any other questions or comments for Alan on the overview before we get into the ISLOCA expert elicitation? If not, let's get into it.

MR. KURITZKY: All right. Before I yield the microphone to Steve, let me just give you a little bit of background just to refresh the subcommittee members or those who may not have been at earlier briefings.

So the issue came up with interfacing systems LOCA when we first started doing this study that we leveraged over and converted over from the licensee's model, and the licensee's model, ISLOCA was almost a no-never mind. Their frequencies of the scenarios, they looked at a lot of different potential scenarios, but they all had frequencies so low that it really was a non-risk contributor. And when we converted over, we had the same result.

CHAIR STETKAR: Non-risk or non-core damage?

MR. KURITZKY: What's that?

CHAIR STETKAR: Non-risk --

MR. KURITZKY: Non-risk because the

frequency was so low that, even though you have high consequence, it was still not -- we didn't know that it was a non-risk contributor, but we could just tell from the small frequency that it would not be a big --

CHAIR STETKAR: Okay.

MR. KURITZKY: But then what happened was when we were looking at some of the data that we used for the model, the INL database that supports the SPAR model that we're using for a lot of events in this model, there actually was some data on common cause failure of MOVs and check valves to leak in what they call large internal leaks greater than 50 gpm.

And so if you go and use that data, which we did, and put it into our model, all of a sudden the ISLOCA frequencies jumped up and, because of the high consequences, it was clearly going to be the, by far, most dominant risk contributor in the study. So we recognized that the data that was in the INL data is extremely sparse, and so the uncertainties or conflicts in those numbers is very low. Uncertainty is very high and the conflict is very low, so we felt that this was an ideal opportunity to pilot the staff's draft expert elicitation guidance for this particular issue.

And so we had Pacific Northwest National Lab undertake that activity, and Steve is going to give

you all the details momentarily. But, essentially, we're looking at, you know, what is a reasonable value for the leakage from a single valve but more importantly through the two successive valves, and also where is the break going to be on the outside containment? Because that can make a big difference in terms of what kind of release you have, and there's a lot of uncertainty associated with that. So those are some issues that we wanted the expert panel to address.

MEMBER BLEY: I think we also saw -- and I might be wrong on this, I'm trying to remember -- some very, very small leakage rates that were probably leakage past a closed disk kind of thing. And we asked if that's where it came from or if you could tell.

MR. KURITZKY: Right. I don't know whether it was just small leakage through a closed disk, but we do know there's obviously a lot more data for the less than 50 gpm leaks than there was for --

MEMBER BLEY: There might have been different kind of failure modes.

MR. KURITZKY: Right. And also what happened was, even though there is some very small amount of data for the large leaks, what we end up doing in the quantification in the INL database was to take the small leakage and multiply it by the ratio of the data

they had for the large leaks to the small leaks. So it wasn't just a pure data-driven large leak frequency.

So for all those reasons, we wanted to have an expert panel take a look at it, and that's exactly what we did. And consistent with SECY, you know, the SRM for SECY-11-0172, we had this become the topic.

CHAIR STETKAR: When you said data, they actually used a, they had no events of large leakage so you --

MR. KURITZKY: Well, they actually had, I think they had --

CHAIR STETKAR: I thought they used a non-informed --

MR. KURITZKY: Three events.

CHAIR STETKAR: Did you really? Okay. We'll hear more about that then. Before we get to Steve, I wanted to ask you, Alan, because you're familiar with the models, what we're going to hear about for the expert elicitation is focused entirely on, as you characterized it, leakage through two or more valves in series when we know that those valves are closed.

MR. KURITZKY: Right.

CHAIR STETKAR: Okay. Does the PRA look at the likelihood where one, let's just take the simple case of two valves in series where one of those valves

is actually not closed so that leakage through only one valve under that condition is all you need. It doesn't look at that.

MR. KURITZKY: That was an issue that was brought up in the expert elicitation, particularly by one of the experts, and it was discussed. And we do not have, we have not modeled those cases. I think we do address them in the report, to some extent, why we are not --

CHAIR STETKAR: Well, let me put that, I read the paragraph or the footnote that said one expert brought it up. I didn't see why it's not important.

From other studies that I've seen, those scenarios can be much more important than leakage through two valves that are closed --

MR. KURITZKY: Right.

CHAIR STETKAR: -- because of the plant-specific ways that people do testing, plant-specific ways that people come out of an outage, and your ability to actually monitor or know the status, the internal status, of valves, whether they're check valves or motor-operated valves, so that, as you get into exceedingly small frequencies of large leaks through two valves that are nominally closed, the importance of these other conditions where you think

one valve is closed but it isn't and maybe even do a test to actively open that second valve and, oh, my God, the first valve is open and you can't re-close the second valve, those can be maybe more important in frequency and in terms of size of leak rates than all of the other stuff that you've done.

I'm not trying to say -- I think that what was done for the expert elicitation was very important and very good. But in terms of completeness in the sense of are we doing a full scope risk assessment, I'm really curious about why you're not addressing those other scenarios.

MR. KURITZKY: So a couple of points. First of all, when we talk about full scope, it's been mentioned a couple of times, full scope deals with all the initiators and other things. Specific issues I don't make full scope or not. Those are various assumptions of things you're going to address in your study. So we're doing a full-scope PRA.

But as to whether or not we've addressed those specific items, again, you're exactly right, Mr. Stetkar. The idea, it's very plant specific. Do they monitor the space between the valves? Do they know if one has been re-closed or not? What type of, what's their order of doing things coming out of shutdown to

see whether or not they close?

Now, we have not done a rigorous analysis of that, and I think you have a good point. The fact that it initially didn't matter because we had such high failure rates that they were not going to be major contributors. Now that, without jumping the gun, their failure rates have come back down, you're right. That could be more of a contributor.

I don't remember the exact basis we gave for not including them in the model, but an argument certainly could be made that that's something that should be looked at more carefully and that might be an item that we have on the list of things for further analysis or review or improvement or update to the model. That's something that we may want to take a look at.

So I'll grant you that. With the numbers now coming down, that becomes, relatively it could become more important. But, again, I don't remember exactly what the basis was that we gave for not considering it.

Okay. So with that, let me give it over to Steve. Oh, excuse me.

MR. SCHRAEDER: John Schraeder from Idaho National Laboratory. To the extent that those events you're talking about are occurring and we're catching

them in the data collection effort, you would see those in the database as mis-positioned events or spurious transfer events. So, yes, we do tabulate those. There is a rate inherent with that, but it's probably conservative. So if the actual rate of specifically what you're asking about is below our measurement threshold, our data capture threshold, then we wouldn't have any idea what the rate actually is. But to the extent it's showing up at a rate that you'd expect to see events, given the amount of exposure we have and the failure rate that's inherent in that, we have it.

MR. SHORT: Okay. Let me just find the slides here.

CHAIR STETKAR: I don't care about the data. You're not modeling the scenarios. That's the important thing.

MR. SHORT: That's the important thing.

MEMBER BLEY: And I don't know which is more important probabilistically, but both ought to be considered. I agree with John.

Before we get into it, Steve, a couple of questions. I did see you gave us your experts later in the slides, and you tried to quantify different leak sizes. Did you have the experts identify different failure modes and the valves that would fit with those?

MR. SHORT: Well, yes, and I can talk a little bit about that. But if you go into the --

MEMBER BLEY: When you hit the right spot --

MR. SHORT: Yes, okay.

MEMBER BLEY: -- you can talk about that. That would be --

MR. SHORT: Just quickly, if you go into the experts' data sheets, which are in the appendix, you'll see that they talk about different possible failure modes that they thought about as we were going through the elicitation process.

MEMBER BLEY: Okay. We're just trying to secondguess you. Here are two, three, six different failure modes and trying to get all the experts to acknowledge there are different failure modes and then the likelihood of each would have seemed a really good structure to me. But that isn't what you did, I think.

MR. SHORT: We did not do it by failure mode. That is correct, if that's the question.

CHAIR STETKAR: Before you start, and I don't know when the best place to ask this is, you restricted this to -- we'll get into how you correlate leak size to re-grade, but you restricted it to leak sizes that are greater than 0.8 inch equivalent diameter because you assert that the operators have enough time

under those conditions to fix things.

Now, the small LOCA initiating event frequency for the Level 3 PRA, I went back and looked it up, is breaks between 3/8ths of an inch, 0.375 inches, and 2 inches. So now I'm not sure why, for a 0.8 inch break for an interfacing system LOCA you don't care, whereas for a small LOCA, for a break that's much smaller than that, we care. So how is this consistent?

MR. SHORT: The logic that we used there was is that we looked at the Vogtle analysis of how long it would take for a leak to drain the RWST and basically result in not having sufficient cooling for the core to keep it cooled. Their analyses, their MAP analyses or thermohydraulic analyses, concluded that they had enough potential actions that they could take over a 30, I think it was 30-hour, 36-hour, somewhere around that time period --

CHAIR STETKAR: Thirty hours.

MR. SHORT: -- a 30-hour time period that they could essentially result, mitigate a leak size that was on the order of 0.8 inches.

CHAIR STETKAR: So there's no risk whatsoever from an interfacing system LOCA leak of the equivalent of 0.79 inches and, yet, we are quantifying explicitly the risk from a small LOCA size, inside the

containment by the way, of 0.376 inches?

MR. SHORT: First of all, there's --

CHAIR STETKAR: So I'm confused. The reason I'm confused is that, in the expert elicitation, we have this mysterious gap between zero and a magic 0.8 inches, and I, for the life of me, can't figure out how the experts accounted for that gap. And so that's part of the expert elicitation.

From a PRA perspective, I don't understand how the PRA team didn't say, well, no, we're interested in small LOCAs, which are leak rates equivalent to 3/8ths of an inch or larger size because we care about those inside the containment where we can have the containment intact and we have a lot more ability to mitigate those small leaks inside the containment. And, yet, you're asserting that, you know, for a 0.79-inch break that goes outside the containment there's zero risk.

MR. SHORT: Okay. So first of all --

CHAIR STETKAR: I don't know how that would affect the expert elicitation results because I have no idea how the experts accounted for that conceptual gap, but we'll get into the gap later.

MR. KURITZKY: Yes. So I, first of all, want to say, there is no zero risk for anything in PRA. So it's just what we model and what we don't model.

There's obviously a risk for everything.

You make a good point. We had some discussions about that afterwards, too, because there was some inconsistency in that lower bound. And I agree with you. If we were to do the whole thing over from scratch, we would have used a different lower bound for the thing. Unfortunately, we do pick it up early on, and so that's what the experts had when they did their analysis. And so we were left trying to figure out, well, can we justify -- I mean, that's the results we have. We're not going to re-panel the experts, so we had to live with those results. And so we had to try to come to grips with ourselves that we were okay with the fact we did not have that lower part of the spectrum covered, and that's what I think Steve was trying to explain to you.

But you're right. I agree. If we were starting over, if this were day one, we would have had, the spectrum would have gone down with that lower limit size. No question about it. No question.

CHAIR STETKAR: Thank you.

MR. SHORT: Any other questions before we get started, I guess?

CHAIR STETKAR: The only reason I brought them up then is I didn't want to throw monkey wrenches --

MR. SHORT: Okay.

CHAIR STETKAR: -- elicitation. That's all.

MR. SHORT: Oh, yes, okay. So let me just kind of go through the project team a little bit. I'm the project manager, co-principal investigator with Mike Zentner, who some of you may know. I don't know. He's a long-time PRA guy, mostly in the DUE world. And then we had Bill Ivans kind of supporting us on the technical integrator scribe role as we were eliciting the results from the PRA, from the experts. Bill is --

MEMBER BLEY: Are these all PNNL guys?

MR. SHORT: Yes, all these are PNNL people. That's correct. Now, Bill has experience, he worked on the Westinghouse WCAP document related to IS common cause analysis and ISLOCA analyses. Don Daly, along with, you'll see, Kevin Anderson, they supported us in developing the probability distributions and taking the expert data and converting those into distributions. Steve Unwin was a project consultant that we used. He was going to be here today but ended up having a conflict, so he couldn't be here.

MEMBER POWERS: Worked out your prior distributions for you.

MR. SHORT: Pardon?

MEMBER POWERS: Did he work out your prior distributions for you?

MR. SHORT: No, no. Steve? He just consulted with us. When he didn't think we were doing the distributions right, he let us know.

MEMBER POWERS: I bet you he did.

MR. SHORT: And then Bruce Schmitt was supporting us. He did some thermohydraulic stuff, and I'll talk a little bit about that for us in a little bit. He basically did the analysis that correlated a leak, a valve leak size to a gallon-per-minute, effective diameter to a gallon-per-minute type analysis.

MEMBER BLEY: Before you leave the first page, can you explain to us in your elicitation process the difference between a facilitator and a technical integrator?

MR. SHORT: Yes, I'll tell you. So Mike Zentner, he was facilitating the meeting itself. He basically pulled most of the presentations and the process together and facilitated and led the exercise. Bill had more of an ISLOCA background, and so he basically helped us make sure that we were addressing what we thought ISLOCA from the right perspective in the analysis.

MEMBER BLEY: Okay. But Mike took care of the things like controlling bias and interactions --

MR. SHORT: That's correct. He took care of all that. That's correct.

So just some background. Obviously, we used the Vogtle plant as the basis for doing the elicitation from, and so that's important because we were looking specifically at valves and the RHR or SI type systems within Vogtle itself. We early on decided to focus on the residual heat removal and safety injection systems as the ISLOCA pathways of interest, predominantly because of what Alan was saying earlier. Those were driving the risks in the all-three PRA model. There are obviously other contributors to ISLOCA, such as charging or RCP seal cooling and pathways such as those. Those, in the Vogtle PRA model, were much smaller contributors. They weren't showing up in the L-3 PRA model, so we focused on the key contributors, and that was the scope that we took on in the expert elicitation.

Some specific things we looked at. Number one, Alan mentioned it earlier. The current database has a failure rate for small leaks and a failure rate for large leaks that's based on, that's an extrapolation or it's basically a ratio of the number of large leaks

to the number of small leaks kind of thing. And so we focused on, our expert elicitation was largely focused on seeing if we could improve upon how the failure rates for large leaks might be or I guess coming up with a better method or approach to determining what a large leak failure rate would be based on expert knowledge. We did that for both the check valves and the motor-operated valves for internal large leak failure modes, okay? Again, we specifically looked at the MOVs and the CV designs that were in in the Vogtle systems, RHR and SI systems.

We also had the experts do elicit a conditional failure probability for the second valve that was downstream from the first valve in a series of two valves, isolation valves. I'll talk a little bit more about that later. We originally were going to try to elicit common cause failure, and we had the expert team kind of ended up concluding that common cause is not really relevant to this type of failure, to the failure of isolation valves that normally are not operated and are normally closed, and so they're not regularly manipulated during operation. So we went to a conditional probability of failure. I'll talk a little bit more about that a little bit later.

We also looked at the possibility of being

able to potentially close a normally open MOV in the pathway that could isolate the failure of the ISLOCA, and so we looked at failure to close probability. And then the last part of it is --

MEMBER BLEY: And for that you looked at many specific valve designs --

MR. SHORT: That's correct.

MEMBER BLEY: -- and operators?

MR. SHORT: That's correct, that's correct. And those MOVs are not isolation valves. They're not really designed to be isolation valves.

MEMBER BLEY: And they're not designed to operate under --

MR. SHORT: Under high differential pressure.

MEMBER BLEY: I want to ask a question about how, I guess, probably how the facilitator controlled the interaction. Looking at your group of experts, a few are real valve experts, a few understand failure modes in steel kind of systems, some are more PRA guys and common cause guys, some have collected data for a long time. When you got into a situation like the one you just talked about where really understanding the forces, the stresses inside the valve are really crucial, did you somehow make sure the people with the

real expertise in that area were either given more weight or somehow --

MR. SHORT: I understand the question.

MEMBER BLEY: -- the expertise was addressed? Because there was a wide variety of folks on this panel.

MR. SHORT: We also had, you know, we'll talk about it later, we also had a system expert from Vogtle there, and we also had a pipe failure type expert. Yes, the way we did that is -- well, without going through the process in a lot of detail, we initially did elicitations individually and brought the group, the team together and had them elicit, you know, talk together about their reasons for why they rated something the way they did or evaluate something the way they did.

So the experts had an opportunity to take all that into account, but the main thing what we did was is we asked the experts to rate themselves in terms of their level of expertise in these different categories. So we're talking about valve failures or mechanisms, talking about common cause or PRA-related stuff, and the pipe failure type stuff. And so we asked them to rate themselves and ranking them one to five, one being an expert and five not being, okay? And in

the end, what we ended up doing is we used that to basically say anybody rating themselves as three and above we use their results in developing the distributions. If they're four or five, they --

MEMBER BLEY: And this was a technical integrator's role, I suppose?

MR. SHORT: That's correct. That was the technical integrator's role. Some, you know, in some cases, the expert chose not to even address the issue because they didn't consider themselves an expert in that.

MEMBER BLEY: I worry more from the other side, the guy who says he's an expert but really has never touched a --

MR. SHORT: Right.

MEMBER BLEY: -- valve or designed one or operated one.

MR. SHORT: Right, yes, yes. I understand the concern. We tried to address that through this ranking process.

MEMBER BLEY: I'm starting to look through the details.

MR. SHORT: You can look through the details --

MEMBER BLEY: I haven't done that yet.

CHAIR STETKAR: But it did rely entirely on those self evaluations?

MR. SHORT: That's correct. We did not make any determination.

CHAIR STETKAR: Three or better, they're in. Less than three, they're out.

MR. SHORT: They're out. That's right.

MEMBER BLEY: Just a little more because I'm concerned about this. When you had brought them all together and they individually laid out their basis and I assume their experience, did it feel like people came to consensus around --

MR. SHORT: We didn't -- I would say, I would say that most people recognized the expertise that the others had. That's for sure.

MEMBER BLEY: Okay.

MR. SHORT: What I want to do is be careful is that we did not try to reach consensus in this elicitation process, but, you know, in general, if I were to --

MEMBER BLEY: You didn't do the SSHAC thing even though you used the SSHAC framework of trying to reach a consensus --

MR. SHORT: That's correct.

MEMBER BLEY: -- from the community?

MR. SHORT: That's correct. We did not feel like we had the resources to try and go towards a consensus.

MEMBER BLEY: Okay. I was really -- that's an important point. But the other point is, even though that wasn't a goal, did you feel as if you coalesced on some of the things or most of the things or --

MR. SHORT: I guess, I think everybody got their opinions out there. I think people took into account additional information that other experts had that they didn't necessarily have. My personal opinion in doing expert elicitation, I've done lots over the years for various types of purposes and things, is that, oftentimes, you have people you wouldn't necessarily consider a specific expert in a given area that has knowledge about how systems operate. So our system expert from Vogtle, he was very familiar with these systems, he understood how they operated, he was familiar with his, he had experience with failure, you know, failures in the plant. And so, personally, I considered his expertise relevant, even if you can't call him a failure modes and effects analysis expert on an MOV.

MEMBER BLEY: That's plenty.

MR. SHORT: Okay.

MR. KURITZKY: Also, Dr. Bley, I just want to mention one thing not directly related to the bias of certain experts versus others but, in talking about the level of expertise and talking about the closing of the leak and whether those valves were designed for that type of differential pressure, etcetera, you had made comments in previous briefings going way back that if we were going to do this we needed to have people who really understood valves, and I just want to say that I was at the expert, the joint meeting when they all came together. What happened was that joint meeting had people discuss, and the experts were allowed to go and readjust their responses based on what they learned at that meeting. And the two gentlemen in particular that were true valve experts, I mean, these guys were valve experts. I'm not a valve expert at all, and they explained things so well in terms of exactly how these valves, every part of the valve, how it would work, how it was designed, how pressures would impact it in different parts, whether there was certain designs that would be subjected to warping or would allow you to take this shock but then still work later. Their knowledge was tremendous, and they imparted that to everybody else, not in the way of biasing them to their personal beliefs but just in the knowledge that the other

experts really had a true understanding of how those valves worked in those environments and that could, you know --

MEMBER BLEY: That's what I was hoping you'd do, and I think that's really important because there are details there that you really don't know unless you've been designing and really testing valves under extreme cases.

MR. KURITZKY: Right. And if I could understand what they were telling me, I know other experts certainly learned from that.

MEMBER BLEY: Thanks.

MR. SHORT: Yes. And I think if you go back into the data sheets, you will see those experts captured a lot of their thinking process about those valves as they were working. Now, their concern, just real quickly, their concern was is they don't think in PRA world. So they were somewhat uncomfortable eliciting a probability of failure in a failures-per-hour kind of thing, and so I'm going to talk a little bit about how we worked through that.

MEMBER BLEY: Okay. Yes, I'm sure they start from either it can't happen or it can happen.

MR. SHORT: That's right. That is right. That's right. And none of them have seen major leaks

like this before.

MEMBER BLEY: Indeed it is.

MR. SHORT: So let me kind of walk through our process a little bit just to kind of tell you how we did this elicitation. The first thing we had to do was we had to lay out the problem description. That took quite a bit of effort. We worked a lot with NRC staff on this and internally at NRC and, to some extent, with the experts as we tried to lay out and define how we were going to develop the, define what parameters we were going to elicit and how we were going to go about doing that.

And so in order to do that, we put together some system notebooks that basically, and this is the proprietary, this contains mostly proprietary information on the Vogtle systems, the different valves, the different piping systems, the layout of the RHR and SI systems, information on the pumps and the heat exchangers and all those. So those are all in the notebook.

CHAIR STETKAR: Steve, let me interrupt you here for a second. We're now, I'm looking through your slides going forward. You've got a ton of information in there. It's 10:10. I want to take a break now and re-group because we have some hard stops. I have a

meeting that I have to go to at noon. We have a hard stop this afternoon at 1:50. We need to allow enough time for the topic this afternoon.

MR. SHORT: Okay.

CHAIR STETKAR: I don't know what the staff is preparing to present in the closed session on the Level 1 model, but there may be enough material on this expert elicitation to take us until noon.

So let's take a break and re-group because I'm concerned that we're going to hear about preparations and run out of time. So let's recess until 10:25 for a break and kind of re-group.

(Whereupon, the above-referred to matter went off the record at 10:09 a.m. and went back on the record at 10:27 a.m.)

CHAIRMAN STETKAR: We are now back in session. We had some discussion during the break, and what we decided was that the amount of material to be presented for the expert elicitation on the interfacing system LOCA is quite a bit of material and that the Subcommittee members are very interested in hearing about that material, both in terms of the elicitation process, because it has implications for other things that the Agency is doing, and in particular for this particular issue for the Level 3 PRA. And because of

that we are going to make the executive decision, we in the royal sense, that we will not hear a presentation today on the Level 1 internal events PRA status that was scheduled originally from 10:45 until 11:50. So we're just going to surplus that.

For the benefit of the Subcommittee members, what I'll do is -- as I've done in the past in terms of fact finding, I'll go through that material and prepare at least my input for the Subcommittee's benefit on those topics. And I think we've shared that with the staff in the past. So we'll try to do that. We may want to convene another Subcommittee meeting. Depending on how much material is available, rather than waiting necessarily until what it looked to be the September/October time frame for a full day Subcommittee, we might want to look at one in the, I don't know, May/June-ish-type time frame to pick up some of these other topics. But let's plan to spend the rest of the morning until 11:50 or noon on the expert elicitation.

And with that, Steve, that will give you a little bit more time and give us ability to have a little better interaction. So we'll go back to that.

Alan, did you have anything else?

MR. KURITZKY: Yes, this is Alan Kuritzky.

During the break I discussed with our Level 1 internal event PRA lead, just addressing one of the issues that got brought before break regarding a valve, one of the valves in series for the ISLOCA pathways being -- failing to close after maintenance or being left in the open position. And we actually do for the RHR hot leg section line -- where we had the two MOVs in series we do include in the fault tree modeling the failure of that one valve being left open, and then just the failure of the other valve to leak. So we do have that covered in the PRA model.

CHAIRMAN STETKAR: Good. Thank you.

MR. KURITZKY: And with that, Steve.

MR. SHORT: Okay. So back to the elicitation process. I'll quickly go through this.

So we prepared a problem description. We selected our experts. And as you've read the reports and we've discussed, we have a variety of different types of experts that encompass the range of expertise we needed for this process. We used a lot of GoToMeetings rather than get-together-type meetings to do some of the initial stuff that you tend to do to train the experts on what you're trying to do, go over the problem descriptions, walk through the data sheets and what we're trying to elicit from them. And then also via

GoToMeetings we did the individual elicitations with each of the individual experts.

And following the completion of that and the compilation of results, we held the group elicitation meeting where we brought the entire group together and discussed some of those results and gave everybody an opportunity to comment on each parameter being elicited, each valve that's being elicited, and an opportunity to revise their thoughts and input based on what they learned there. And then we developed a draft report that was reviewed by both the NRC and the experts. And what you have in front of you is the result, or what you have I think sent to you is a result of that, incorporating the comments that we received on that report.

MEMBER BLEY: So that was one thing I wanted to confirm --

MR. SHORT: Yes.

MEMBER BLEY: -- that in fact your expert group did see the final results and have concurred in --

MR. SHORT: Yes.

MEMBER BLEY: -- the way you presented it?

MR. SHORT: Yes, every one of them I think has accepted the report. We addressed all their issues,

I think. That doesn't necessarily mean that they necessarily liked the way we did the elicitation, but in the end the results were -- they were concurrent upon the results of what we did.

Just quickly, I wanted to walk through some of the comparison between the ISLOCA process and the SSHAC process. We had this preparation -- and we kind of went over this already. We had a preparation period where we worked with and trained the experts on what the problem was and working through training them on how we're going to go about doing the elicitation. Some of them didn't have expert or working knowledge of probabilities, and so we had to have some training on that. I'll talk a little bit later about some lessons learned from that. The training we had wasn't necessarily effective, I don't think, and so we do something different there. We're going to do it again.

We held the individual meetings where we put the data sheet in front of them. They had the data sheet in front of them. And as we talked with them over GoToMeeting we elicited values. We entered those values from our end, sent those back to them for their review so that they could have a chance to see how we entered their information into our data sheets. And then they'd then send those back to us. We had put some

constraints on what they could do. They couldn't just change the values. If they were going to change a value, they had to tell us. What we were really looking for was the explanation, make sure we had the explanation for why they elicited the value they did rather than changing any values.

CHAIRMAN STETKAR: Steve, as preparation for this --

MR. SHORT: Yes.

CHAIRMAN STETKAR: -- in the report you have a list of references --

MR. SHORT: Yes.

CHAIRMAN STETKAR: -- that you provided to the experts. I suspect that not all of the experts had ever been involved in this type of elicitation process.

MR. SHORT: That is correct.

CHAIRMAN STETKAR: I didn't see in that list that you -- you've characterized this process as kind of an adaptation of SSHAC, or a SSHAC-like process, or something like that. I didn't see that you provided the experts either of the SSHAC NUREGs as a reference so that they kind of understood what a full expert elicitation, if you will, might be, the NUREG/CR-6372 --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- or NUREG-2117, which

is sort of the SSHAC in practice for Level 3, Level 4.

MR. SHORT: Yes, I guess what we did there is is it came up in our training that they could go get those; they're on the Internet, but we didn't feel it particularly relevant to the ISLOCA process and what we were trying to do. So in order to -- and trying to not overwhelm them with information -- and you recognize those NUREG documents are fairly large.

CHAIRMAN STETKAR: Yes.

MR. SHORT: We did mention to them what those were in our training stuff in our opening two GoToMeetings, but we didn't necessarily provide those to them. Is that is correct.

CHAIRMAN STETKAR: Okay.

MR. SHORT: And what we did give them was a lot of information, and I'm pretty confident that most of that information they really didn't look at anyway. So, but --

CHAIRMAN STETKAR: Yes, you can't ever control what --

MR. SHORT: What they do.

CHAIRMAN STETKAR: -- people read or what people don't read, but at least pointing people toward --

MR. SHORT: The right place.

CHAIRMAN STETKAR: -- this is how it ought to be done or has -- not even how it ought to be done, how it has been done in the past is -- you know, they can then choose whether or not they have enough time to do --

MR. SHORT: Time to look at it, yes.

CHAIRMAN STETKAR: -- to read that. Okay.

MR. SHORT: The group meeting and -- oh, and following the individual meetings after -- we talked about we had a group meeting here in Crystal City and where we brought all the experts together and had the opportunity to talk through each of the issues.

So, want to do the next slide? We tried to maintain the basic principles of SSHAC by using a structured process. We did that through a data sheet-type process. Those are laid out in the report. Don't want to go through those in a lot of detail, take a lot of time, but they're in there.

We tried to make sure we had the breadth of the state-of-knowledge, so we had quite a wide variety of individuals that represented the different types of expertise we had. All of them are very expert in their areas, 30-plus years, so various involvements with MOV Working Groups, PRA Working Groups and the industry.

Independence. We tried to sustain that by

making sure that the people that we brought in were coming from different parts of industry, not from the same company, different companies. And so, like our PRA experts, one we had was mostly spent a lot of his career at NASA. The other was from the nuclear industry.

Interactions. We tried to deal with that through our group elicitation and through our GoToMeetings where we got everybody introduced to each other, helped everybody to understand what each brought to the table.

And then integration. We can talk a little bit about that. We did not try to achieve consensus. I think we talked about that earlier. Rather what we tried to do is have each expert elicit to the best of their knowledge and what they thought the right answer would be or what the right estimate would be for a leak rate, for instance. And so then we combined those results up into distributions. And we can talk about that a little bit.

So we had different training sessions. And so the rest of I think we've kind of talked through already.

So I wanted to just quickly give -- the report gives a very detailed layout of a simplified flow diagram of the RHR and SI systems. This kind of gives

you a real summary of the basic configurations, valve configurations we were concerned about. For the RHR side you've got two isolation MOVs that are inside containment. And at the Vogtle site they're inside containment. And they're motor-operated valves. These valves are verified to be closed before they ramp up to full pressure. And then right on the other --

MEMBER BLEY: That's with the leak test between the valves?

MR. SHORT: That's correct, with the leak test between the valves.

And they also have a pressure relief valve, just for your information, right between the containment and MOV 1 there. That's about a three-inch valve that can -- the leak rate is about -- it can handle about 450 gallons per minute, something like that.

MEMBER BLEY: That's a thermal expansion ring --

MR. SHORT: Yes.

MEMBER BLEY: -- so, yes.

MR. SHORT: Yes. Other configurations. On the other side, on the hot leg injection/cold leg injection side there's --

CHAIRMAN STETKAR: I'm sorry, Steve. I'm

an engineer.

MR. SHORT: Yes.

CHAIRMAN STETKAR: I've carved out enough time for us here.

MR. SHORT: Yes, okay.

CHAIRMAN STETKAR: Where did you say that relief valve was?

MR. SHORT: Relief valve is between the containment and the MOV 1.

CHAIRMAN STETKAR: Okay. There's another relief valve downstream of MOV 2.

MR. SHORT: On the RCS side?

CHAIRMAN STETKAR: Yes, I think so. I think you made a big deal --

MR. SHORT: Upstream of RCS 2?

CHAIRMAN STETKAR: Well --

MR. SHORT: I mean, upstream of --

(Simultaneous speaking.)

CHAIRMAN STETKAR: I'm sorry.

(Simultaneous speaking.)

PARTICIPANT: -- the RHR System.

CHAIRMAN STETKAR: Outside. Okay. I'm sorry. I'm reading the drawing wrong.

MR. SHORT: Backwards? Yes.

CHAIRMAN STETKAR: Backwards. The relief

valve that you're talking about is outside containment.

MR. SHORT: No. No, in this plan it's inside containment. You have a three-inch relief valve --

MEMBER BLEY: And it dumps inside containment?

MR. SHORT: Pardon?

MEMBER BLEY: It releases inside --

MR. SHORT: Into containment. So it's available for recirculation in this -- it goes into the sump.

CHAIRMAN STETKAR: I'll pull up the drawing. Keep going.

MR. SHORT: Okay.

CHAIRMAN STETKAR: My understanding was from my notes that the relief valve is actually located physically outside the containment.

MR. SHORT: Well, there's --

CHAIRMAN STETKAR: And it relieves back into the containment.

MR. SHORT: Okay.

CHAIRMAN STETKAR: But keep going --

MR. SHORT: Okay.

CHAIRMAN STETKAR: -- because I don't want to keep us --

MR. SHORT: All right. Okay. For the hot leg injection side there is two check valves and then a closed MOV that basically only operates when you want to use hot leg injection. You've already kind of -- you've basically depressurized the system, so it's not really an isolation valve. It's a normally closed valve. That's the -- those -- that MOV is -- and then -- well, I'll move on.

So for the cold leg injection side there's the two check valves and then you've got a normally open MOV. And MOV 4 was the one we looked at and said, well, can we take any credit for that potentially in isolating an ISLOCA through those check valves 3 and 4 under certain scenarios? And so that's really where we looked at the failure to be able to close a probability for that MOV.

Quickly I'll go through the expert panel members. I think you guys have kind of -- you've already all looked at this.

CHAIRMAN STETKAR: I found it. Sorry, I was wrong. It is inside the containment.

MR. SHORT: Yes. Okay.

CHAIRMAN STETKAR: Never mind.

MR. SHORT: I was worried I had that wrong.

CHAIRMAN STETKAR: You were right; I was

wrong.

MR. SHORT: Let's see, the expert panel members. Let me just point out -- I'll kind of organize them into the different groups. Neal Estep, Kalsi Engineering, and Paul Knittle, MPR Associates. They're the valve engineers. They definitely have experience in evaluating the reasons valves have failed, what causes their failure. They work with the MOV Working Groups and the industry to improve the reliability of valves. All right. So they're expertise is vast.

On the PRA side we had Dr. Karl Fleming, Dr. Michael Stamatelatos. I don't think I need to describe those -- tell you who those guys are. They're fairly well known.

And on the pipe failure side we had Dr. Fred Simonen from Lucius Pitkin. Used to be PNNL, actually. And he's done a lot of work over the years on pipe fatigue and failure analysis.

And then we had Mike Horton. He's from Southern Company. He represented the systems that we were evaluating. He's a senior reactor operator. Had a lot of experience with how these valves operate and how they're tested and that kind of stuff. So he's able to really speak to those elements of the --

MEMBER BLEY: You talked about -- and I'm

sure he has lots of experience about operations and various kind of valve failures, but I bet he never saw a valve leak through at 50 gpms.

MR. SHORT: That's correct. That is correct.

Let's see. So I guess we're kind of ready now to go into each of the different parameters we elicited. So the first is the internal large leak failure rate. We basically provided the experts with a significant amount of information. You saw it in the report. We produced these system notebooks that gave a very detailed description of these systems, pieces from the safety analysis reports.

We actually went down to the Vogtle plant. Well, actually to Birmingham to Southern Nuclear's headquarters. And we were provided individual drawings and design specifications and operating procedures, test procedures for all the different valves and components that were in the RHR and SI systems. So we compiled all that and sent that to the experts. That was a lot of information. The valve experts had clearly gone through each of those valves and looked at them. I mean, I was pretty impressed.

MEMBER BLEY: Let me ask some questions here. I didn't get to study your report as much as I

will in the future.

(Laughter.)

MR. SHORT: Okay.

MEMBER BLEY: I mean, you did a lot of stuff. I mean, there's a lot of reporting there.

MR. SHORT: Right.

MEMBER BLEY: The thing that's always worried me about this area is that the ways in which a valve can leak through at these large flow rates seemed to be pretty limited. Now, it's been 30 years since I delved into it in any detail, but the founder of the company, one of your valve guys came from -- had reported back then that the only case he ever saw of one like that was a failed forging, and it was a bad forging. And they found it in the test program. They fixed it. None of those valves ever went out to anybody anywhere.

MR. SHORT: Made it into a plant, yes.

MEMBER BLEY: Why I was hoping you would have focused on failure modes is I've seen lots of people extrapolate from very, very milliliters per day out. And it strikes me that the failure mode that leads to that kind of leak-through --

MR. SHORT: Is not --

MEMBER BLEY: -- isn't physically related to how you'd get these large ones. And did your valve

guys talk extensively and is it in the report, because I didn't --

MR. SHORT: Well, I think --

MEMBER BLEY: -- read it yet --

MR. SHORT: Well, yes, I didn't --

MEMBER BLEY: -- about how this can actually happen --

MR. SHORT: Okay. Well --

MEMBER BLEY: -- physically.

MR. SHORT: -- I guess we didn't really summarize those elements in the report itself.

MEMBER BLEY: Yes.

MR. SHORT: We kind of left those back in the data sheets. But if you go back there and you look at the two valve experts specifically, you will see where they talk about different sizes and how you might get a two-inch leak versus a four-inch leak or something bigger. And --

MEMBER BLEY: And see, this is the part I was hoping really got conveyed well to the guys who might be extrapolating from small failure rates or coming up with some uninformed prior and zero out --

(Simultaneous speaking.)

MR. SHORT: Well, I will tell you that these valve experts were not shy about sharing what their

understanding of how these valves might --

MEMBER BLEY: Okay.

MR. SHORT: -- fail during the expert elicitation. They're in a group meeting, okay?

Now, I'm not going to say that they specifically walked down through all the different types of failure modes. I think what the focus was is they looked at what they thought might be causes for a different gap size leak through those valves. Okay.

MEMBER BLEY: Okay. As long as they shared that.

MR. SHORT: Yes, and they --

MEMBER BLEY: Not just put it in their data sheets. That's what I'm really hoping happened.

MR. SHORT: I think Mike Zentner did a really good job facilitating. He actually --

MEMBER BLEY: That's good. That's good.

MR. SHORT: For each parameter and each valve and each leak size he gave each expert an opportunity to share their thoughts about that particular leak size for that particular type of valve. I thought that was a really good way he did it. And to the extent --

MEMBER BLEY: That should have worked, so I'm glad to hear --

MR. SHORT: Yes, to the extent --

MEMBER BLEY: -- that kind of detail.

MR. SHORT: -- that those who are more PRA-focused were able to understand their logic, you know, I don't know. Okay? I can only leave that to them. You're right, the PRA guys tended to focus on the small leaks and extrapolate when they're thinking. And so did our pipe failure expert. He's used to working in -- he had been involved in the LOCA expert elicitation meeting, so he kind of saw how this information got used. And so, he focused on the small leaks and then extrapolated. But he ended up being the one that evaluated himself out as a non-expert, so we didn't use what he had anyway in the valve failure rate analysis.

MEMBER BLEY: Probably shouldn't say this out loud, but out of all the people I read about in that group --

MR. SHORT: I know. I understand.

MEMBER BLEY: -- I sure wish he would have stayed and perhaps some others had --

MR. SHORT: I understand.

MEMBER BLEY: -- left.

MR. SHORT: I understand.

MEMBER BLEY: I will study those data sheets in some detail at some point in the future and

compare them with --

(Simultaneous speaking.)

MR. SHORT: Some of them were very extensive.

MEMBER BLEY: Yes.

MR. SHORT: And there's a lot of repetition because -- while the valves may have been different, in a lot of respects the designs were very similar, even though they're different sized valves. And so they went through a lot of the same stuff with the different valves.

MEMBER BLEY: Multiple times? Okay. Thanks.

MR. SHORT: I don't think it's a hard read for you. Okay?

MR. KURITZKY: I'll just make one point, Dr. Bley. And I do remember from the group meeting that the valve experts did discuss in the group setting exactly how some of these valves would -- I mean, they got into the details of how physically the stems and the operators and the plugs would all possibly warp, or what it would take to make a certain leak size -- you know, that can make you a -- give you a bigger leak size.

CHAIRMAN STETKAR: Was that the leak size or was that failure to close? I read a lot of that stuff

under the failure to close under high differential pressure --

MR. KURITZKY: Right.

CHAIRMAN STETKAR: -- the design information. It seemed to --

(Simultaneous speaking.)

MR. KURITZKY: But I remember -- I thought I remembered them talking about --

CHAIRMAN STETKAR: Was it also --

MR. KURITZKY: Oh, yes.

MR. SHORT: Okay. Yes, because they talk about how it wouldn't take very much to get a fairly big leak size. I mean, one of the things -- I think the insights that they brought that may have been not intuitively understood by other people was that it didn't take a lot of a problem to get you a relatively decent leak rate through those valves.

MEMBER BLEY: I mean, it doesn't take much of a problem if a valve doesn't completely close.

MR. SHORT: Right.

MEMBER BLEY: Especially a gate valve.

MR. SHORT: Okay.

MEMBER BLEY: But if it's already closed and seated under pressure, for it to suddenly start leaking there are some failure modes that just cannot

get worse and lead to that. And that's what I was hoping there would have been some emphasis on.

MR. SHORT: And on the MOV side we did specifically talk about that. They have interlocks on those MOVs. Okay? So they'd talked about common cause. They just didn't see any way that if you opened one accidentally you could ever open the other one because of the -- and that kind of thing. So that was one area we'd specifically talked about.

MEMBER BLEY: I'll only say this, and I won't dwell on this, but I'm going to study later, the case I'm worried about is the case where the valve is seated under pressure --

MR. SHORT: Okay.

MEMBER BLEY: -- and suddenly it starts to leak. And I think the number of failure modes that can lead to that are pretty restricted. And I hope the valve guys made that clear. If you send a signal to open it, lots of reasons it won't open, but it might crack a little bit, and that could lead to a very large leak. And I can understand that. It's that other case I'm worried wasn't discussed as thoroughly as I want. And I'll look at the data sheets to see how well that was done.

MR. SHORT: Yes, and you can kind of look at our -- one of the things we tried to do to prompt

discussion was we had a column in our data sheets that was PNNL comments.

MEMBER BLEY: Okay.

MR. SHORT: And we said, well, when you're considering these, you ought to consider these different types of failure modes that we're aware of. Okay? We're not valve experts, but we're aware of these kind of things, so you ought to be thinking about these things when you're doing your elicitation.

MEMBER BLEY: Thanks. And I do know Mike well and I'm sure he did that quite --

(Simultaneous speaking.)

MR. SHORT: Zentner? Okay. So, yes. Yes.

Well, let's see. One of the things we made sure to communicate to the experts was known information about failure rates. Okay? And so, we did spend some time with them in our first set of training sessions going over 6928, what's in there and what that data means, and the appendices on how the large failure rates developed for internal leaks, large leaks.

So we're basically -- the way we elicited this -- well, okay. This is -- oh, I'll talk about that in a minute, but that's -- so we shared with them current information. And in addition, we shared with them EPIX

data on historical internal leaks from the RHR and SI systems. Not a lot there. Some. We did share that with them.

CHAIRMAN STETKAR: I wanted to ask you about that because there's not much --

MR. SHORT: Yes, hardly any --

CHAIRMAN STETKAR: -- information in the report.

MR. SHORT: -- on that.

CHAIRMAN STETKAR: However, if I look at NUREG/CR-6928, the 2010 version, it lists, or it asserts that there are 145 small internal leakage events for motor-operated valves and 204 small internal leakage events for check valves. And that's ostensibly the basis for the two numbers you have up here on the slides for the small leakage rates which are then multiplied by 0.02 to get to the large leakage rates.

MR. SHORT: Right.

CHAIRMAN STETKAR: So I have now an information base of 349 actual events that are somehow documented somewhere. Were the experts provided with those events so that I could go read and see that of the 349 events 267 were a few milliliters per hour?

MR. SHORT: No, we did not provide them with the information on the leaks from all of those that were

in 6928.

CHAIRMAN STETKAR: Now, they may not have actual leakage events, because I've read failure events, leakage rates, but sometimes you can infer from the description of the event how large the leak might have been.

MR. SHORT: Might have been, right.

CHAIRMAN STETKAR: So that if I were thinking about -- even if I was thinking about scaling or however the -- I'm not trying -- I don't know how the experts made their judgments and I don't care.

MR. SHORT: Right.

CHAIRMAN STETKAR: I do care about what information they had available to them. And it strikes me that having information -- you noted that you tried to explain to them what those failure rates mean and how they were derived. Well, I don't understand what a 2 times 10 to the minus 9 number is.

MR. SHORT: (Laughter.)

CHAIRMAN STETKAR: I don't.

MR. SHORT: Yes. Yes.

CHAIRMAN STETKAR: Honestly, I don't --

MR. SHORT: It's a small number.

CHAIRMAN STETKAR: -- understand that.

MR. SHORT: Right. But if I were being

asked to say what's the relative likelihood of getting a 4,500 gallon a minute flow through a break based on the 349 events --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- that I have that show me whatever they do, because I don't know what they show. I only know that they're characterized as small, and I don't even know what small means in the sense of 6928, because I couldn't find a definition of what small is.

MR. KURITZKY: Less than 50 gpm.

CHAIRMAN STETKAR: Okay. That's --

MR. SHORT: That's kind of written in the original 6928. The update I don't think is real clear.

CHAIRMAN STETKAR: Well, but the update just updates the data sheets.

MR. SHORT: Yes, that's right. If you went to the original report --

(Simultaneous speaking.)

CHAIRMAN STETKAR: And I thought I went back to the original and I couldn't even find it in the original, but it might be in there somewhere.

MR. SHORT: I think greater than 5, less than 50.

CHAIRMAN STETKAR: Greater than 5, less than 50? Okay.

MR. SHORT: I think is my understanding. Okay?

CHAIRMAN STETKAR: Okay. But anyway, in terms of -- they weren't given those actual event --

MR. SHORT: We did not actually give them those actual events. Yes, I guess maybe that would have been helpful. I'm not sure. Most of those failures are associated with systems -- normal MOVs or CVs and operating environments.

CHAIRMAN STETKAR: Well, that was my other question, is if some subset of those events actually applied to valves that are exposed to reactor coolant system pressure --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- that are exposed to a delta P --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- whether it's reactor coolant system pressure or for some other reason. Because it's a charging system you have a DP across the valve to see how the leakage rates for those types of valves compare to the general population that was used for these frequencies might have been useful. I just don't know.

MR. SHORT: Yes, I guess my --

CHAIRMAN STETKAR: And because we're not looking at 10,000 events, we're looking at -- we're not looking at 6, we're looking at a couple of hundred, 350 or so.

MR. SHORT: Yes, I guess my perspective on that was is that we have these valve experts that have spent the last 30 years diagnosing and working with industry on why valves fail, trying to determine what caused the failure. In my mind they are well aware of the types of leaks that have caused problems in the past in the industry and have worked significantly with industry in these working groups to help diagnose and solve and improve the reliability of valves. So from my personal perspective they should already have -- the valve experts themselves should have definitely had knowledge about past failures and what were the most significant ones and what were the causes for them and what were the design issues that caused them and that kind of stuff.

CHAIRMAN STETKAR: That may be true for the valve experts, but --

MR. SHORT: But for the other --

CHAIRMAN STETKAR: -- the valve experts don't think in terms of numbers.

(Simultaneous speaking.)

MR. SHORT: -- right.

CHAIRMAN STETKAR: The PRA experts don't understand valves at all. They think in terms of numbers, but they can look at a population -- a set of evidence; and as I said, I don't know what thought processes they used --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- and try to extrapolate from that set of evidence. It's a different type of thought process. And --

MR. SHORT: Okay. Yes.

CHAIRMAN STETKAR: -- I don't know who did what. Okay. Thank you.

MR. SHORT: That's a good comment.

So our elicitation approach, I'll just quickly go through that. We used the same elicitation form for all experts for each of the different types of parameters we were eliciting. Those are in the report, so you can see what those are and how we laid those out.

Basically for the large internal leak we asked the -- we used as a calibration point the NUREG/CR-6928 values for small internal leaks and we asked the experts to elicit -- with that knowledge they could tell us -- they could elicit -- they could give

us the leakage rate for each of the leak sizes in two different ways: One is is they could tell us relative to the 6928 a failure rate, or they could just give us their own failure rate based on their own modeling, or whatever knowledge they had.

And so, I guess we felt that that was a reasonable way to do it because, one, it captured the available information about internal leak rates from 6928. That's for which significant efforts have gone on over the years to capture.

We also felt it was a pretty decent approach for helping the experts understand how the information gets used in a PRA model. And so, while a valve expert may understand how a valve fails and have a general idea that this type of valve is hard to conceive could fail under the kind of conditions we're talking about, putting it into probability terms, they could understand, well, from my knowledge base of past failures and my knowledge base of what kinds of valves are out in the industry or used in the nuclear power plants what -- how would this valve under this kind of condition look different relative to my knowledge base of what's going on and the failure rates that have gone on in -- or failures and valves that have happened in the past. So I think it set a pretty good calibration

point for them.

I did want to note we weren't funded to have these experts go off and develop mechanistic failure models. When we talked with these experts, they clearly don't do development of mechanistic-type failure models. Their expertise is in understanding why a valve fails and improving the reliability of them. And so, they're not convinced that you could ever develop a good mechanistic failure model for different failure modes. And so, we did not see how it was possible to elicit out failure rates for each individual type of failure mode, so in the end we went with an aggregated failure mode, failures rates relative to those in 6928. So that's what we did.

I thought it worked pretty good. I do not believe that the experts were biased, that that biased them in any way. It helped calibrate them to past leaks and what failure rates those materialized in.

And alternatively, the experts could develop their own failure model. A couple individuals did do that, okay, and chose not to do the other method. And again, we elicited for different leak size categories. And we elicited lower bound, best estimate and upper bounds so that we could develop distributions. NUREG-6928 has those, or you can derive those from 6928.

So we used that. And then we elicited for each isolation MOV and CV, so on both the suction valves -- the RHR suction sized MOVs and then the hot leg and cold leg CVs.

CHAIRMAN STETKAR: A few questions on this one, Steve. Let me talk about process first.

MR. SHORT: Yes.

CHAIRMAN STETKAR: When I read the report it said the facilitator asked the expert to provide -- I think it said in sequence a lower bound, a best estimate and an upper bound for each of them. My experience, it's often useful to ask an expert first to say, well, how bad could it be, how good could it be, and what's your basis for how bad and how good could it be? And then based on your thoughts about that, now what might be your best estimate? Oftentimes if you ask someone how good it could be, that immediately biases them because they say, well, my best estimate is it's something higher than that and my worst estimate is, well, it's got to be a lot higher than that.

So why did you use this kind of sequential lower bound, best estimate, upper bound elicitation order rather than something that's been tried in the past and in terms of trying to get the experts to first understand the range of their uncertainty and then

provide a best estimate?

MR. SHORT: Well, I guess I'd answer that from the perspective that we're talking about failure rates that are 10 to the minus 9 order. So how are you going to elicit from a valve expert something that is almost impossible --

CHAIRMAN STETKAR: But --

MR. SHORT: -- never been experienced --

(Simultaneous speaking.)

CHAIRMAN STETKAR: But you weren't asking them, I hope, to give you a 3 significant figure on the order of 10 to the minus 9 or 12, or whatever it is, per hour. You were asking them given what you understand about the failure modes and leakage rates that contribute to that teeny-tiny number, what's your best -- what's your uncertainty and your best estimate about how the leakage -- the likelihood of leakage would decrease given what you understand about how valves work, or don't work?

And that's not -- that same question would apply if the absolute leakage rate was 10 to the minus 1 per year. Doesn't make any difference what the absolute leakage rate is because my understanding about how the leakage rate would scale and what types of failure modes would contribute in theory should be the

same. It shouldn't depend on what the absolute value of the leakage rate should be.

So I hope you weren't asking them understand teeny-tiny numbers, because even the PRA people don't understand those teeny-tiny numbers.

MR. SHORT: Well, I think that the -- so if I understand your question correctly, you're suggesting that an expert could -- well, I think what you're asking is is did the experts look at different failure modes and decide which ones are more likely and which ones -- which -- for different leak sizes which might -- what type of failure mode might most cause a different type of leak -- that particular leak size?

CHAIRMAN STETKAR: I'm not trying to get even that precise. I'm trying to ask about the process in terms of if I ask an expert first; and I don't care whether I ask him how bad it could be or how good it could be first. I tend to be negative in terms of my outlook on life, so I usually ask people how bad could it be. So if I ask them first how bad could it be and why could it be that bad -- so I get them to think about all the things that could contribute to how bad it could be. And then I say, well, how good could it be and what are all the things that can contribute to that, now I've got them thinking about a range of their knowledge given

the they have available.

And then I say, well, now that you've carefully thought about that range of how bad it could be and what contributed to that, how good could it be, what could make it that good, now if you had to bet over that range, where would you bet? And it might not be the midpoint. I might bet now considering everything that it could be closer to how good it could be than just a -- I don't care whether it's a geometric or arithmetic mean or whatever.

MEMBER BLEY: Let me just toss in one thing. I agree with John, but for a different reason.

Back in the '70s and '80s there was a fair amount of literature where people tried different approaches. And it was pretty well documented if you come in with your best estimate -- I don't know anybody started with a low estimate --

MR. SHORT: Yes. (Laughter.)

MEMBER BLEY: So even --

MR. SHORT: I'm sorry. I'd say that's the way ours started, too, with the least estimate.

MEMBER BLEY: Or even if you started with an arbitrary number and tell me how much worse it could be or better, that once you have an anchor point, even if you know it's not a real one, you tend to anchor to

it and have more narrow distributions, where pushing for the extremes tends to expose the uncertainty better. So I think there's a fair amount of literature supporting that point of view. But that isn't what you did, so --

CHAIRMAN STETKAR: Yes, and the reason I brought it up was that in the slide presentation in Appendix E on the training exercise --

MR. SHORT: Okay.

CHAIRMAN STETKAR: -- you went through that seemed to anchor first on the best estimate median value --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- within an assessment of the uncertainty, but in Section 3.5 of the report where you describe the individual elicitation sections it explicitly says "and for each leak size began with lower bound and proceeded to best estimate and then to upper bound," which is this sequential-type process.

MR. SHORT: Yes.

CHAIRMAN STETKAR: And what I'm probing is if indeed that's the way that the elicitations were performed, that --

MR. SHORT: Yes, I guess the way -- I don't know. I might not have described that quite right. I think the experts tended to focus on the 50 percent

first, right? And I think the intent of that sentence was to say that we elicited each of those data points and we elicited -- and probably what it should say is we elicited in kind of the order that they were most interested in starting with. And usually that was the 50 percent. That was kind of the -- yes, well, the 50 percent value as their starting point.

Now what they did also do; and I think this is the part of your contention, is is that when we looked at the 5 percent and then the 95 percent, there were those experts who felt that they were -- that the 95 percent -- well, they didn't all use the same ratio. I should say that. So they didn't say that I came up with a factor of 100 lower for the 50 percent and then we used that also for the 5 percent and the 95 percent. Most of the experts looked at that as -- a 95-percent confidence means I have a sure confidence what the rate is. And so they would have done a higher -- they would have done a different ratio than -- and five percent I think tended -- they tended to look at that kind of the same as a moderate. But, so I guess I do want to say that the experts generally I think started with the moderate and then looked at the 95 percent and the 5 percent relative to how they answered the 50 percent. Okay? And so --

CHAIRMAN STETKAR: But I think as Dennis mentioned there's been a lot of work done to show that that type of process tends to underestimate the actual uncertainties compared to a process that first asks the experts to answer the question how bad could it be, then how good could it be, and then what is your best estimate?

MEMBER BLEY: And to answer how bad could it be in terms of what are the things that could make it --

CHAIRMAN STETKAR: Yes. No, that's --

(Simultaneous speaking.)

MEMBER BLEY: -- given the high end, given that pseudo-model or something of what are the things that could make this worse, then hitting that anchor point high tends to give you broader uncertainty bounds --

MR. SHORT: Okay.

MEMBER BLEY: -- and probably more appropriate ones.

CHAIRMAN STETKAR: The other question I had related to this is the upper and lower bounds are used quantitatively to represent the 5th and 95th probability percentiles. Given the fact that some of your experts likely have very little background in probability, what sort of training was done to make them aware of the fact

that when you say this is my upper bound, worst case, however you want to characterize it orally, that there's still a five percent probability that things could be worse than that, that it isn't the absolute worst that the world could be or the absolute best that the world could be, there's still on each end a five percent probability that it could be better or worse? Was anything done to sort of orient people that way?

I mean, here's where the PRA people who think maybe in uncertainty distributions would intuitively understand that, but maybe not the valve experts.

MR. SHORT: The valve kind of experts. Did we -- so I'm trying to think back to our training exercises. I guess we talked about -- we generally talked about distributions when we did the training exercise. We showed how a distribution was developed based on their provided input and laid those out in their -- as part of the second online meeting that we had to kind of talk about those distributions and what they mean, the fact that there are tails on both ends. And so, we used their elicited values to develop that distribution and let them know, I guess, that there were tails on each end, that the distribution didn't end just at 5 percent and 95, or min-max, or whatever. But other

than that I don't think we did much more than that.

MR. KURITZKY: Steve, did we ever characterize the 5th or 95th percentiles as being as good or as bad as it could be?

MR. SHORT: I don't think we ever characterized it that way. We never characterized it as good or as bad as it could be.

MR. KURITZKY: We just talked to it as a 59 percent distribution --

(Simultaneous speaking.)

MR. SHORT: Yes, the 95-percent confidence is what we talked about it as. And so recognizing that you might be able to get worse or you might be able to do better. I mean, so --

MR. KURITZKY: Right. So I think the PRA guys, as has been mentioned, would clearly understand that concept. The other guys also being engineers and whatnot, they may not have been as sensitive to it, but I think the concept of having an 95th percent confidence or percentile I think was probably not totally lost on them.

MR. SHORT: Well, we wanted to make sure that they weren't coming up with the actual worst case thing that they could think of. I mean, that -- so --

CHAIRMAN STETKAR: Okay. I mean, as long

as that was part of the --

MR. SHORT: That was part of our discussion of the distribution for the training exercise we had, okay, on distributions and -- which we used the same training exercise that was used in the LOCA analysis, the 2008 LOCA Frequency Report. If I had to do it again, I'd do something different for these distributions, because those elicitations -- that sample problem was more probability is associated with what you'd ordinarily think of, you know, 30- percent, 50-percent, 90-percent-kind of thing. Not things like what we're talking about. So we had to do some more discussion of that during our group meeting about what really small frequencies really mean.

MEMBER BLEY: I wanted to ask you a little about that because as you said 10 to the minus 9 per hour is a really small number, and as John said, he doesn't know what that means.

MR. SHORT: Right.

MEMBER BLEY: Well, for me I have to get out my pencil and say, well, there's 10,000 hours in a year and we got 100 plants over 10 years, real rough, so it's about a 10 to the minus 2 over the industry lifetime, which is still pretty darn small.

MR. SHORT: That's still small. That's

right.

MEMBER BLEY: But putting it into those terms at least I can think about it.

MR. SHORT: Yes, I think we talked about it terms of a reactor year, so we went over reactor year and it was still kind of small, right? I don't think we did --

MEMBER BLEY: But we've got a lot of reactor years, but still we don't have --

MR. SHORT: Right.

MEMBER BLEY: -- enough reactor years to have expected to see something this small.

MR. SHORT: To have seen one of these, right? Yes.

MEMBER BLEY: Yes.

MR. SHORT: And we kind of explain that, and we talked about that in terms of what causes deaths. I mean, I think that we put the figure in the report about different -- what's the likelihood of being killed by various types of events, solar flares, that kind of thing, and meteors, whatever, in the end is what we ended up trying to describe that.

MEMBER BLEY: I mean, that approach over the life of the industry ought to resonate with guys like the valve guys. I mean, they don't know what a 10

to the minus 9th per hour is, but they know what they've seen and what other people have reported on, and that ought to work better. I'm sorry --

(Simultaneous speaking.)

MR. SHORT: But what they do know is is that they've never seen one.

MEMBER BLEY: Yes.

MR. SHORT: And the industry's never seen one.

MEMBER BLEY: So that gives you at least an anchor point, yes.

MR. KURITZKY: Right. And as Steve was saying, it became clear during the joint meeting that they didn't have a feel for some of these low, very low probability numbers, so I think Mike Zentner had put this -- a chart that talked about cause of death in very, very low numbers to try to calibrate them a little bit on that.

But what I wanted to bring up, which I think is almost now becoming moot because we're kind of moving at a slow pace and we have a lot more to go, but there was an option -- we want to put the option on the table. As part of the Level 1 presentation, the closed meeting, we had a couple of slides, just two slides on ISLOCA implementation, how it's in the model and how we use

what came out of the expert elicitation for that, which addresses some of the issues that have been raised throughout this morning.

CHAIRMAN STETKAR: Yes, and we'll --

MR. KURITZKY: So if we had 10 minutes or so at the end we could throw that up there, but at this point I think it might be --

CHAIRMAN STETKAR: We're not going to have that time. We're going to be very lucky --

MR. KURITZKY: Yes.

CHAIRMAN STETKAR: -- to get through this.

MR. KURITZKY: Okay. So let's --

(Simultaneous speaking.)

CHAIRMAN STETKAR: Let me ask before we get to the results here --

MR. KURITZKY: Okay.

CHAIRMAN STETKAR: -- because quite honestly it would be good if we get through all of the material, but I think we want to understand the leak stuff, because that's more of the process and important as a contributor also.

MR. KURITZKY: Yes.

CHAIRMAN STETKAR: You made a note that or you noted that the expert -- the initial elicitations were done with the forms that you provided that showed

leak size and leak rate, and that the leak rates were wrong.

MR. SHORT: Right.

CHAIRMAN STETKAR: So you went back and you -- and they were wrong on the low end.

MR. SHORT: Right.

CHAIRMAN STETKAR: So you went back and redid the leak rates to show the range of leak rates that would apply under specific thermal hydraulic assumptions or whatever for that range of sizes, and that as part of the group elicitation everybody went through the process of reevaluating their estimates based on the leak rates. Now I'm a leak rate kind of guy. I'm not a leak size kind of guy --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- because I -- so --

MR. SHORT: We have --

(Simultaneous speaking.)

CHAIRMAN STETKAR: -- it would have probably affected me quite a bit, but that's just me. I'm curious how much it actually affected the experts when you went back?

MR. SHORT: It did not affect the valve experts because they think in terms of leak size --

CHAIRMAN STETKAR: Okay.

MR. SHORT: -- rather than leak rate.

CHAIRMAN STETKAR: All right.

MR. SHORT: Okay? I'd say that two experts changed their evaluations as a result of the revised leak rate.

CHAIRMAN STETKAR: Leak rates?

MR. SHORT: Okay? So it certainly affected one expert specifically --

CHAIRMAN STETKAR: Okay.

MR. SHORT: -- because he was relying upon those to come up with his failure probabilities.

CHAIRMAN STETKAR: Yes, okay.

MR. SHORT: So --

CHAIRMAN STETKAR: Okay. That's good enough to keep us kind of --

(Simultaneous speaking.)

CHAIRMAN STETKAR: That was a curiosity.

MR. SHORT: So basically the way we compiled results is we took the individual expert's results and developed distributions. So basically for each leak size/leak rate category for each valve. And for each expert we developed these distributions. For large internal leak rate we used the gamma distribution function primarily. We did look at other distributions. For these low failure rates it didn't

make any difference, so we used the historical gamma distribution. That's what people usually use for large internal leak rates.

We then took the individual results, combined those into a single mixture distribution that my peer here Kevin can discuss, if you've got specific questions on that.

Basically we ended up deciding and combining those into a mixture distribution. We ended up using the same method as was used in NUREG-1150, which was an arithmetic average of the individual probability distributions. And you'll see that in 1150 they talk about some of the positive and negatives of that approach. Generally we kind of picked it because it results in more conservative 95th percentile extremes, okay, because the extremes dominate. So that's kind of why it worked for us. We decided it worked for us.

So after we developed that mixture distribution, we reported it in two different ways. Because that mixture distribution is not in a form that can be expressed in an algorithm, we provided the tables in an appendix for that mixture distribution. But because we want to use the results for a PRA use, we also fit a gamma distribution to that mixture distribution and reported that.

CHAIRMAN STETKAR: Okay. If you go to the -- I'll let you get this --

MR. SHORT: Slide.

CHAIRMAN STETKAR: You're essentially through this slide?

MR. SHORT: Yes, I'm essentially through it.

CHAIRMAN STETKAR: So flip to the next one, because it's got pictures on it.

MR. SHORT: Okay.

CHAIRMAN STETKAR: And I like pictures.

MR. SHORT: Yes.

CHAIRMAN STETKAR: So the first thing you did is the experts gave you best estimate upper and lower bounds and you fit a gamma distribution to those --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- because you like to do that.

MR. SHORT: Right.

CHAIRMAN STETKAR: And then you did a mixture distribution, the green picture here, of those, which was weighting each -- if you had n distributions, you weighted each of those distributions by one over n and merged them.

MR. SHORT: Yes, basically.

CHAIRMAN STETKAR: And the green distributions are back in Appendix M where you give the 100-bin histograms.

MR. SHORT: Yes.

CHAIRMAN STETKAR: So aside from the fact that you have fit a gamma to each of the experts, the green stuff is in principle the pure merged results?

MR. SHORT: That's correct.

CHAIRMAN STETKAR: Okay.

MR. SHORT: Yes.

CHAIRMAN STETKAR: And then you fit a gamma distribution to the green, which is the red on this picture.

MR. SHORT: That's right.

CHAIRMAN STETKAR: And if I look at the red on the picture on the left, I notice that its uncertainly is quite a bit less than the green.

MR. SHORT: Yes.

CHAIRMAN STETKAR: And hence, the mean value of the red is less than the mean of the green. And in fact, I actually did it for one thing and it's a factor of about one-and-a-half less --

MR. SHORT: Okay.

CHAIRMAN STETKAR: -- than the mean of the

green.

So my question is why are we doing this? You said, well, because we want to use it in a PRA model. Well, in a PRA model I want to use the best evidence available. And I got a 100-bin histogram back in Appendix M for each of those things, given the constraint that I fit each expert by a gamma, but at least I'm merged those gammas and just reported the results. Why for a PRA do we need a gamma distribution that reduces the uncertainty and gives me a smaller mean value?

MR. SHORT: Well, I guess our logic is is that --

CHAIRMAN STETKAR: Well, I'll ask Alan --

MR. SHORT: Okay.

CHAIRMAN STETKAR: -- because Alan's the PRA guy.

MR. SHORT: Okay.

CHAIRMAN STETKAR: Alan's got to use this stuff.

MR. KURITZKY: I honestly don't even say that. I mean, we've used the numbers that are in the table. I couldn't even tell you exactly --

CHAIRMAN STETKAR: Alan -- turn your mic on, Alan --

MR. KURITZKY: Oh.

CHAIRMAN STETKAR: -- because --

MR. KURITZKY: Sorry. I couldn't even tell you if those numbers I used came from the green or the red distribution. All I know is we used the numbers that are in the table in our model. And so whether they should come from the green or the red --

CHAIRMAN STETKAR: Yes, well, they came from -- the numbers on this slide came from the red distribution.

MR. KURITZKY: That's correct. That's correct.

CHAIRMAN STETKAR: And I will tell you that the 1.94E to the minus 9 for the first line item on there -- if I go back to the green stuff in Appendix M -- now, granted the fact that I didn't do a continuous differentiation of the smooth curve -- so I just did s step-wise differentiation -- I can't quickly find my number here, but it comes to be 2.6, or something like that. Big difference? I don't know. It's roughly a factor of one-of-a-half different.

MR. KURITZKY: Yes.

CHAIRMAN STETKAR: I only did it for one because I just wanted to make the point that we're now suddenly fitting a smooth-form distribution to something that we have already. It's not something that

you didn't have. You have it already in Appendix M. You can calculate a mean value because it's a 100-bin histogram from Appendix M, if you just want a mean value. And if you look at all of the curves in the report, Alan -- this is for Alan.

MR. KURITZKY: Yes.

CHAIRMAN STETKAR: If you look at all of the curves in the report, they all behave this way such that the fitted gammas are narrower than the pure -- I'll call them the distributions in Appendix M. They're all narrower. And hence, the uncertainties will be narrow and the mean values, because these tend to be very, very broad distributions, things that people don't realize unless you carefully look at this is the hash marks on the X-axis are two orders of magnitude. They're not even single order of magnitude.

MR. KURITZKY: Right.

CHAIRMAN STETKAR: So these are really broad distributions. They tend to have -- this one in particular has a factor of -- in the green a factor of 1,600 between the 5th and 95th percentiles. So they're really broad distributions. When I reduce it to the gamma, it's a factor of 1,090, if you want to be precise. But it's reduced considerably 5th through 95th.

MEMBER BLEY: I think it's a good question

for Alan. I would ask Steve, though, when you said because we're going to use it in a PRA, you wanted a parametric distribution that you could --

MR. SHORT: Well, the thing is is in a PRA if you're going to -- yes, if you want to do an uncertainty analysis on your results, right --

(Simultaneous speaking.)

CHAIRMAN STETKAR: But don't say in a -- maybe using the tools we use for calculating PRA at PNNL we have to have gamma distribution or some parametric distribution. That's what I think you're saying.

MR. SHORT: I'm saying generally that in CAFTA-type models, okay, the general use is gamma distributions, beta distributions --

(Simultaneous speaking.)

MEMBER BLEY: Well, gamma --

CHAIRMAN STETKAR: Can CAFTA take a histogram?

MR. SHORT: I am not aware of that CAFTA can take a histogram.

CHAIRMAN STETKAR: Well, boy, that's a pretty rotten --

(Simultaneous speaking.)

MR. SHORT: Okay. So --

(Simultaneous speaking.)

MR. SHORT: Well, SAPPHIRE can.

CHAIRMAN STETKAR: SAPPHIRE can?

MR. KURITZKY: So even though you're not directing the question at me, I'm not the person to answer it, because I don't have background in that area, but I'm hoping that John Schroeder, INL, can shed some light.

John?

MR. SCHROEDER: Yes, John Schroeder, Idaho National Lab. The tendency to resort to gamma distributions is for downstream users that like to do Bayesian updates. There is no other reason than that.

The quantification tools can use about any distribution that you might choose. So we could have made use of any value that you had come up with.

MEMBER BLEY: So can a Bayesian update.

CHAIRMAN STETKAR: Yes, but by the way, I have -- I can't give it to you because it was developed by the company that I used to work for, but I see a Bayesian update here that I can do on a histogram. It's not so good if I got a three-bin histogram. It's a lot better if I have a 100-bin histogram. It would be more analytically different -- I was going to use the term "precise," but that's not the right word to use. If I

knew that the thing was a pure form analytical function --

MEMBER BLEY: And there are more tools than the one from your former place. And in fact, in the NRC's own handbook for parameter estimation it gives a very nice Bayesian analysis tool that will do any kind of distribution you want.

MR. SCHROEDER: All right.

MR. KURITZKY: I will mention just to keep things in perspective that if the mean is off by a factor of 1.5, these ISLOCA contributions that we have in our study right now I'm not really going to lose a lot of sleep --

(Simultaneous speaking.)

CHAIRMAN STETKAR: No, no, but --

MR. KURITZKY: But whether or not it's --

(Simultaneous speaking.)

CHAIRMAN STETKAR: It might be 1.5 times 1.5 times 1.5. Okay? You're multiplying all of these things together.

MR. KURITZKY: Right. So --

CHAIRMAN STETKAR: So be careful because three times a factor of 2 is almost a factor of 10. Two times two times two.

MR. KURITZKY: And as you mentioned, that

there -- what was the range? It was 1,600 between the lower and the upper?

CHAIRMAN STETKAR: Sixteen hundred from the lower to the upper in -- just all I'm focusing on is the 0.8 to 2 distribution, because that's the only one I looked at. In the green curve in Appendix M the ratio is 1,600.

MR. KURITZKY: So I think that --

CHAIRMAN STETKAR: They show on the red curve is 1,090. They're still both very broad distributions.

MR. KURITZKY: Right.

CHAIRMAN STETKAR: But if you look at it, the differences -- and if you look at all of the pictures in the report, the biggest differences are on the upper bound tails, and the upper bound tails have the biggest effect in these skewed distributions on the mean values. So the worst we do -- if we try to do really, really good in the median down to the zeroth percentile, we aren't affecting the mean at all. If we try to do really good on the upper bound, we affect the mean quite a bit.

MR. KURITZKY: Yes, so I'm not a statistician. I can't give you an educated answer on why we should use one or the other. The arguments you make seen sound to me, and we take that feedback. I mean,

we'll take that back. But we've used those values. How much is that going to affect the results of the analysis? I can't tell you. I still don't think it's going to make a huge difference in terms of risk insight, but I agree that --

CHAIRMAN STETKAR: My point is that you don't need to create any new information. You have it already in the report. So when you say I don't know how much difference it's going to make, I'll say use the information that is the actual results from the expert elicitation, which is in this sense the green curve or the tabulated distributions back in Appendix M. You don't have to create anything more. You don't have to say, well, if I used this other stuff it wouldn't make much difference. Just use it. You have it available. You don't need to create it from anything. It's there.

MR. SHORT: Right, and we'll take that feedback and consider that.

MEMBER BLEY: But remember, this isn't the ACRS speaking. These are --

(Laughter.)

MEMBER BLEY: I would at least take a lesson home that there isn't a whole lot of reason to fit a distribution that you don't need to do if it's going to skew your answer, particularly if it's going to skew

the mean.

MR. SHORT: Which it does a little bit, yes. We worked a lot on that distribution, too, that fit distribution.

(Laughter.)

CHAIRMAN STETKAR: Well, I know. There's a lot of discussion about them and I know that a lot of work was put into it and it --

MR. SHORT: It's a hard thing to come up with.

CHAIRMAN STETKAR: Yes.

MR. KURITZKY: Okay. Duly noted.

MR. SHORT: Now, but it is -- and, yes, so I'd have to think about -- we were asked to develop a total failure rate distribution. And so we used those best-fit distributions to do that. And you can see that that also narrows the --

(Simultaneous speaking.)

CHAIRMAN STETKAR: Yes, that's -- there's --

MR. SHORT: So that was kind of a hard thing to do, but -- and if you want to get into how we did that, I'm not sure how we do it. I guess we might be able to do it from the basis data. I'd have to think about that. I guess I'd let my probability guys help

me figure out how to take the green curve and create a total distribution, because we -- that's --

CHAIRMAN STETKAR: You'd probably have to -- it's -- we don't have the time to do that --

MR. SHORT: Right. Right.

CHAIRMAN STETKAR: -- in terms of trying to solve the problem.

MR. SHORT: Right.

CHAIRMAN STETKAR: I think you'd have to step back to the individual distributions for each of the size ranges.

MR. SHORT: Well, yes.

CHAIRMAN STETKAR: Right, because it's -- the blue curve is intended to be the -- I don't know, the multiplier or the total failure rate --

MR. SHORT: Right. That's right. That's right.

CHAIRMAN STETKAR: -- for any size greater than --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- 0.8 inches in this case.

MR. SHORT: So, yes, I guess fundamentally if you kind of conclude on this slide here, what's interesting is is the large failure rate in 6928 to the

2010 update not much different than our total -- the mean from our total distribution after we've added them all up. So it was kind of an interesting conclusion even though our distribution is pretty wide on it.

Moving onto the conditional probability of failure of a second valve given failure of the first valve. I'll quickly go through some of this because it's kind of redundant. Again, we use the same elicitation form for all experts. I do want to focus on this point a little bit. We originally planned to try and elicit common cause failure probabilities, and that was the way the forms were originally set up. And so if you look in the training sessions back there, that's the way they were set up. After the group together the -- in last June, the team got together. They kind of came to a consensus that common cause failure didn't make a lot of sense for these type of failure modes. Wasn't really a failure mode-type thing for these ISLOCA-type of events because the valves are not regularly operated during operation. They're pretty much static.

But we did define a -- there was agreement that you might have some sort of increased probability of the second valve failing as a result of the first valve failing due to a pressure spike or some impact

upon the second valve. And so, we changed our method. We changed what we were listening here to just a conditional probability of failure given that the first valve failure -- the conditional probability that the second valve fails given that you had the first valve fail. And the experts consolidated, I guess, around that thought.

Then so we revised the elicitation to reflect that. Then that was a totally open elicitation. There was nothing to benchmark to or to calibrate to, or anything like that. So we also did the 5, 95 and 50 percent distribution on that.

CHAIRMAN STETKAR: Steve?

MR. SHORT: Yes?

CHAIRMAN STETKAR: On this, when I read through the -- I got really confused on the common cause stuff.

MR. SHORT: Okay.

CHAIRMAN STETKAR: And because of the time constraints I'll just cut to one of the issues that I wanted to raise.

When I read through it, it seemed to say that you asked the experts to give you a conditional probability of failure of the second valve as a function of leakage rate through the second valve without regard

to the leakage rate of the first valve. Is that correct?

MR. SHORT: No, we based it on the leakage rate of the first valve.

CHAIRMAN STETKAR: Okay. That didn't come --

MR. SHORT: Okay.

CHAIRMAN STETKAR: When I read the report, it didn't --

MR. SHORT: I probably need to -- I need to make --

(Simultaneous speaking.)

CHAIRMAN STETKAR: Because if I was thinking about it, I would think that the conditional -- but I don't know about valves -- that the conditional probability for failure of the second valve would be less perhaps if I had a smaller leak through the first valve compared to a very large leak through the first valve.

MR. SHORT: So, yes -- so --

CHAIRMAN STETKAR: And it didn't --

MR. SHORT: Come across.

CHAIRMAN STETKAR: -- come across when I read the report.

MR. SHORT: Okay. So if you'll look at the elicitation sheets, you'll see that what we do is for

each failure rate, each failure size we elicit conditional probabilities for any failure size given that failure size. And then we move to the next failure size and we elicit failure rates for that size.

CHAIRMAN STETKAR: Oh, okay.

MR. SHORT: Okay? So --

(Simultaneous speaking.)

CHAIRMAN STETKAR: Yes, so you do it for each size? Yes, okay.

MR. SHORT: That's what we did.

CHAIRMAN STETKAR: Okay.

MR. SHORT: And maybe I need to make it --

CHAIRMAN STETKAR: Okay.

MR. SHORT: -- expand --

(Simultaneous speaking.)

CHAIRMAN STETKAR: Yes, you're right. You're right.

MR. SHORT: Okay?

CHAIRMAN STETKAR: You're right. Okay. Good. Thanks. That helps. Thank you.

MR. SHORT: Yes. Let's see. Oh, and just the final bullet there. We did elicit for each pair of isolation MOVs and CVs in the RHR and SI system. So we used basically the same valves that we looked at from an independent failure point of view. We now looked at

them in pairs.

So the results. Same thing. We did the same thing as we discussed earlier. We did each valve design, each leak size category, each expert developed distributions. We used the gamma again. We did look at other distributions again. There was no difference because the failure rates were all -- I mean, the conditional probabilities were always a lot lower than one. And so, basically the beta and gamma distributions, the log-normal distributions, they all kind of -- they basically became the same, between the 5 and 95 percent anyway.

Again, when we combined them into a single mixture distribution, we used that arithmetic average of the individual probability distributions. I will note that there was a lack of spread sometimes for these. Some of the experts really didn't give us a spread on this. And so we did some mathematical manipulations to try and incorporate their input into the distributions. And we can talk a little bit about that, what I call additional data handling.

We tried to put a spread around the -- so that we didn't have these -- or 90-degree changes in the curves. Okay?

CHAIRMAN STETKAR: Did you -- again,

because of time, I disagree with perturbing my -- if I'm an expert, I wouldn't want somebody going in and saying that my uncertainty in my estimate is based on the average of the other people who expressed their uncertainties two sigma.

MR. SHORT: Okay.

CHAIRMAN STETKAR: That would bother me an awful lot.

MR. SHORT: Okay.

CHAIRMAN STETKAR: Did you go back and ask each of the experts who did not provide uncertainty bounds about why the didn't?

MR. SHORT: We -- well, yes, of course.

CHAIRMAN STETKAR: because they might have had --

MR. SHORT: What we discussed with them was is that -- well, I guess what we pointed out is is that developing distributions is really hard when you don't have anything to put a distribution on. (Laughter.) And so we did kind of pursue that a -- we did try to pursue that in the context of if you thought that you had a -- so I'll just kind of start -- most of the experts, they kind of thought from a median or a -- not median perspective. That's kind of where their starting point was, right? And so, we

specifically would ask them, well, so -- and discuss with them when you look at a 95 percent, that implies that you have greater -- whatever you're going to give us there gives you greater confidence that your end result is pretty good, right? It's pretty -- you have pretty high confidence.

And so, do you really -- we would ask the question do you want to keep that value that you put in there? The same as what you've had for your median value or mid-value, do you want to keep that as your 95 percent? So we questioned them about it.

CHAIRMAN STETKAR: Okay. Suppose --

MR. SHORT: And most of the times --

CHAIRMAN STETKAR: -- you asked me and I said hell, yes, I do for the following reasons, and I also want to keep the 5th percentile the same value --

MR. SHORT: Yes, right.

CHAIRMAN STETKAR: -- for the following reasons. Why then when you did your mathematical perturbations did you then tell me that I can't think that way? And how would that affect the overall results if you kept my distribution as I'll call it extremely narrow? Because it might not make it -- I don't know whether -- I don't know numerically how it would affect the results, because all I see is the results from those

expanded distributions merged together and then with a gamma distribution fitted to it.

MR. SHORT: Yes, I guess the only answer I can really give to that is in order to develop a mixture distribution it was --

CHAIRMAN STETKAR: You could have developed a mixture distribution treating me though as --

MR. SHORT: Line?

CHAIRMAN STETKAR: -- a line. I mean, if I'm an accepted expert and I'm adamant about the fact that there are real physical reasons; because you've asked me about this now, why the uncertainty is in this case exceedingly narrow, but very narrow, why not treat me that way?

MR. SHORT: Kevin?

MR. ANDERSON: Sure. Kevin Anderson, PNNL. If you look at the next picture, it looks like -- I was actually when I saw this surprised to see that those two straight up and down designs --

(Simultaneous speaking.)

CHAIRMAN STETKAR: I was, too, and I didn't have enough time to go examine where --

(Simultaneous speaking.)

MR. ANDERSON: Yes, I didn't do these

calculations, but that's -- the effect of the straight lines --

CHAIRMAN STETKAR: Yes.

MR. ANDERSON: -- is causing those -- well, usually a mixture distribution will be kind of humpy. But of course when you have these straight up and down things, it starts becoming step-like, the mixture distribution.

MEMBER BLEY: And when they're the high estimates, I guess.

MR. SHORT: That's right. Yes, that's right. They are. That's right.

CHAIRMAN STETKAR: That's why I was surprised, because I saw this in the results. And I ran out of steam. Because I read what was done -- I would have expected to see no vertical lines based on what I read was done. I would have expected to see three or four distributions having the same uncertainty range --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- on a relative sense. Which actually I did when I went and looked at the individual results. I saw three distributions that had basically the same factors between the 5th and the 95th.

MR. SHORT: Right. Right.

CHAIRMAN STETKAR: They were shifted a

little bit based on what the best estimate was. So I was surprised to see the vertical lines and I didn't go --

MR. SHORT: So I guess we'll take that back as a comment. I'll talk with Don about --

MEMBER BLEY: I'm just going to mumble once more about the thing I said earlier. If in fact you'd ask people to talk about, think about, build a little model about what could make this --

MR. SHORT: Yes.

MEMBER BLEY: -- as bad as possible. And then they first estimate the higher end, they're almost forced into thinking about what it would be like under other conditions. In fact, that's exactly the way the elicitation was done for 1150 twenty years or more ago. That isn't what you did. So now you're stuck with something like this or some kind of machinations. Did you feed back what you -- I know you gave them the report, but did you specifically say, hey, expert No. 3, look what we did to your distribution?

MR. SHORT: We did share with them their individual distributions. We had experts who were not willing to go off of the straight line. (Laughter.)

MEMBER BLEY: Okay. Even when you showed them what you did, they said I don't like that? So you

kind of didn't accept their comment about their own judgments? (Laughter.) Okay.

CHAIRMAN STETKAR: I'll just say on the record if I was one of them, it would have really pissed me off.

(Laughter.)

MEMBER POWERS: We did not have that problem in 1150 that I recall.

MEMBER BLEY: Well, at least what they did on the internal event side was -- I forget what they called them, but they had everybody for each issue lay out a little model of what are the things that could make this worse? Rather than just saying what's your best estimate for this and how much higher could it be, that forced you to think about what are the things that could make this different? And once you do, you're almost forced into a distribution.

MEMBER POWERS: Yes.

MEMBER BLEY: So, no, they didn't have that problem.

MEMBER POWERS: Yes, we didn't -- I mean --

MEMBER BLEY: And I didn't follow the Level 2 side of it too much, so I --

MEMBER POWERS: Well, when the --

MEMBER BLEY: But I think they did it the same way.

MEMBER POWERS: Exactly the same way. And then when they asked -- when they produced their final distributions, they asked does this adequately reflect --

MEMBER BLEY: Yes, what you --

MEMBER POWERS: -- your view on things? And I think what happened is that if that cumulative distribution included the high side that the high people like, then it was okay. And if it included the low region that the low people like, they said that was okay. And we didn't -- we never got into violent disagreements about the resulting final distribution as --

MEMBER BLEY: Now, I do have a counter-example, and I think I can't say exactly what it was, but it was done for the Department of Energy. It was done in the area of proliferation and physical protection. And they did a giant elicitation and then they did multiple machinations. And then they published the report and several of the experts disavowed the report as being nonsense later. You don't want that.

MR. SHORT: Yes, we didn't have that problem and --

MEMBER BLEY: They bought in, I mean, yes.

MR. SHORT: And they bought into what we did, but like Kevin says, I can't quite explain the text in the report and the figure that we're seeing here either, so --

CHAIRMAN STETKAR: And as I said, I looked at some of the individual distributions and I didn't try to derive everything.

MR. SHORT: Right. Right.

CHAIRMAN STETKAR: It's not productive. But I did notice that the ranges of uncertainties for -- I'm going to say three; I don't remember --

MR. SHORT: Yes. Yes.

CHAIRMAN STETKAR: -- looked like the same. And from what I read in the report, at least the words, it said it -- okay, these must be the people that had --

MR. SHORT: Right.

CHAIRMAN STETKAR: -- that average uncertainty essentially applied to it. And then as you said, I did -- then I looked at these curves and said, well, gee, the --

MR. SHORT: Just something a little different, yes.

CHAIRMAN STETKAR: It's something different.

MR. SHORT: Yes. So, yes, we'll have to take that back and I'll have to ask Don about it. So I'll see what he did.

CHAIRMAN STETKAR: Okay. Let's --

MR. SHORT: Because my -- yes, the way he explained it to me is is he needed to go off of the straight line in order to really make the distribution work.

CHAIRMAN STETKAR: Maybe he did for some sort of --

MR. SHORT: I need to ask --

CHAIRMAN STETKAR: -- math that he was most familiar with, but one does not need to do that in an absolute sense.

MR. SHORT: Okay.

CHAIRMAN STETKAR: I'm going to let us run until 12:15, and no later than 12:15. I need to ask for public comment. So need to wrap up everything by -- in the next 10 minutes or so, 10 to 12 minutes. We're not going to get through all your slides, obviously.

MR. SHORT: Oh, we're almost there.

CHAIRMAN STETKAR: Yes. Sure. I have to set that time limit because we have other constraints.

MR. SHORT: I guess this table is intended to show kind of how the -- you know, if you're going

to compare the conditional probability thing to -- or conditional probability failures, second failure, second valve failure to let's say the alpha factor model for conditional failure probability, this is kind of how it would rack up. We're on the order of the conditional failure probability for the pathways would be 50, 100 -- a factor of 50 less than if you added up all the sequences for the common cause failure model. So we are somewhat -- it'll be less in the end. That's all that's intended to show, trying to do a comparison.

So the failure to close probability. I don't have anything really new to report on this. Again, we used -- we calibrated the team to the failure to close probability that's currently in 6928. That's of course contains all data that's in the database. What we're looking at is is potentially having to close a valve against a differential pressure that it was not designed to close against in order to isolate the ISLOCA. And so, that's just a reference point.

We use the same I guess --

MEMBER BLEY: I wanted to correct that a little.

MR. SHORT: Okay.

MEMBER BLEY: I think specifically it was intentionally designed not to be able to open at those

pressures, which means it's very unlikely to be able to close.

MR. SHORT: That's correct. Yes, that would be another way to say it.

MEMBER BLEY: But it was designed so that it wouldn't be accidentally opened while you were at power?

MR. SHORT: You're talking about -- I'm not sure you're talking about the same valves I'm talking about.

MEMBER BLEY: Oh, okay.

MR. SHORT: Okay? I'm sorry.

MEMBER BLEY: Not the RHR?

MR. SHORT: No.

CHAIRMAN STETKAR: No, these are not -- these are other motor-operated valves.

MEMBER BLEY: I'm sorry.

CHAIRMAN STETKAR: These are flow paths --

MEMBER BLEY: Okay.

CHAIRMAN STETKAR: -- that are normally open that need to close that were designed to close under like 200 pounds differential pressure --

MR. SHORT: That's right. That's right.

CHAIRMAN STETKAR: -- or something like that that now need to close under 2,000 pounds

differential pressure.

MR. SHORT: Well, we wanted to see if we might be able to credit them in some ways, right --

CHAIRMAN STETKAR: Yes, yes, yes.

MR. SHORT: -- to mitigate the ISLOCA. So, let's see. Okay. So again we used the 6928 value as a calibration point for the experts to elicit against. We did different categories of differential pressure, and so we looked at 1,000, 1,500, 2,000 psi differential pressure across that valve. We did 5, 95 and 50 percent again. And we elicited for each of the normally open MOVs that could be potentially used to isolate the ISLOCA. And there are just two of them.

And then the results are for this one here, we did use a beta distribution functions for this because we wanted it to stop at one as our top probability. For the mixture distribution again we used the arithmetic average. And we also developed distribution tables, so we did the same thing. Okay? We developed a -- we put a beta best fit around that distribution.

And here are the results. You can see that it's an interesting distribution because we had some people say it would absolutely fail and we had others that said it would not fail. Okay?

(Laughter.)

MR. SHORT: So we were trying to combine those, which is kind of difficult, but -- and then the results showed that -- and you can see over there the comparison to the 2010 update that that failure rate, the mean failure rate probability definitely going up. And in some cases at 2,000, 2,700 psi it definitely valuated by most of the experts to fail, but obviously there's one expert who -- given the results didn't think it would necessarily fail.

CHAIRMAN STETKAR: I think one expert thought it would get better, didn't --

MR. SHORT: One expert thought it would get better. Now we actually dropped him out because --

CHAIRMAN STETKAR: Yes.

MR. SHORT: -- because he evaluated himself as not an expert. But he did give a reasoning for his thought basis there.

CHAIRMAN STETKAR: Yes.

MR. SHORT: Okay?

MR. KURITZKY: So one thing just to quickly mention and going along with one of those expert's idea was that the differential pressure when you first start can be the, say, system pressure on one side and very low pressure on the other side. But once you actually

have the break of outside containment, you start to depressurize. And you really don't need to isolate the break until sometime afterwards. And so pressure will start coming down fairly rapidly depending on the size of the ultimate ISLOCA break. And so the bigger isn't so much -- well, I mean, this is a big issue coming up with these failure probabilities, but also from a modeling point of view is what differential pressure do you assume when we stick our value into our PRA?

CHAIRMAN STETKAR: Right.

MR. KURITZKY: And that was something we had to wrestle with because even if we could do a calculation to show that we had enough time, that pressure would come down very low, and so we could use a fairly lower failure probability. But the thing is that they may attempt to close it earlier on, and depending on the design of the valve and the -- they made damage the valve enough when they first attempt it that when they want to go back to do it later, they may --

(Simultaneous speaking.)

CHAIRMAN STETKAR: Sure, you could --

MR. KURITZKY: Yes, so --

CHAIRMAN STETKAR: But the torque limits are going to --

MR. KURITZKY: Right.

CHAIRMAN STETKAR: -- trip out on you and --

(Simultaneous speaking.)

MR. KURITZKY: So there's a lot of uncertainty there.

MR. SHORT: But we did have one expert specifically comment that -- he said, you know, he doesn't even see this as a problem. You'd wait until you blew down and then you'd close that valve.

CHAIRMAN STETKAR: He would. And nobody's every melted a nuclear power plant either, so --

(Laughter.)

MR. SHORT: So, I mean, that's -- but he ended up opting out as being an expert on it. But that was a comment he made. And that was a reasonable -- that was a good comment.

MEMBER BLEY: That's a good comment if you're already trained on it and you --

MR. SHORT: Yes. Sure.

MEMBER BLEY: -- were thinking about it and had been --

CHAIRMAN STETKAR: Well, and you knew --

MEMBER BLEY: -- focused on --

CHAIRMAN STETKAR: -- and you knew --

MEMBER BLEY: -- and you knew the valve design --

CHAIRMAN STETKAR: -- and you knew -- well, and you knew everything and you knew that indeed you're supposed to sit there and wait despite the fact that everybody's telling you you ought to isolate it if it's possible.

MR. SHORT: Yes. (Laughter.)

CHAIRMAN STETKAR: Yes.

MR. SHORT: Right. If you got the pressure on you, right, to isolate this leak?

CHAIRMAN STETKAR: Yes.

MEMBER BALLINGER: I have a question. The torque limiters will trip it out?

CHAIRMAN STETKAR: Oh, yes.

MEMBER BALLINGER: Okay.

CHAIRMAN STETKAR: Yes, that's why they have them. They'll trip out the motor contactor.

MEMBER BALLINGER: Right.

CHAIRMAN STETKAR: So you got to go, you know --

MEMBER BALLINGER: Okay.

CHAIRMAN STETKAR: Yes.

MEMBER BALLINGER: I have a different experience.

(Laughter.)

MR. KURITZKY: Well, some valves --

MEMBER BLEY: And they're the right ones.

MR. KURITZKY: -- may only have a position when they're --

CHAIRMAN STETKAR: Usually they'll have a torque limit though on --

(Simultaneous speaking.)

MR. KURITZKY: Right, but if you only have a position limit, you'll be in trouble.

CHAIRMAN STETKAR: The idea is typically the position limit kicks in before the torque limit, because you basically want to try to not break the valve.

MR. KURITZKY: Right. Right. But if some valves do only have a position limit, then they would get damage. It wouldn't cut off.

CHAIRMAN STETKAR: Anyway, let's -- I'm going to cut us off.

MR. SHORT: Oh, you're ready to end? Okay.

CHAIRMAN STETKAR: Yes, because this is interesting, but it's --

MR. SHORT: This last page, is that what you're saying?

CHAIRMAN STETKAR: Yes, we're --

MR. SHORT: Okay. Yes.

CHAIRMAN STETKAR: We just don't have time to get through it. It's an interesting exercise and it's really useful for the PRA, I think, but we just don't have time. And I apologize for that. It's just there's more material to cover than we anticipated when we set up the schedule, and if we would have done it differently, we might have had this session in the afternoon so we could run long, but we didn't.

What I'd like to do here is see if we can get the bridge line open. I don't know if we have anybody on the bridge line, but get that open. And while we're doing that as if there is anyone in the room who has any comments that you'd like to make. If you do, please come up to the microphone and do so.

(No audible response.)

CHAIRMAN STETKAR: It's open?

PARTICIPANT: Let me try --

CHAIRMAN STETKAR: Okay. I just heard a pop. If someone is out there on the bridge line, do me a favor and just say hello just so I can confirm that it's open. Anybody.

MS. GIBBS: Hi, this is Kathy Gibbs and the bridge line is open.

CHAIRMAN STETKAR: Thank you so much.

Now, if there's anyone out there who would

like to make a comment, please identify yourself and do so.

(No audible response.)

CHAIRMAN STETKAR: Hearing nothing, thank you, Kathy, for confirming that it's open.

We'll re-close the bridge line and as a final wrap-up, I'll go around the table and see if any of the members have any additional comments that you'd like to make. Ron?

MEMBER BALLINGER: I had some questions, but I think they're probably --

CHAIRMAN STETKAR: Ron, turn your microphone on.

MEMBER BALLINGER: I'm going through this and I was looking in particular at figure 4.10(a) in the elicitation report. And I'm looking at this and I'm saying these are valve experts, but --

CHAIRMAN STETKAR: Steve, be careful with the mic.

MR. SHORT: Yes, sorry.

CHAIRMAN STETKAR: As long as it's on, you make terrible crashing noises. Thank you.

MEMBER BALLINGER: First off, I have a conceptual problem, and it's probably because of my ignorance of why the estimates of the failure

probability of the second valve to operate are higher -- the conditional probabilities are higher after the first valve doesn't work.

MEMBER BLEY: Over a shorter time period, I think.

MEMBER BALLINGER: Huh? Okay. Maybe it's just my ignorance, right?

CHAIRMAN STETKAR: Be careful. What is it, 4.10(a).

MEMBER BALLINGER: 4.10(a).

CHAIRMAN STETKAR: Exactly what parameter is that one eliciting?

MEMBER BALLINGER: It's the conditional probability of failure of two motor-operated valves in series.

MR. SHORT: It's a figure that kind of shows the --

PARTICIPANT: Microphone.

MR. SHORT: Oh.

CHAIRMAN STETKAR: That's the other thing is with your --

MR. SHORT: It's a figure that basically shows what each expert elicited. Okay?

MEMBER BALLINGER: Right. So if you unpack this a little bit, you see the folks, whoever

they were, would have no uncertainties, they're all high.

MR. SHORT: Yes.

MEMBER BALLINGER: The ones with uncertainties, you have six orders of magnitude in uncertainty. And the total uncertainty is at least six or seven orders of magnitude. And I'm just curious as to where the valve experts were on this. Okay? You can't tell by A, B, C, D or E. And were they the ones that put uncertainties on there or were they the ones that didn't?

CHAIRMAN STETKAR: No, because the data sheets are --

(Simultaneous speaking.)

MR. SHORT: Can I answer that?

MEMBER BALLINGER: I mean, I'm sure it's a dumb question, but it just --

MR. KURITZKY: Okay. So the reason you can't tell from that is because we've used letters specifically to hide the names of the experts.

MEMBER BALLINGER: Right.

MR. KURITZKY: So I don't think it would be appropriate for us to actually identify them.

CHAIRMAN STETKAR: Why did you do -- I read that in the report, and that seems to be silly. Isn't

it counter to the general SSHAC process where each expert has to own their particular estimates and the basis for it and defend them to the other experts so that I, John Stetkar, have to defend why I believe, and all of the other experts get to attack me and question my beliefs? And I might alter my beliefs based on that exchange. So why this notion of anonymity?

MR. KURITZKY: That's a good question. I remember we had this discussion at the joint meeting, because there was certain information that we wanted to share with all the members and there was discussion of whether that would violate the independence. And then there was the decision, well, we would share it but we would block out the names so they wouldn't know who the other people were. And unfortunately I'm not a SSHAC expert. Jing Xing was our --

(Simultaneous speaking.)

MEMBER BLEY: Yes, just a couple of things. I don't know why you did it. I know why it was done in 1150, but the general rule is, as John said, you want experts who will stand behind what they say and you want to know who you're getting the information from, if you're looking at this kind of expertise. And as a reader I want to know, or if I'm you I want to know where it came from.

MR. SHORT: I know.

MEMBER BLEY: In 1150 when they did their elicitations a limited number of people came from organizations for whom they were worried if anybody saw their expert opinions, it would get them in trouble and -- with their organizations. And there was a policy decision to allow them to participate and then not put anybody's names on anything. But if you didn't have something like that, a real extenuating circumstance, I don't know why you don't show who the experts are attached to their information, their data sheets and all of that.

MR. SHORT: Yes, I know. Honestly, I don't have an answer for that. I don't know what the decision basis was behind that.

MEMBER BALLINGER: But there's a clear pattern, at least in my mind here, which --

MEMBER BLEY: Yes, you can figure it out.

MR. SHORT: Yes, you can figure it out. It's not that hard.

MEMBER BALLINGER: Okay. Then I'd ask --

MR. SHORT: But I will say that generally I don't think any of our experts would have a problem with us showing --

MEMBER BLEY: Then why did you hide the

names?

MR. SHORT: There was a concern about maintaining this individual --

(Simultaneous speaking.)

CHAIRMAN STETKAR: It says it was based upon -- the quote in the report says, "However, based on concerns by an NRC observer." So if PNNL didn't do this, the NRC did it. So now, Alan, why does the NRC do this?

MR. KURITZKY: The NRC observer, whom I'm intimately familiar with --

(Laughter.)

MR. KURITZKY: -- raised the issue did it make a difference whether people knew their name for independence? Didn't rule on the decision one way or the other. Just raised that concern. What the ultimate decision -- well, we know what the ultimate decision was. Why that decision was made, I don't recall.

CHAIRMAN STETKAR: Okay.

MR. KURITZKY: I do --

(Simultaneous speaking.)

CHAIRMAN STETKAR: Anyway, I read it in the report. That was a direct quote from the report --

MR. KURITZKY: Right.

CHAIRMAN STETKAR: -- that the reason that it was done was based on concerns by an NRC observer.

MR. KURITZKY: Actually there were multiple observers, but I think I recall the individual who brought that issue up. But it was just raised as an issue, not as a decision.

MEMBER BLEY: Okay.

CHAIRMAN STETKAR: We got that on the table.

Ron, anything else?

MEMBER BALLINGER: No.

CHAIRMAN STETKAR: Dr. Powers, sir?

MEMBER POWERS: So I have a task?

CHAIRMAN STETKAR: You have a task.

MEMBER POWERS: It's NUREG-1764?

CHAIRMAN STETKAR: Whatever the number was.

MEMBER POWERS: And you're going to get that for me?

CHAIRMAN STETKAR: He will.

MEMBER POWERS: And I will report back to you what I learn from same?

CHAIRMAN STETKAR: That would be -- yes, seriously that would be good.

MR. KURITZKY: 1864.

CHAIRMAN STETKAR: 1864? Whatever the NUREG is.

MEMBER POWERS: And I will do that with aplomb.

CHAIRMAN STETKAR: I like peaches better, but never mind. Anything else?

MEMBER POWERS: I am the peach.

CHAIRMAN STETKAR: You are. Anything else?

MEMBER POWERS: No, just that we are exploring alternate ways of confabulating expert opinions, especially from the point opinions. And in a way I have taken the point of view that we will not assume a distribution. I mean, you guys use gammas. I'm surprised they don't us Weibulls, because failure guys seem to love Weibulls for everything known to man for reasons that are unknown to me.

But we're doing non-parametric types approaches for those that have the infraction and will not assume the distribution, but not primed to handle these guys on expert elicitations that say here's the probability and the probably is one and it's right here versus the guy that somehow had smeared that all over the place.

And it's -- there's always the hard spot

of how do you rate the relative experts of opinions? We're not getting into that. The guy's either an expert or he's not. If he's not an expert, then we assign zero weight to his view and whatnot. But the issue, the approach we've taken though is that we generally ask our experts to provide us a distribution of where they think the technical community's uncertainty is in a quantity we're asking, but not their own. They can tell us what their own opinion is, but we want to know what they think.

If we could poll an infinite number of experts, what that community would give is a distribution. And that gives us very different results than if we ask just for their opinion on things.

MR. SHORT: I will just kind of point out that we did emphasize to the experts that they weren't just representing themselves. They were representing the knowledge base of the industry to the extent that they knew it. Okay? And so to the extent they took that into account, only they can answer that question.

MEMBER POWERS: Yes, you never know how much, but we spend a lot of time harping on that. And then when you have the meeting of the experts and the panel, we say, well, how come you came up with this step-function distribution when you can hear these other

experts --

MR. SHORT: Right.

MEMBER POWERS: -- have different views and you're trying to reflect that opinion? And in general people say, oh, okay, I forgot that and they just -- and give us a distribution. We're interested from a methodological point of view of suppose we didn't do that and we just took their point value versus distributions. How do we combine those things into a distribution? It's an interesting intellectual exercise. It surprises me that it -- it doesn't seem to make a huge amount of difference.

MR. SHORT: Yes. Right. I think that's a hard thing to ask of someone, right? I think that's a very hard thing to ask of somebody.

MEMBER POWERS: Well, you know going in you're going to get an imperfect answer --

MR. SHORT: Right.

MEMBER POWERS: -- because most people don't give a damn about what the rest of --

(Laughter.)

MR. SHORT: People have got very strong opinions about their own opinions.

MEMBER POWERS: Yes, I think it was Professor Apostolakis said his first reaction when

somebody says I have 32 years of experience is, oh, that means you've been wrong for 32 years?

(Laughter.)

MR. SHORT: I can see him saying that.

(Laughter.)

CHAIRMAN STETKAR: Anything else?

MEMBER POWERS: No.

CHAIRMAN STETKAR: Dennis?

MEMBER BLEY: Yes, I'm glad you did this. I'm glad you got some real valve experts involved. You've heard a few things I'm not as happy about in how it was implemented.

You keep saying this is full scope, but you keep telling us the things that are ruled out. And it seems odd. I would call it full scope with the following exceptions. And it just reminded me of Douglas Adams and "The Hitchhiker's Guide to the Galaxy" when he turned it into books. It started as a trilogy. By his fifth book he said the increasingly misnamed trilogy. And I don't want those words to apply to the name of your report when it eventually comes out.

CHAIRMAN STETKAR: Thank you. Anything else?

MEMBER BLEY: Nothing I haven't said earlier.

CHAIRMAN STETKAR: Again, despite everything I said, I think this was a very useful exercise. I think that if I were the PRA team I would be careful about how I used the results from it rather than -- not necessarily just pluck numbers out of a table for some of the reasons that we discussed here. I think that the lessons learned that you document are really important lessons learned.

I think that part of the reason for doing this was in response to the Commission's SRM on developing methods for using expert opinion in risk-informed decisions or regulatory decision making. I Know the staff is somewhere, somehow, sometime working on guidance for doing that. I'm sure that this will help the staff in that effort also.

So with that, I'd like to really thank you. I have to apologize both to Alan and the Level 3 PRA people for not getting to the summary of the model. As I said, I will go through that in parallel with Dana and provide my comments in terms of fact finding on what the current snap shot of the model is so that the Subcommittee can benefit from that. And again, I apologize for terrible time management.

I'd really like to thank PNNL. I think you crammed a heck of a lot of material into even this

expanded time and I really appreciate the effort that you made.

And with that, we will adjourn. And we will reconvene at 1:00, because we have somebody from an external organization planning to come in at that time. So we are recessed until 1:00.

(Whereupon, the above-entitled matter went off the record at 12:18 p.m. to reconvene at 1:00 p.m. this same day.)

CHAIR STETKAR: We are back in session.

This afternoon we are going to have a presentation by Jack Vecchiarelli.

I hope I have not butchered your name too badly.

MR. VECCHIARELLI: No, not at all.

CHAIR STETKAR: He is from Ontario Power, on the topic of whole-site risk assessment and safety goals. The reason that we organized it as part of the Subcommittee meeting on a Level 3 PRA is that, obviously, the topic of whole-site risk assessment is directly germane to what the staff is doing for the Vogtle site, because they are evaluating both units there.

We didn't have enough time. We had a Subcommittee meeting back in December of 2015 with presentations on other forms of safety goals. In

particular, the Canadian industry and the government up there have been doing quite a bit of work in this area. It is also germane to the Level 3 PRA project because, at least at one time or another, the Subcommittee was informed that the Level 3 PRA project might be examining other metrics in addition to the traditional health objectives that are examined in terms of fatalities and long-term cancers and land contamination and things like that.

So, with that, that is kind of a brief introduction. Unless any of the members have any questions, hearing none, I will turn it over to you, Jack. You have the floor, and John Lai will be running your slides for you.

MR. VECCHIARELLI: Thank you very much.

You have my presentation up for viewing?

CHAIR STETKAR: We do.

MR. VECCHIARELLI: Excellent. Thank you very much.

First, I would like to thank the Subcommittee for this opportunity to share with you some of the work that has been performed by the CANDU Owners Group.

I am joined today by one of my PRA experts, Agnes Moisan, and perhaps on the line is my colleague

Keith Binney**10515**Giminey from Amec Foster Wheeler.

Keith, are you there?

(No response.)

He may be joining momentarily.

MEMBER BLEY: Could he be on the other line?

CHAIR STETKAR: Now we are running into another issue.

MR. VECCHIARELLI: No worries.

CHAIR STETKAR: Because we have two lines. One line I believe, Jack, you are on, so that you can speak to us. We have another line that is available to the public. Anybody in the world can all in and be on that line.

MR. VECCHIARELLI: I see.

CHAIR STETKAR: Your companions may be on the second line. If you want them to participate actively, we may need to get them a different phone number to dial-in on.

MR. VECCHIARELLI: No problem. I just wanted to acknowledge that Keith has been a long-time expert on the topic of safety goals in Canada, and that I am also accompanied here by my PRA expert at OPG, Agnes Moisan.

With that, I, again, thank you for this opportunity. We are very much interested in the

initiatives being developed in the United States as well as the ongoing work in other jurisdictions internationally. So, we are grateful to have the chance to exchange information here.

I was asked to describe our industry's use of risk metrics, especially any additional risk metrics beyond those used to assess health effects. In so doing, I need to talk about risk assessment and safety goals, as these are two separate but intertwined issues. Hence, the title of my presentation is Whole-Site Risk Assessment and Safety Goals. I will clarify what I mean by whole site in a moment.

Moving on to slide 2, if you could, please, I do have to make a disclaimer that this ongoing work that is described in the presentation is preliminary in nature and it does represent the finalized views of the members of the CANDU Owners Group. It is a work-in-progress and the work is subject to further discussions within the Canadian industry and with our regulator as well. So, I do want to make that clear. This is by no means a final position or conclusion on the work-in-progress.

Slide 3, please.

Just to give you an outline of what I will be discussing, I would like to give a little bit of

background on this topic of whole-site risk, what are the key issues that we are facing, and an overview of the work that has been conducted by COG, CANDU Owners Group. Lastly, we want to focus on risk metrics and how we see their role in the bigger picture of assuring nuclear safety.

Slide 4, please.

By way of background, what I would like to mention is that our current risk metrics are applied on a per-unit, per-hazard basis. So, for example, we have a large release frequency safety goal. That is defined on a per-reactor-year basis. It is applied separately for each of the various hazards, internal events, seismic, fire, flood, et cetera. It is applied on a per-unit, per-reactor-unit, and per-hazard basis.

As a result of this, there is a lot of public interest around the overall site risk, and to the point where in 2013, as part of a licensing hearing in Ontario, there was a license hold-point placed on the Pickering Nuclear Generating Station, which has six operating units just east of Toronto.

One of the hold-points or the hold-point in question here was that we were asked to provide a whole-site PRA or a methodology for it. The intention of this whole point was to characterize the overall risk

of the site due to aggregation of risk from a number of things: the fact that we have multiple reactor units on the site, the fact that there are other onsite radiological sources such as spent-fuel bays, given that there are different hazard types, internal and external hazards, and that there are various plant operating modes, full power, low power, and shutdown state.

The idea was, how do we characterize the overall risk of the site, given that to date we have been assessing risk on a per-reactor-unit, per-hazard basis? So, that was the challenge that was set forth as part of background to my discussion here today.

On slide 5, I would like to highlight some of the key issues that are germane to this challenge. The topic of whole-site risk is not really new. It has been around for some time. However, to the best of our knowledge, there really isn't an international consensus on the methodology with respect to risk aggregation, in particular.

The simple addition of all risks from the various hazards, so if you just look on a per-unit basis, simply adding up the risks from internal events and fire and flood and seismic and high wind, that can lead to an overly-conservative result. This is, in part, due to the different levels of uncertainty associated with

the various hazard PRAs. This is a disparity in the maturity level of internal versus external hazard PRAs.

If you apply that on a per-unit basis, summing up all the hazards, that can be over-conservative. But, even for a given hazard, the multi-unit risk does not necessarily equal the per-unit risk times the number of units. For example, the per-unit risk for internal events on a four-unit station, the multi-unit risk is not four times the per-unit value.

CHAIR STETKAR: Jack?

MR. VECCHIARELLI: Yes?

CHAIR STETKAR: Since you don't get absolved of being interrupted or queried simply because you are north of the border --

(Laughter.)

MR. VECCHIARELLI: By all means.

CHAIR STETKAR: Explain to me, if I am a member of the public sitting at the fencepost and I am curious about how often I might be exposed to an event at a site, now let's just take the second part of your discussion there you said, "If I have four units at the site...," and let's just assume for the moment that they are completely independent and they are isolated from -- they are all in their own little bubbles, so

they can't be affected by common external hazards. Why wouldn't the risk to me as someone at the fencepost, if I have four units at the site, be four times "N", where "N" is the single-unit risk?

MR. VECCHIARELLI: All right. Well, first, I do want to preface it with the comment that, in particular, the multi-unit CANDU stations, there is a fair degree of dependency or interconnection amongst the supporting systems and we share a common containment as well.

But, in your scenario where there is complete independence, what I would say is that, for large release frequency, we do calculate the total offsite release. So, in a case where there are four totally independent units, you could have a common-mode event, say a seismic event, that let's just theoretically say all units are affected in exactly the same way and the accident progresses in the same manner. Then, our calculation of the large release frequency would consider the total releases from all units.

And so, if you were to now try to do an aggregate risk in a multi-unit perspective, you shouldn't be quadrupling the initiating-event frequency for the seismic hazard. You have already accounted for the total release from all units --

CHAIR STETKAR: Yes.

MR. VECCHIARELLI: -- for the same initiating event.

CHAIR STETKAR: I understand what you are saying. I tried to walk you into a case where we were not discussing units that had shared systems or that were subject to the same external hazard. I thought I heard you saying that, if I had four units at a site, that if I talked about only internal initiating events, that I couldn't add the risk from those four units.

And I understand what you are saying about units that have shared systems, that have shared confinements or containments, that have shared external hazards. Those are certainly different issues. So, maybe we weren't communicating directly, but I would think that internal initiating events for units, if they were independent of one another, could be added.

MR. VECCHIARELLI: To a certain extent, they can. But the problem is there are also internal events, such as a loss of grid, that affect multiple units at the same time. And so, we have to be careful not to double-count those initiating events.

CHAIR STETKAR: Right. Okay. I will let you go because we do have a hard stop at 1:50 because we have another meeting at 2:00. I was abysmal at

managing the meeting this morning. So, go on.

MR. VECCHIARELLI: I just want to touch on the third key issue, which is really a perception issue. Although the risk metrics, safety goals, historically, they were introduced to help answer the question how safe is safe enough, I think there has been a misconception that these safety goals are a hard delineation between what is safe and unsafe plant design. And this was not the intention with the introduction of safety goals in Canada. So, there is this misconception out there, and that is an issue to be dealt with from a public communication point of view.

Slide 6, please.

In terms of the role of safety goals, as we see it, ultimately, safety goals are there; they are intended to ensure that risks are kept acceptably low. And hence, that helps to support the case that the nuclear plants are licensable.

Now PRA as applied provides an indicator of risk. We don't see it as a true measure of risk. And so, we need to consider and incorporate the broader aspects of what contributes to managing planned risk.

What I am referring to here is the various programmatic elements together with analytical elements, that these help to support the process of

communicating about nuclear safety. The message here is that it is not all about the PRA numbers at the end of the day. One needs to put PRA numbers into perspective, and I will be elaborating a little more on what I mean by that.

But I am just trying to convey the use of PRA in a bigger context. Yes, they do help to ensure that the risks are given some sort of a criterion or target to ensure that risks are kept low, but they are not the be all and end all. I will elaborate on that in a moment.

On slide 7, just to give you an overview of some of the work that has been performed by COG, we hosted an international workshop in 2014. That was very well-attended. We had Dr. George Apostolakis participate in that workshop. There were representatives from the International Atomic Energy Agency, from EPRI, our Canadian regulator, and many others.

That was a very useful workshop. We took the insights and feedback that we heard at that workshop and incorporated it into a paper, a concept-level paper, on the topic of whole-site PRA and safety goals. So, that was a COG publication which we made publicly available through the Ontario Power Generation external

website.

Following that concept-level paper, we initiated a COG joint project. There are three phases to this joint project that is underway.

Phase A focuses on safety goals and in the context of a safety goals framework. I will describe what that means. This is really intended to help provide a basis for the development of a public communication tool. This work is being supported by Amec Foster Wheeler.

Phase B looks at risk aggregation studies, where the intention here really is to determine how you go about quantifying whole-site risk in a comprehensive manner. This work is being supported by Kinectrics and Amec Foster Wheeler as well.

Within this phase, just to touch on some of the activities there, it includes identify the risk sources and the various reactor operating states that need to be considered as part of a whole-site risk evaluation. It also looks at developing risk assessment methods for the non-reactor sources, so a spent-fuel pool, for example, or other sources.

We also are considering habitability effects and how that needs to be taken into account in the PRA modeling. Is there some source of onsite

radioactivity that could impede the mitigation of emergency equipment, for example?

Phase B also includes trials of different risk aggregation methods. The one option is the simple arithmetic addition, but we are also keeping an open mind and considering other techniques and weighing the pros and cons, identifying what the strengths and weaknesses are of those alternative methods.

Lastly, we are also considering other risk assessment approaches that are not necessarily purely PRA. They may be other risk assessment methods that we want to explore as part of a whole-site risk assessment approach. So, that is all within Phase B. My focus really today is on Phase A as it concerns risk metrics.

Lastly, Phase C is to pilot the lessons learned, the information from Phases A and B, and apply that to the Pickering Station and conduct a whole-site PRA or risk assessment for the entire Pickering site. That is slated to be performed by the end of 2017.

CHAIR STETKAR: So, Jack, if it is going to be performed by the end of 2017, I would assume that that is well underway now. Is that correct?

MR. VECCHIARELLI: The Phase B work is well underway, and that is really a very important part of the legwork to get Phase C completed. So, we will be

looking to initiate Phase C, in all likelihood, a little bit later this year.

CHAIR STETKAR: Okay.

MR. VECCHIARELLI: A lot of the groundwork that will be used in Phase C is being put in Phase B.

CHAIR STETKAR: This is in the context of the NRC's Level 3 PRA for a two-unit site that has been going on for quite a while now. So, I hope you folks can accomplish this by the end of 2017. I would personally be really interested in seeing that.

MR. VECCHIARELLI: Uh-hum, uh-hum. Mind you, this is not a Level 3 PRA, and a lot of the groundwork is being done using existing information and the data-gathering that is part of Phase B. So, we are looking to leverage existing information as much as possible.

CHAIR STETKAR: Okay. Thanks.

MR. VECCHIARELLI: Yes.

I am on slide 8 now, where I would like to talk a little bit more about risk metrics. In particular, from the Phase A portion of the joint project, these are some emerging views that we have on the topic of risk metrics.

First, a primary focus of safety goals should remain the protection of the life and health of

the public. Indeed, some Canadian utilities have quantitative health objectives. Some do; some don't.

We do make use of surrogate risk metrics. Where surrogates are used, we need to show that they represent an equivalent or more limiting criterion than the underlying health-related goals. So, for example, large release frequency, as I mentioned earlier, is an existing safety goal in Canada. That is based on the sum of frequencies of event sequences that can lead to an offsite release of more than 10 to the 14 becquerels of cesium. It is understood or expected that a greater release may require long-term relocation of the local population. This is straight out of a regulatory document that really is applicable for new-builds.

But the point is that the large release frequency, essentially, it limits the frequency of long-term relocation to similar or the same frequency values as that associated with the health risks. So, it is a more stringent or limiting criterion, if you like. As such, both health-related and societal disruption effects are considered in the large release frequency metric. It actually addresses both health effects and societal disruption issues. The particular the societal disruption issue of concern is long-term relocation.

CHAIR STETKAR: That is, by the way, just for the record, that is a fundamental difference between what the U.S. NRC uses as, I will call it a philosophical basis, if not a quantitative basis for large release frequency, right, Jack? Our large release frequency is anchored to prompt fatalities, directly related to health effects and only health effects.

MR. VECCHIARELLI: Understood, yes.

CHAIR STETKAR: Okay.

MR. VECCHIARELLI: What we are saying is that our large release frequency risk metric can address both long-term relocation concerns as well as having margin to health effects.

CHAIR STETKAR: Right. Thank you. Good.

MR. VECCHIARELLI: On slide 9, I just wanted to talk a little further about the existing risk metrics for current plans in Canada, the existing CANDUs. We actually, I mean, the two surrogate risk metrics that we tend to use are large release frequency and severe core damage frequency. What we have actually instituted is a space-equal limit and safety-goal target.

So, on the left side of this figure you will see that there is an upper limit and a lower goal. That lower goal is actually a target. For example, for large

release frequency, the safety goal limit is 10 to the minus 5 per year; whereas, the target is an order of magnitude lower, 10 to the minus 6.

What we maintain is that we should be migrating to a revised lexicon, if you like, this idea of a limit. You know, it is creating the perception that there is a hard delineation between what is safe and unsafe. And so, we are looking to relax or soften the language around safety goals. Perhaps what we would call the limit may just be a safety goal, and what is currently a safety goal target could be considered an administrative goal. So, that is a bit of a nuance in terms of how we have been referring to risk metrics for the existing plants. We want to move away from this notion of calling it a limit and recognize that we have, essentially, a target and a more stringent lower administrative goal, if you like. It is the administrative goal of the lower value that we try to meet that lower value as much as practicable, but we are typically well below the actual safety goal, quote, "limit".

MEMBER CORRADINI: So, can I just ask -- I think I understand what you are saying. You have to be below one 10 to the minus 5th or one 10 to the minus 4th for the CDF or the LRF?

MR. VECCHIARELLI: Correct.

MEMBER CORRADINI: But you could be above the one 10 to the minus 6th and one 10 to the minus 5th?

MR. VECCHIARELLI: That's correct. What we would do, if we were above, say, 10 to the minus 6 for LRF, we would see what we could do from a cost/benefit perspective to further reduce the risk. We would endeavor to get below target. But, ultimately, what we need to show is that we are below the so-called limit.

MEMBER CORRADINI: Okay. Thank you.

MR. VECCHIARELLI: Yes.

On slide 10 now, other considerations. There is a growing international recognition that the protection of public health may not be enough and that certain other societal impacts due to nuclear accidents should be avoided to the extent practicable.

So, the Fukushima accident is a case in point. While it appears that radiation-induced fatalities may have been averted by the protective measures, there was a large impact of societal disruption.

Following the Fukushima event, the CNOs in Canada established a set of principles to address beyond-design-basis accidents where the stated objective of these principles is to, quote, "practically

eliminate the potential for societal disruption due to a nuclear incident by maintaining multiple and flexible barriers to severe event progression".

Here the underlying intention of the CNOs is to avoid any extensive permanent relocation of society to the extent practicable. This was meant as a qualitative objective and it has largely been the driving force for the implementation of emergency mobile, emergency mitigating equipment, which you would refer to as FLEX in the U.S. So, it is a qualitative objective that was brought in post-Fukushima to really address this growing international recognition that, while, yes, we want to protect the health of the public, we should be striving for more than that.

Really, the OPEX is supporting this. I mean, that is true of Fukushima. It is true of Chernobyl, and it is also consistent with the ASME nuclear safety construct as well as other stated views internationally, that this is something that we need to be very mindful of and actually address in one manner or another.

CHAIR STETKAR: Jack, hold on a second. I want to get a clarification for the record.

A lot of folks down here may not be familiar with the acronym OPEX. So, just for the record, it is

operating experience.

MR. VECCHIARELLI: Correct. I apologize for that.

CHAIR STETKAR: Dr. Corradini, sir?

MEMBER CORRADINI: So, you keep on adding a phrase at the end of this, "to the extent practical".

MR. VECCHIARELLI: Yes.

MEMBER CORRADINI: So, tell me what you mean by that. Are you saying cost/benefit; there's a cost/benefit measure that, if it cost more than this for a certain benefit, it is not practical? I am trying to understand the definition of that because, while a laudable goal, I imagine there's got to be some sort of measure here that, if something seems impractical, you would -- can you define what you mean by that?

MR. VECCHIARELLI: Well, my view on that is that "to the extent practicable" meaning that, where we have comprehensibly reassessed the robustness of the facilities following the Fukushima event and identified that there is risk/benefit to introducing an additional layer of defense-in-depth through our FLEX-like equipment, and the point is that we have looked at various possible event scenarios, focusing on sort of station blackout-type conditions and considered the various means by which we can ensure continued reactor

cooling and maintenance of containment integrity.

So, there is a point where, when you have applied enough diversity and redundancy with respect to our mitigation capability, that that is within all reason sufficient. Some utilities have actually incorporated the FLEX-like equipment into the PRA and sort of gauged the risk/benefit in terms of the risk results. It makes a very significant reduction in the calculated risk, to the point where we feel that, with this additional equipment that has been procured and has been implemented, that has provided a substantial improvement in real plant safety, that we are at the point where we feel this is reasonable and it is practicable.

MEMBER CORRADINI: So, I will ask it one more time slightly differently, just so I get it. But at some point, I mean, there is going to be a residual risk. That residual risk, to eliminate it or cut it down by half is going to cost something. And so, I am still wondering, is there some sort of cost/benefit ruler that is applied to this, so that if it gets too costly, you live with the residual risk? You don't eliminate it or eliminate 50 percent of it?

MR. VECCHIARELLI: The way I would approach it is that, when we look at the PRA results, they are

quite low, having included the additional mitigating equipment; that together with other programmatic measures that we have in place to address residual risk, including, for example Severe Accident Management Guidance, which is typically not included in the PRA modeling because it is guidance and not prescriptive procedures, we have a more pragmatic approach to all of this. It is not a hard cost/benefit line in the sand. It is more of an overall assessment of how much is enough, given the PRA results, given the other measures that are in place such as Severe Accident Management Guidance and other provisions at the facility. And it provides a reasonable case to say that this is sufficient.

MEMBER CORRADINI: Okay. So, let me ask a number now and, then, I will stop bothering you. If you looked at all the units for Ontario Power, how much did you spend per unit to essentially install these post-Fukushima measures? Is there an approximate average number per unit?

MR. VECCHIARELLI: I think I would rather discuss that offline, if it is possible.

MEMBER CORRADINI: Okay.

MR. VECCHIARELLI: It is substantial. Let's put it that way.

MEMBER CORRADINI: So, is substantial more

than a million and less than 10?

(Laughter.)

MR. VECCHIARELLI: It is many millions.

MEMBER CORRADINI: Okay. Thank you.

MR. VECCHIARELLI: I am on slide 11 now. This is providing you a construct, if you like. This illustration is really an adaptation of an approach that is emerging from the IAEA. There is a Draft Tech Doc on Safety Goal Framework, where the idea is that one can define a set of safety goals arranged in a hierarchical framework.

Now there are other constructs that we are considering, but this is our preliminary adaptation of the IAEA approach. We are considering other formats to sort of convey the same message, basically. But the idea is that one can envision that there is a mix of both qualitative and quantitative safety goals, and that they can be arranged in different levels, and that there is a logical interrelation from the bottom to the top of these safety goals, such that the top safety goal, the overarching safety goal around public health and well-being, is met.

If I were to just sort of proceed from the top-down here, I will just highlight a few things about this concept. At the top level, this would be, for

example, a qualitative goal that you would find in the Nuclear Safety Control Act, for example. But this is an alternative version of that wording.

But the idea is, qualitatively, you would have a statement around the protection of public health and the well-being of the public. And then, at the upper level, moving down a notch, you could capture the notion of wanting to essentially practically eliminate long-lived radionuclide releases that could lead to extensive land contamination, in light of the experience that we have seen with accidents such as Fukushima and Chernobyl, for example, as I mentioned earlier.

And then, you move down to the intermediate level. These are more generic, still generic-type safety goals or objectives. On the left side, there are various safety and control programs. So, these are, if you like, action-oriented, defense-in-depth-type provisions that are programs around the testing and maintenance, training of personnel, emergency preparedness, et cetera. These are all action-oriented things that are happening at the facility that are based on defense-in-depth, good things to be doing to essentially help ensure that the risk is maintained low.

Moving a little more inwards, we have beyond-design-basis programs. For example, the Severe

Accident Management Guidance framework, or SAMG, that is something we have in place.

As well, moving further along, you tend to have, you find in this level quantitative criteria for deterministic and probabilistic safety analysis at the site level. So, what this would mean, for example, for design-basis accidents, we have public dose limits. For beyond-design-basis, this is where you would have your, you could have your PRA risk metrics defined at a site level. That could be a quantitative health objective or it could even be, as an option, it could be a site-based large release frequency, for example.

At the lowest level, this is where it becomes mostly quantitative and tends to be plant-specific. You have compliance criteria for the various provisions in the intermediate level. In the PRA space, this is where you would tend to see, for example, the per-unit-based risk metrics. So, large release frequency or severe core damage frequency would appear here.

The whole point of this illustration here is to try to put PRA into a broader perspective, that you see that the risk metrics are part of the supporting care. They, along with other qualitative or action-oriented programmatic-type activities

collectively, they accomplish the top-level objective of providing protection of public health and well-being.

So, that is really the overarching message in this illustration here. It is one construct. We are considering other formats. But this is something that the IAEA right now has drafted in a Tech Doc as an approach to conveying the notion that there are a multitude of safety goals, not just PRA risk metrics, which are also safety goals.

On slide 12, this is really summarizing some of the key messages that we see coming out from a public communication point of view, the key messages that arise from this perspective of a safety goal framework. That is that PRA is part of the safety story. It is not the be all and end all. It has a place in the greater scheme of things and it is part of it. It is an important part of it.

The PRA safety goals are targets, not hard limits. Really, the main benefits of PRA are in identifying the risk insights that one can use to improve plant design and operation.

Lastly, another key message here is that the existing PRA safety goals which are currently applied on a per-unit, per-hazard basis, together with the existing programs, we view that this provides

confidence that the site risk is low. Now this is not suggest that each unit could be up to the safety goal value for each hazard right at the limit. That is not the intention here.

But the fact that the programs that are in place actually tend to drive the individual PRA results low enough, such that they support, if you were to aggregate them, they provide a supporting rationale for claiming that on a whole-site basis the risk is relatively low. So, existing safety goals on a per-unit basis low enough, as driven by exiting programs, provide us the confidence that the site risk is low.

To help support that, on slide 13, I would like to talk a little bit about a preliminary assessment of the risk metrics. What we did was we assessed the margins to possible quantitative health objectives for a range of large release frequency values and consequence assumptions. This would be, for example, the quantitative health objective, one possible one is around incremental risk of delayed fatalities, for example.

What we found is that, as an overall judgment, that the total large release frequency, on the order of 10 to the minus 5 per year, that provides margin to possible quantitative health objectives for

a wide range of accident sequences while serving as a reasonable basis for practical elimination of the potential for long-term relocation.

This gets back to an earlier comment: what is practicable? If the aggregated large release frequency is on the order of 10 to the minus 5 per year, that is a reasonable basis to say that you, in our view, have practically eliminated long-term relocation, which is our prime concern from a societal disruption point of view. It also generally provides a robust margin to the quantitative health objective.

This is being stated in a qualitative sense. I recognize that. The reason is that, in terms of acceptance criteria for risk metrics, we see that the issues are really what I call trans-scientific, that you can't solve these issues solely by means of science. There are other factors that come into play, such as socioeconomic considerations.

And so, it is not purely a numbers assessment. You have to sort of be more of a judgment approach to how much is enough in terms of the aggregate risk.

So, on average, what we are finding is that a total large release frequency on the order of 10 to the minus, that is a reasonable, in our judgment, that

is a reasonable value to ensure that quantitative health objectives are reasonably met as well as a basis for practical elimination of long-term relocation.

Just to summarize, then, on slide 14, our view is that nuclear safety and low risk is assured through a collection of safety goals and objectives, not necessarily by a single numerical value or risk metric. One can envision a hierarchical framework of safety goals consisting of a mix of qualitative and quantitative safety goals in different levels and logically interrelated, such that the overarching safety goal or health objective is met, while also adequately addressing other important considerations, in particular, long-term relocation. And this may be used as the basis for the development of some public communication tool or mechanism.

Lastly, in our view, there is flexibility in what is the acceptable value of a total calculated large release frequency. It is not a pass-and-fail in our view. For example, you could have a total large release frequency somewhat in excess of 10 to the minus 5 per year, which is our current per-unit base value. The risk metric is not limited to addressing health objectives. There are other considerations, in particular, long-term relocation impacts.

In terms of managing whole-site risk, we believe this can be managed through compliance with the current per-unit-based risk metrics together with programmatic measures, which actually drive the PRA results to be sufficiently low to provide confidence that site risk is also low.

CHAIR STETKAR: Jack, thank you very much. Stay on the line here --

MR. VECCHIARELLI: Yes.

CHAIR STETKAR: -- because we have got a couple of other administrative things to do. I want to make sure you have a chance to hear those.

We are in the process of getting the public line open, which I think it is.

Let me, first, ask if there is anybody in the meeting room here who would like to make a comment. Come up to the microphone and do so.

(No response.)

Seeing no stampede to the microphones, I will ask, are there any members of the public out on the public line who would like to make a comment?

Just somebody, again, because of the high technology, somebody other than Jack, please just say "Hello," so we can confirm that the other line is open.

PARTICIPANT: Hello.

CHAIR STETKAR: Thank you.

PARTICIPANT: Hello.

CHAIR STETKAR: That is good enough. Thanks.

Now, if there is anybody on that other line who would like to make a comment, please identify yourself and do so.

14913MR. GIMINEY: This is Keith Giminey14915 in Toronto.

I think we are trying to draw a balance here in terms of --

CHAIR STETKAR: Sir, sir?

**14924MR. GIMINEY: Yes?

CHAIR STETKAR: Step back from your phone just a little bit. You are kind of overloading the line here.

**14930MR. GIMINEY: Okay. How about that?

CHAIR STETKAR: That is I think okay. Try saying something.

**14938MR. GIMINEY: I just need to add that we believe that it is absolutely not health impacts which are the primary cause of public concern these days from large nuclear accidents. What we are trying to do here is to come across with an approach which covers

a broader range of consequences and, in doing so, ensures adequate public health protection.

But I think none of the methods we currently have for assessing the cost/benefit, for example, seriously underestimate the economic consequences of large releases. So, rather than go through a complex methodology, we are trying to come up with a safety goal approach which encompasses these broader considerations.

CHAIR STETKAR: Thank you very much.

Because you were kind of overloading the line when you first came on, could you again give us your name and your affiliation?

15042MR. GIMINEY: Yes. This is Keith Giminey15044 from Amec Foster Wheeler here in Toronto.

CHAIR STETKAR: Okay. Thank you very much, Keith.

Anybody else on the public line who would like to make a comment?

(No response.)

If not, we will reclose the public line because it gives us pops and whistles and things here in the meeting room.

As we usually do in a Subcommittee meeting, I will go around the table and ask each of the

Subcommittee members if you have any additional comments that you would like to make.

Dr. Bley, let's start with you.

MEMBER BLEY: Only a thank you to Jack for the presentation.

I was looking forward to seeing what approach they were taking on this societal risk issue. Now that I see that, it is kind of straightforward. So, I understand it and I appreciate what they had to say.

Thanks.

CHAIR STETKAR: Dr. Corradini, sir?

MEMBER CORRADINI: Thanks to Jack from Ontario Power Generation. I think he answered most of my questions.

I am still struggling on how I deal with the gray area that still exists, but I think I understand the process and the approach you guys are taking.

So, thank you so much.

CHAIR STETKAR: Ron?

MEMBER BALLINGER: Again, thanks for the presentation, but everybody has covered everything that I would say.

CHAIR STETKAR: Jack, this is John Stetkar again.

I really appreciate your taking the time

for putting this together. I am sorry that you couldn't make it down here and get grilled in person, but you may have an opportunity to do that sometime later.

I think that this has been very interesting to me because it illustrates a little different thinking. It illustrates a thought process that has come out of the industry or at least with a lot of input from the industry in Canada.

I think you heard from a couple of the questions that we had it is a little different perspective than we are used to here in the U.S. I think that is useful for us to hear those different perspectives.

So, again, I would like to thank you very, very much for the time and effort you put into this. We may be in touch in the future as you get further along on that full-site risk assessment for Pickering.

With that, I think we are finished, and I will adjourn the meeting because we have another meeting starting in six minutes.

(Whereupon, at 1:53 p.m., the meeting was adjourned.)

Full-Scope Site Level 3 PRA

Advisory Committee on Reactor Safeguards
Reliability and PRA Subcommittee

March 1, 2016
(Open Session)

Outline

- Open Session
  - Project status overview
  - ISLOCA expert elicitation
- Closed Session
  - ISLOCA expert elicitation
  - Level 1 internal event and flood PRA

Level 3 PRA Project Status Overview

March 1, 2016

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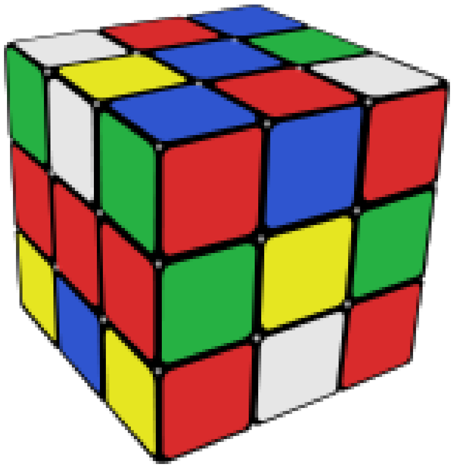
Outline of Project Status

- Reactor, at-power, Level 1
  - Internal events and floods
  - Internal fires
  - Seismic events
  - High winds, external flooding, and other hazards
- Reactor, at-power, Level 2
- Reactor, at-power, Level 3
- Reactor, low power and shutdown
- Spent fuel pool (SFP)
- Dry cask storage (DCS)
- Integrated site risk
- Path Forward



Model Phases

- Initial model – The first model developed for a particular part (scope element) of the Level 3 PRA project. Often referred to as the R01 version of the model.
- Updated model – The model developed for a particular part of the Level 3 PRA project after incorporating comments from the PWROG-led ASME/ANS PRA standard-based peer review and technical advisory group (TAG) review, and other feedback. Often referred to as the R02 version of the model.
- Revised model – A revision to the initial model, prior to peer review, that involves significant changes due to updated information provided by Southern Nuclear Operating Company (SNC). Currently, only applies to the reactor, at-power, Level 1 PRA models for internal fires and seismic events.

Internal Events and Floods (Reactor, At-Power, Level 1)

- Completed ASME/ANS PRA standard-based peer review, led by PWR Owners Group (PWROG)
- Revising model and documentation to address peer review and other comments
  - Revised (R02) model essentially complete
  - Significant changes to event trees, some fault trees, human reliability analysis, number of flooding scenarios modeled, and flooding initiating event frequencies
  - Currently revising reports
- Completed expert elicitation for interfacing systems LOCA (ISLOCA)

Internal Fires (Reactor, At-Power, Level 1)

- Beginning update of initial Level 1 fire PRA model and documentation based on new input from SNC
  - Refined fire modeling for a subset of sequences
    - Electrical enclosure fire modeling techniques
    - Fire growth/spread assumptions (i.e., cable tray spread)
    - Zone of influence screening conservatisms (i.e., plume vs. flux)
    - Fire protection suppression systems
- Conducted another site visit in November 2015 to gather information to evaluate new fire modeling approaches and to support update to fire HRA
- Anticipating completion of updated model and documentation by the end of 2016

Seismic Events (Reactor, At-Power, Level 1)

- Beginning update of initial seismic PRA (SPRA) model and documentation, based on new input from SNC
  - New seismic hazard bins
  - Updated seismic fragilities
  - Additional seismic considerations
- Revised SNC seismic PRA report not currently available
  - NRC may need to make some simplifying assumptions due to lack of information or analysis (e.g., regarding relay chatter)
- Anticipating completion of revised model and documentation in August/September 2016

High Winds, External Flooding, and Other Hazards (Reactor, At-Power, Level 1)

- Completed ASME/ANS PRA standard-based peer review, led by PWROG
- Revising Level 1, at-power, high wind PRA and "other hazards" evaluation
  - PWROG-led peer review comments
  - TAG comments
  - Site walkdown by Applied Research Associates (ARA)
- Anticipating completion of revised documentation and, if necessary, revised high wind PRA model and additional other hazards analyses, in September 2016

Reactor, At-Power, Level 2

- Completed ASME/ANS PRA standard-based peer review, led by PWROG
- Revising model and documentation to address peer review, TAG, and other comments
  - Overhaul of plant damage state binning
  - Significant modifications to MELCOR model and re-computation of all MELCOR analyses
  - Re-visiting many containment event tree issues/analyses
- Anticipating completion of revised model and documentation in Summer 2016

Reactor, At-Power, Level 3

- Completed ASME/ANS PRA standard-based peer review, led by PWROG
- Revising model and documentation to address peer review, TAG, and other comments
  - Elimination of Vogtle construction worker cohort
  - Refinement of emergency and intermediate phase protective action models
  - Use of updated decontamination model parameters
- Anticipating completion of revised model and documentation in November 2016

Reactor, Low Power and Shutdown

- Developing new PRA model in SAPHIRE
  - Some information provided by SNC from an earlier effort
- Identified set of plant operating states and (internal) initiating events to be modeled
- Completed several event trees
- Currently:
  - Developing additional event trees
  - Updating initiating event frequencies
  - Beginning to exercise human reliability analysis approaches
- Anticipating completion of initial model and documentation in August 2016

Spent Fuel Pool PRA

- Marginal progress since February 2015 (owing to competing priorities)
- Areas of movement include:
  - Accident sequence modeling for large seismic events
  - System modeling of SFP cooling
  - Estimating liner/structure over-temperature regimes
  - MELCOR modeling of two pools simultaneously
  - Documentation

Dry Cask Storage PRA

- Completed human reliability analysis for the vertical cask transporter (VCT) crane reliability model
- Completed seismic tip-over frequency analysis
- Completed Hazard and Operability Study (HAZOP)
- Continuing to evaluate
  - Structural performance of fuel and multi-purpose canister during impact events
  - Thermal events (e.g., vent blockage)
  - VCT crane reliability analysis
  - Cask support systems (e.g., ventilation system failure, overhead crane failure)
  - Aircraft impact frequency analysis
  - Source term for consequence analysis
- Anticipating completion of initial DCS Level 1/2/3 PRA and documentation in Summer 2016

Integrated Site PRA

- Developed integrated site operating configuration (SOC) matrix
  - Identifies distinct combinations of operating states for major site radiological sources and their relative contributions to site operating cycle duration for prioritization
- Developed integrated site dependency matrix
  - High-level framework for identifying, classifying, and documenting potential dependencies or interactions across major site radiological sources for different SOCs
- Reviewing insights and results from available single-source PRA models to identify:
  - Significant contributors to risk for modeled initiators
  - Dependencies with potential multi-source effects for each significant risk contributor to focus integrated site PRA model development efforts

Path Forward (1 of 2)

- Continue work in all technical areas of the study
  - Complete updated reactor, at-power, Level 2, internal event and flood PRA (July 2016)
  - Complete initial dry cask storage, Level 1, 2, and 3 PRA (July/August 2016)
  - Complete initial reactor, LPSD, Level 1, internal event PRA (August 2016)
  - Complete revised reactor, at-power, Level 1, seismic event PRA (August/September 2016)
  - Complete updated reactor, at-power, Level 3, internal event and flood PRA (November 2016)
  - Complete revised reactor, at-power, Level 1, internal fire PRA (December 2016)

Path Forward (2 of 2)

- Continue with PWROG-led, PRA standard-based peer reviews
  - Dry cask storage, Level 1/2/3 PRA (September 2016)
  - Reactor, LPSD, Level 1, internal event PRA (October 2016)
  - Reactor, at-power, Level 1, seismic PRA (December 2016)
- Schedule challenges
  - Diversion of key staff
  - Conversion and "ownership" of SNC peer-reviewed PRA models
  - SNC's active PRA program for Vogtle
- Acknowledgements
  - SNC
  - PWR Owners Group
  - Westinghouse and EPRI

Interfacing Systems LOCA (ISLOCA) Expert Elicitation

March 1, 2016

ISLOCA Modeling in the Level 3 PRA

- Issues
  - For large internal leaks (≥50 gpm) for check valves and motor-operated valves in the various ISLOCA pathways, the Level 3 PRA uses alpha factors for common-cause failures from the 2010 update to NUREG/CR-6928, though it is recognized that these are very uncertain and could have an overly conservative impact on ISLOCA frequency.
  - The break size and location of an ISLOCA are also highly uncertain, and can significantly impact the radiological consequences.
  - Combined, these uncertainties can significantly distort the risk profile for VEGP, Units 1 and 2, developed under the Level 3 PRA project.
- Proposed resolution
  - An expert elicitation will be performed to increase our understanding of these parameters and phenomena.
  - The expert elicitation will pilot the staff's draft expert elicitation guidance (consistent with SRM-SECY-11-0172).

Results of Expert Elicitation supporting ISLOCA Modeling

Presentation to ACRS PRA Subcommittee
March 1, 2016

Steve Short, PE
Kevin Anderson/Don Daly
Pacific Northwest National Laboratory (PNNL)

Jing Xing
Nuclear Regulatory Commission (NRC/RES)

PNNL Project Team

- Mr. Steve Short, P.E.
  - Project manager, co-principal investigator
- Mr. Michael Zentner, P.E.
  - Facilitator, co-principal investigator
- Mr. William (Bill) Ivans
  - Technical integrator/scribe
- Dr. Don Daly
  - Development of probability distributions
- Dr. Stephen Unwin
  - Project consultant
- Other project support
  - Dave Engel
  - Kevin Anderson
  - Bruce Schmitt

Scope of Elicitation Project

- Vogel Electric Generating Plant (VEGP) Units 1 and 2
- ISLOCA pathways:
  - Residual Heat Removal (RHR) System
  - Safety Injection (SI) System
  - Other pathways judged to be smaller contributors to CDF (e.g., charging, letdown, RCP seal cooling)
- PRA model parameters:
  - Normally-closed isolation valves:
    - Failure rates (failures/hour) for check valves (CV) and motor operated valves (MOV) for internal large leak (ILL) failure mode
    - Conditional probability of failure of the second down-stream valve given failure of the first valve (two valves in series)
  - Normally-open MOVs that could be used to mitigate the ISLOCA:
    - Failure-to-close (FTC) probability (failures/demand)
  - Probability of break by location outside containment

Elicitation Process

I. Prepare Detailed Problem Description

- Problem definition
- Elicitation process and objectives
- Level of detail expectations
- System Notebooks

II. Select Expert Team for Elicitation

- PRA
- Common Cause Failures
- Piping and Valve Failure Experts
- System Engineers

III. Expert Training

- Initial Video Conference, Expert Elicitation Training
- Second Conference – Review Training, Systems Familiarization

IV. Individual Elicitation Meetings

- Individual Elicitation with Each Team Member
- PNNL Collects and Collates Results
- Provide Draft Results to Team

V. Group Elicitation Meeting

- Review Results of Individual Elicitation Meetings
- Group Elicitation with All Team Members
- PNNL Collects and Collates Results

VI. Issue Draft Report for Review

- Review by NRC and Experts
- Incorporate Comments

Adapted SSHAC process for ISLOCA

Preparation

Prepare detailed problem description and data

Select expert team for elicitation

Training

Individual meetings

Understanding of problems, models & data

Evaluate data

Initial elicitation of judgment (center/body/range with justification) on the stated problems

Workshop – Group meeting

Review and discuss results of individual meetings

Elicit and modify individual judgment

Integrate individual judgments and document the results

Review the results by NRC and experts

Participatory peer review, transparency, and documentation

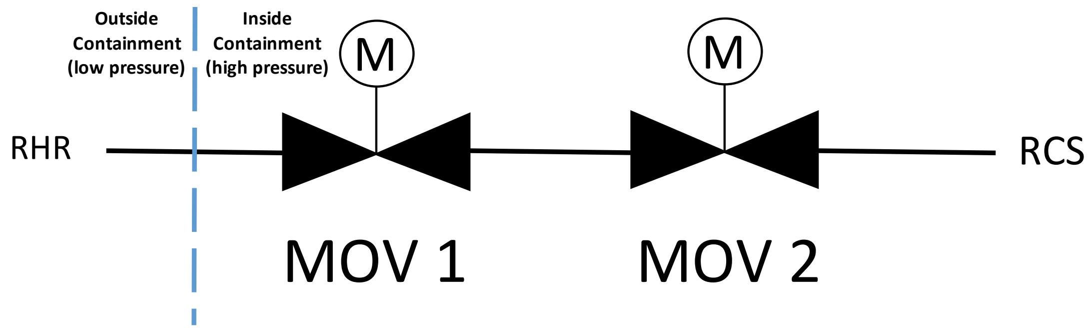
Summary of the adapted SSHAC process

- The adapted process preserved SSHAC principles:
  - ✓ Structured process to facilitate elicitation and minimize biases
  - ✓ Breadth of State-of-Knowledge – Evaluation of available data, balance of expertise
  - ✓ Independence – Judgment based on knowledge and individuals' expertise
  - ✓ Interaction in evaluating models/data and assessing uncertainties
  - ✓ Integration (rather than consensus) of interpretations / judgment

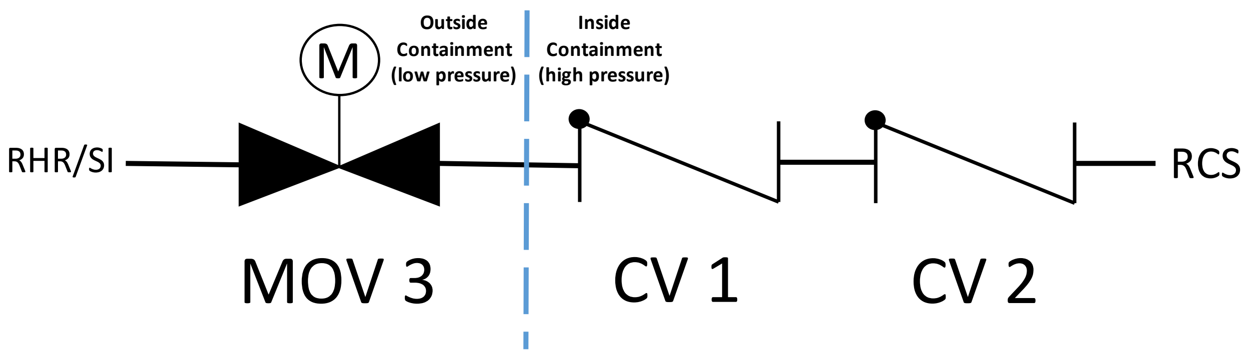
- The three training sessions were effective and ensured that the experts understand the stated problems and expressed uncertainties with probability distribution.

- Using individual meetings in lieu of SSHAC Workshop #1 achieved the goals with some minor caveats that were fixed at the group meeting.

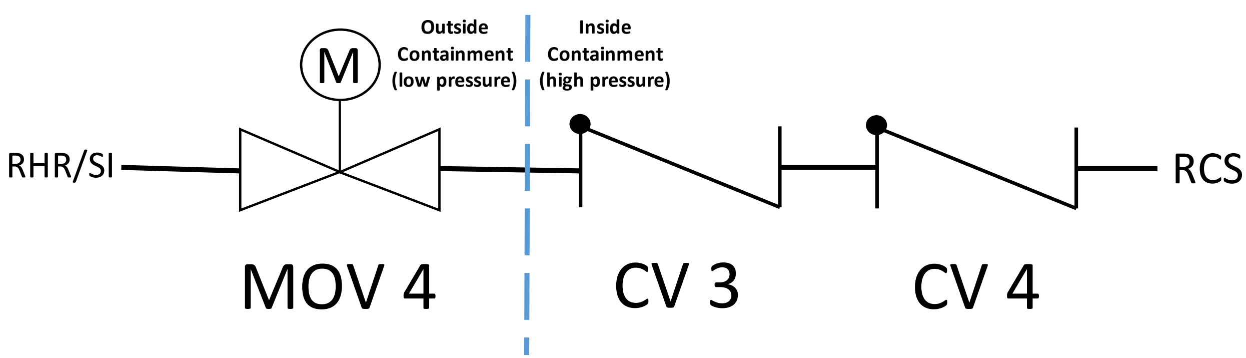
ISLOCA High/Low Pressure Interface Configurations on RHR/SI Systems



- RHR Suction Pathways
- Two normally closed MOVs in series, both inside containment
- MOVs leak tested each outage



- RHR/SI Hot Leg Injection Pathways
- Two CVs and one normally closed MOV in series; CVs inside containment, MOV outside containment



- RHR/SI Cold Leg Injection Pathways
- Two CVs and one normally open MOV in series; CVs inside containment, MOV outside containment

Expert Panel Members

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- Mr. Neal Estep – Kalsi Engineering, Inc.
  - Nuclear power plant (NPP) valve engineer, 30+ years experience
- Dr. Karl Fleming – KNF Consulting Services LLC
  - NPP PRA/common cause failure, 40+ years experience
- Mr. Michael Horton – Southern Co.
  - System engineer, Sr. Reactor Operator license, 35 years experience
- Mr. Paul Knittle – MPR Associates, Inc.
  - NPP valve engineer, 30 years experience
- Dr. Frederic Simonen – Lucius Pitkin, Inc.
  - NPP piping fatigue/failure analysis, 40+ years experience
- Dr. Michael Stamatelatos – Self (Retired – NASA)
  - PRA/common cause failure, 40+ years experience

Internal Large Leak Failure Rate

- Information provided to expert panel:
  - VEGP RHR and SI System description
    - System notebooks
    - Valve/component design, fabrication, and test specifications, including drawings
  - Current small internal leak failure rate assumption from NUREG/CR-6928 based on actual valve failure data:
    - MOVs – 2.02E-09 failures/hour (mean)
    - CVs – 6.15E-09 failures/hour (mean)
  - INPO Equipment Performance and Information Exchange (EPIX) data on historical internal leaks in RHR/SI systems

Internal Large Leak Failure Rate

- Elicitation approach:
  - Use common Elicitation Form for all experts
  - Each expert provides the change in failure rate relative to the failure rate for small internal leaks from NUREG/CR-6928
    - Information represents the best available data on valve ILL failures
    - Best approach for experts not experienced with expressing failures in probabilistic terms
    - Not funded to develop mechanistic failure models
  - Alternatively, expert can provide the component failure rate (failures/hour)
  - Failure rate elicited for different leak size categories [effective diameter (inches) and leak rate (gpm)], depending on size of valve
  - Failure rate elicited for lower bound (5%), best estimate (50%), and upper bound (95%)
  - Elicited for each isolation MOV and CV

Internal Large Leak Failure Rate

- Results
  - Cumulative distribution functions developed for each “unique” valve design, each leak size category, and each expert
  - Gamma distribution functions used based on industry practice; no technical reason to change
  - The individual distributions developed for each expert were combined to estimate a single mixture distribution reflecting the uncertainty in the elicited results
    - Used same method as used in NUREG-1150 (arithmetic average of the individual probability distributions)
    - Method results in higher mean and 95th percentile and lower 5th percentile results than other methods (because extremes dominate)
  - Two distributions reported:
    - Actual mixture distribution represented by a lookup table of values
    - Best fit parametric gamma distribution represented by the mean, alpha, and beta parameters
  - Total large internal leak failure rate
    - Gamma distribution fit to the sum of the individual mixture distributions

Internal Large Leak Failure Rate – RHR Hot Leg Suction MOVs

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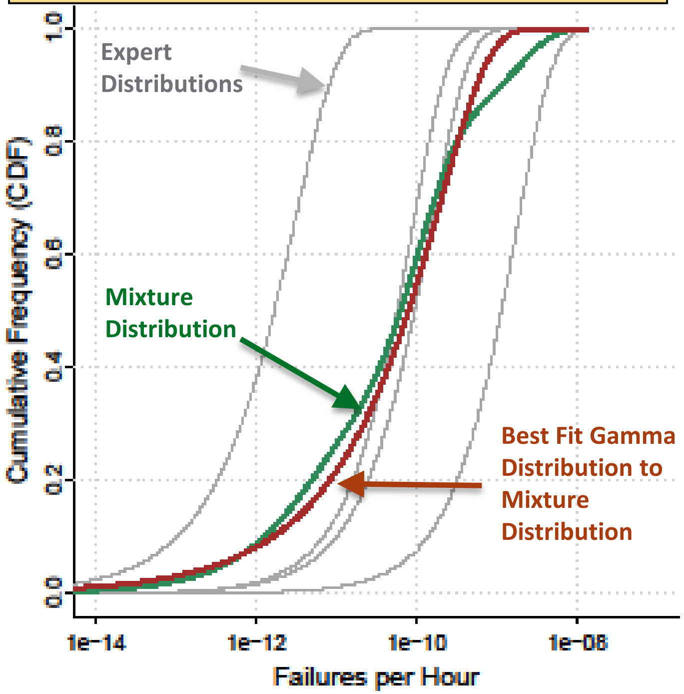
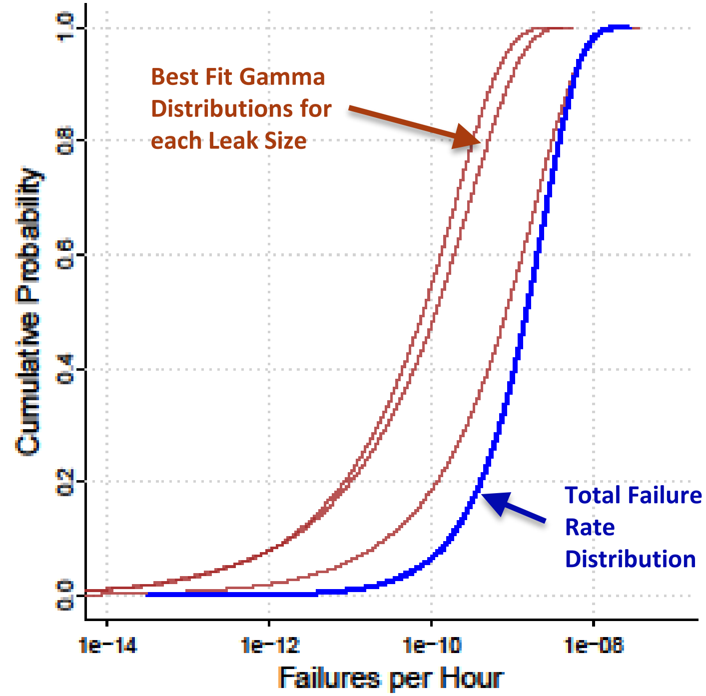
Leak Size: 5” to 10.75” (effective diameter)

Leak Rate: 14,500 to 67,200 gpm



Leak Size: 0.8” to 10.75” (effective diameter)

Leak Rate: 370 to 67,200 gpm



Leak Size (inches effective diameter)	Leak Rate (gpm)	Mean ILL Failure Rate (failures/hour)
0.8 to 2	370 to 2,325	1.94E-09
2 to 5	2,325 to 14,500	3.04E-10
5 to 10.75	14,500 to 67,200	2.04E-10
Total (0.8 to 10.75)	370 to 67,200	2.35E-09
NUREG/CR-6928 (2010 Update)		2.02E-09

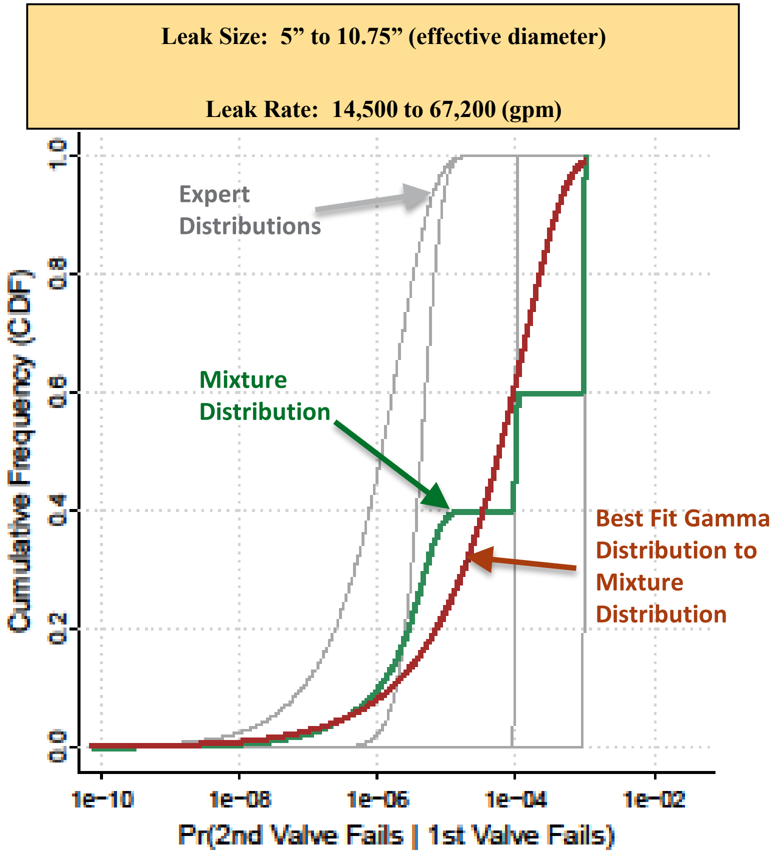
Conditional Probability of Failure of 2nd Valve (MOV downstream and in series with 1st MOV)

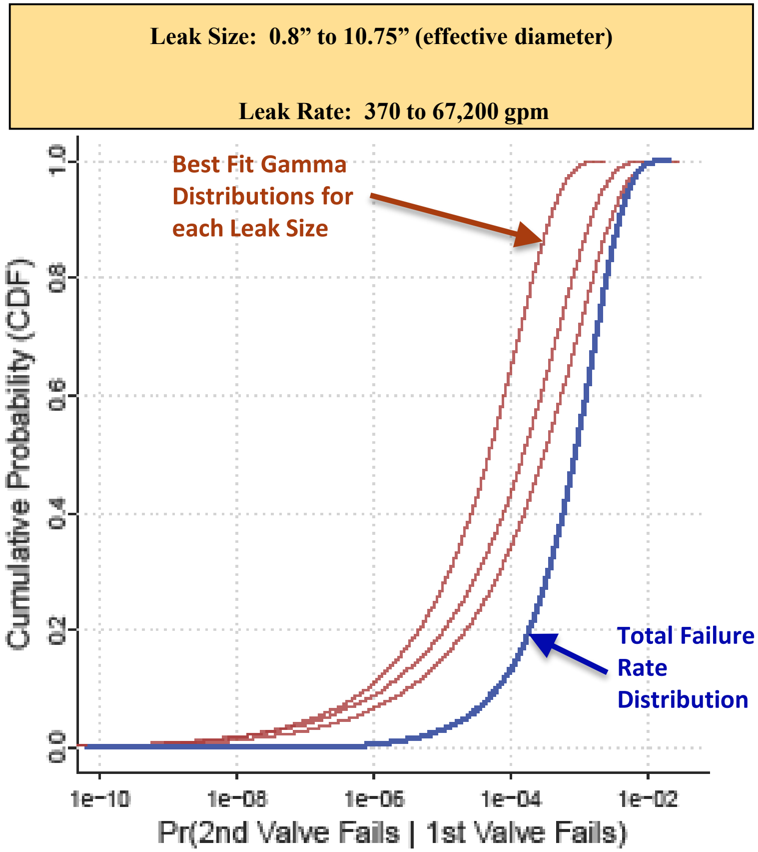
- Elicitation approach:
  - Use common Elicitation Form for all experts
  - Changed from initial plan to elicit common cause failure probabilities (for input to common cause failure model)
  - Each expert provides the conditional probability of failure of the 2nd valve in series with the 1st failed valve (as a consequence of the change in conditions due to the independent failure of the first valve, i.e., sudden pressure surge)
  - Conditional failure probability elicited for different leak size categories [effective diameter (inches) and leak rate (gpm)], depending on size of valve
  - Conditional failure probability elicited for lower bound (5%), best estimate (50%), and upper bound (95%)
  - Elicited for each pair of isolation MOVs and CVs

Conditional Probability of Failure of 2nd Valve (MOV downstream and in series with 1st MOV)

- Results
  - Cumulative distribution functions developed for each “unique” valve design, each leak size category, and each expert
  - Gamma distribution functions used (essentially same result as beta distribution)
  - The individual distributions developed for each expert were combined to estimate a single mixture distribution reflecting the uncertainty in the elicited results
    - Again, used same method as used in NUREG-1150 (arithmetic average of the individual probability distributions)
    - Lack of spread between 5%, 50%, and 95% (i.e., all same values) required some additional data handling in order to include this input in the development of the distributions
  - Two distributions reported:
    - Actual mixture distribution represented by a lookup table of values
    - Best fit parametric gamma distribution represented by the mean, alpha, and beta parameters

Conditional Probability of Failure of 2nd Valve (MOV downstream and in series with 1st MOV)





Conditional Probability of Failure of 2nd Valve (MOV downstream and in series with 1st MOV)

Leak Size (inches effective diameter)	Leak Rate (gpm)	Conditional Failure Probability	×2 for 2 pathways
0.8 to 2	370 to 2,325	1.03E-03	2.06E-03
2 to 5	2,325 to 14,500	5.19E-04	1.04E-03
5 to 10.75	14,500 to 67,200	1.37E-04	2.74E-04
Total (0.8 to 10.75)	370 to 67,200	1.52E-03	3.04E-03
Alpha Factor Model, group size of 4, staggered-testing, alpha factors from INL Database (α_1 = 9.47E-01, α_2 = 3.46E-02, α_3 = 1.41E-02, α_4 = 4.70E-03)		1.13E-01 (conditional probability after summation of frequency for all combinations/cutsets)	

Failure-to-Close Probability (RHR MOV)

- Information provided to expert panel:
  - VEGP RHR and SI System description
    - System notebooks
    - Valve/component design, fabrication, and test specifications, including drawings
  - Current failure-to-close (FTC) probability assumption from NUREG/CR-6928 based on actual valve failure data:
    - 9.63E-04 failures/demand (mean)

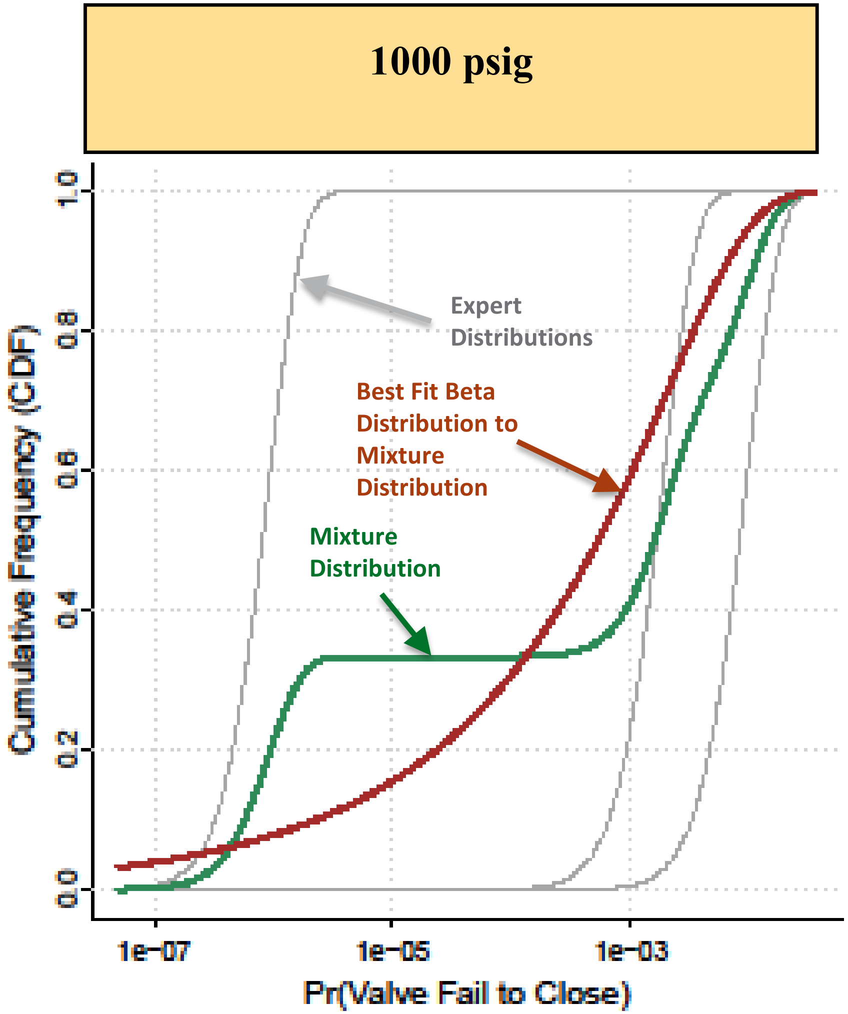
Failure-to-Close Probability (RHR MOV)

- Elicitation approach:
  - Use common Elicitation Form for all experts
  - Each expert provides the change in failure probability relative to the FTC probability from NUREG/CR-6928
    - Information represents the best available data on valve FTC probabilities
    - Best approach for experts not experienced with expressing failures in probabilistic terms
    - Not funded to develop mechanistic failure models
  - Failure probability elicited for different categories of differential pressure across the valve
  - Failure probability elicited for lower bound (5%), best estimate (50%), and upper bound (95%)
  - Elicited for each normally-open MOV that could potentially be used to isolate/mitigate an ISLOCA

Failure-to-Close Probability (RHR MOV)

- Results
  - Cumulative distribution functions developed for each “unique” valve design, each differential pressure category, and each expert
  - Beta distribution functions used based on industry practice; no technical reason to change
  - The individual distributions developed for each expert were combined to estimate a single mixture distribution reflecting the uncertainty in the elicited results
    - Used same method as used in NUREG-1150 (arithmetic average of the individual probability distributions)
  - Two distributions reported:
    - Actual mixture distribution represented by a lookup table of values
    - Best fit parametric beta distribution represented by the mean, alpha, and beta parameters

Failure-to-Close Probability (RHR MOV)



Differential Pressure (psig)	Mean FTC Probability
1000	2.19E-03
1500	5.67E-02
2000	5.93E-01
2695	5.93E-01
NUREG/CR-6928 (2010 Update)	9.63E-04

Probability of External Break Location

- Information provided to expert panel:
  - VEGP RHR and SI System description
    - System notebooks
    - Valve/component/piping design, fabrication, and test specifications, including drawings

Probability of External Break Location

- Elicitation approach:
  - Use common Elicitation Form for all experts
  - Each expert provides the likelihood that the external break will occur at a specific location relative to a reference location (inside containment)
    - Assumes an external break will occur at some location
  - Eliciting probability of external break not within the project scope
  - Best estimate probability elicited
  - Elicited for each ISLOCA pathway

Probability of External Break Location

ISLOCA in the RHR system is initiated due to failure of the redundant MOVs on the suction lines from Hot Leg Loop 1

RHR ISLOCA	Probability	Break Location
	0.0004	1
	0.048	2
	0.008	3
	0.008	4
	0.726	5
	0.014	6
	0.168	7
	0.012	8
	0.003	9
	0.014	10

Backup Slides

Adapted SSHAC process for ISLOCA Preparation

Preparation

Prepare detailed problem description and data

- Problem definition
- Project plan development – elicitation process, objective, etc
- Level of detail expectations
- System notebook – available models and data

Select expert team for elicitation

- PRA
- Common cause failures
- Piping and valve failure experts
- System engineers

Training

- Initial video conference on expert elicitation training
- Second video conference for systems familiarization
- Workshop training on probability distribution and uncertainties

Adapted SSHAC process - Training

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Initial video conference on expert elicitation training

- Review and discussion of the problem description.
- Overview of the current NRC L3PRA ISLOCA model.
- Description of the elicitation process.
- Discussion of some of the pitfalls of the elicitation process, such as bias, anchoring, and uncertainty underestimation.
- Tutorial of the elicitation training exercise and associated questions.

Second video conference for systems familiarization

- Review the initial results of the elicitation training exercise.
- Briefly re-review the problem description.
- Provide an overview of the content of the RHR and SI System Notebooks
- Describe and discuss the information to be elicited at the individual and group elicitation sessions.

Workshop training on probability distribution and uncertainties

- Exercise on identifying uncertainty factors and expressing uncertainties with probability distribution

Adapted SSHAC process for ISLOCA – Individual meetings

Individual meetings

Understanding of problems, models & data

Evaluate data

Initial elicitation of judgment (center/body/range with justification) on the stated problems

Datasheets for elicitation

1) Large internal leak failure rate for CVs and MOVs
2) Common cause failure likelihood for pairs of in-series CVs and MOVs
3) Probability of failure-to-close (FTC) against differential pressure for normally-open MOVs
4) Likelihood of external break location due to a large internal valve leak relative to a reference location inside containment

Meeting procedure:

- The facilitator introduced the Datasheet; the expert was given the opportunity to ask additional questions to clarify the intent and meaning of any of the data fields.
- The integrator recorded the expert's judgment (probabilities) in an expert-specific Datasheet and comments (justification).
- Expert sometimes made changes to previously entered values and comments to ensure consistency or to reflect an evolution in the Expert's thought process.
- The outcome of the meetings was distributed to all the experts prior to the next workshop.

Adapted SSHAC process for ISLOCA - Workshop

Group meeting

Review results of individual meetings

Have group discussion and elicitation

- Each expert presented the basis for their individual results, with discussion among the panel members encouraged.
- Following completion of discussions, each expert was given an opportunity to modify their original judgment based on the additional information presented by the various experts.
- Each expert provided their updated Datasheets to PNNL during a three month period after the workshop – Experts reviewing their changes, adding comments, and reconsidering their input in light of the additional information discussed during the meeting and made available subsequent to the meeting.

NUREG/CR-6928 (2010 Update)

Table 1-7. Selected industry distributions of p and λ for MOVs.

Pooling Group	Failure Mode	Source	5%	Median	Mean	95%	Distribution		
							Type	α	β
All	FTO/C	EB/PL/KS	1.76E-04	8.12E-04	9.63E-04	2.27E-03	Beta	2.05	2.123E+03
	FC	EB/PL/KS	7.40E-09	5.18E-08	6.62E-08	1.74E-07	Gamma	1.46	2.205E+07
	SOP	EB/PL/KS	2.54E-10	1.72E-08	3.39E-08	1.24E-07	Gamma	0.57	1.684E+07
	ILS	EB/PL/KS	1.36E-09	5.64E-08	1.01E-07	3.52E-07	Gamma	0.65	6.477E+06
	ILL	EB/PL/KS	2.16E-13	4.92E-10	2.02E-09	9.24E-09	Gamma	0.30	1.485E+08
	ELS	EB/PL/KS	9.81E-11	1.42E-08	3.28E-08	1.28E-07	Gamma	0.48	1.451E+07
	ELL	EB/PL/KS	2.46E-13	5.59E-10	2.29E-09	1.05E-08	Gamma	0.30	1.308E+08

Table 1-28. Selected industry distributions of p and λ for CKVs.

Pooling Group	Failure Mode	Source	5%	Median	Mean	95%	Distribution		
							Type	α	β
All	FTO	JNID/IL	4.20E-08	4.86E-06	1.07E-05	4.10E-05	Beta	0.50	4.684E+04
	FTC	EB/PL/KS	6.68E-06	1.50E-04	2.38E-04	7.70E-04	Beta	0.81	3.384E+03
	SOP	JNID/IL	1.08E-09	3.16E-09	3.48E-09	7.00E-09	Gamma	3.50	1.005E+09
	SC	JNID/IL	2.28E-09	5.15E-09	5.47E-09	9.79E-09	Gamma	5.50	1.005E+09
	ILS	EB/PL/KS	2.32E-09	1.56E-07	3.08E-07	1.13E-06	Gamma	0.57	1.856E+06
	ILL	EB/PL/KS	6.58E-13	1.50E-09	6.15E-09	2.81E-08	Gamma	0.30	4.876E+07
	ELS	JNID/IL	5.77E-09	1.01E-08	1.05E-08	1.63E-08	Gamma	10.50	1.005E+09
	ELL	JNID/IL	7.87E-14	1.79E-10	7.35E-10	3.36E-09	Gamma	0.30	4.082E+08

Internal Large Leak Failure Rate

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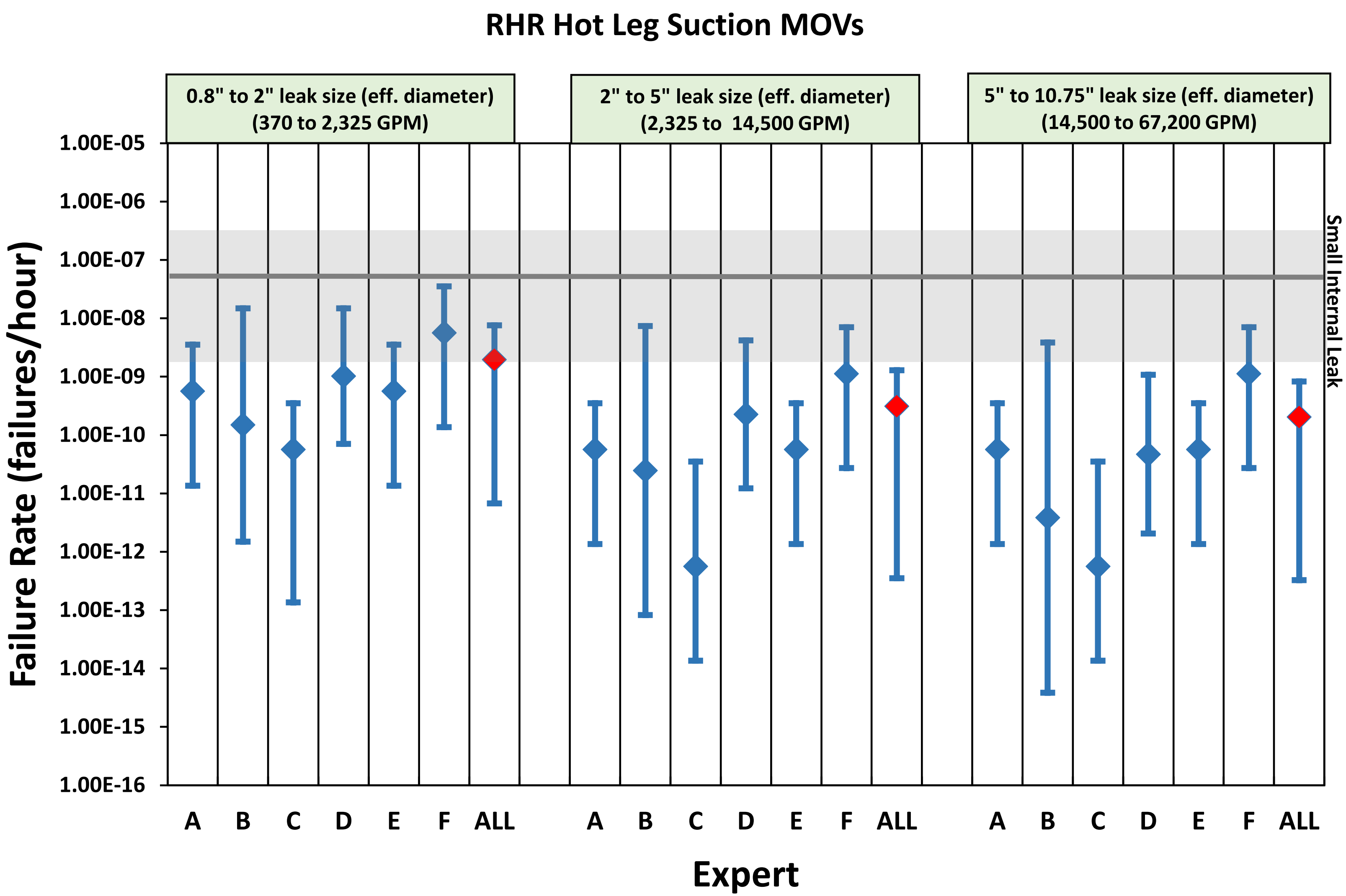
RHR ISLOCA Elicitation Form											Date: 06/24/2015	
											Expert: XXXXXXXXXX	
Large Internal Leakage Failure Mode for High Pressure/Low Pressure Isolation Valves					Change in Component Failure Rate Relative to Small Internal Leak (e.g., 0.1x, 10x)			Component Failure Rate (failures/hour)			PNNL Comments	Expert Comments
RHR ISLOCA Scenario	***Component ID***	***Event Number***	***Internal Leakage Size (effective diameter - inches)***	***Leakage Rate (gpm)***	***Lower Bound (LB)***	***Best Estimate (BE)***	***Upper Bound (UB)***	***Lower Bound (LB)***	***Best Estimate (BE)***	***Upper Bound (UB)***		
RHR Suction from Hot Leg Loop 1	MOV HV-1, Gate Valve	1	very small	5 to 50	NA	NA	NA	1.36E-09	5.64E-08	3.52E-07		
		2	<0.8	<370		No Need to Evaluate			No Need to Evaluate			
		3	0.8 to 2	370 to 2325								
		4	2 to 5	2325 to 14500								
		5	5-10.75 (maximum for schedule 120 12" pipe)	14500 to 67200								

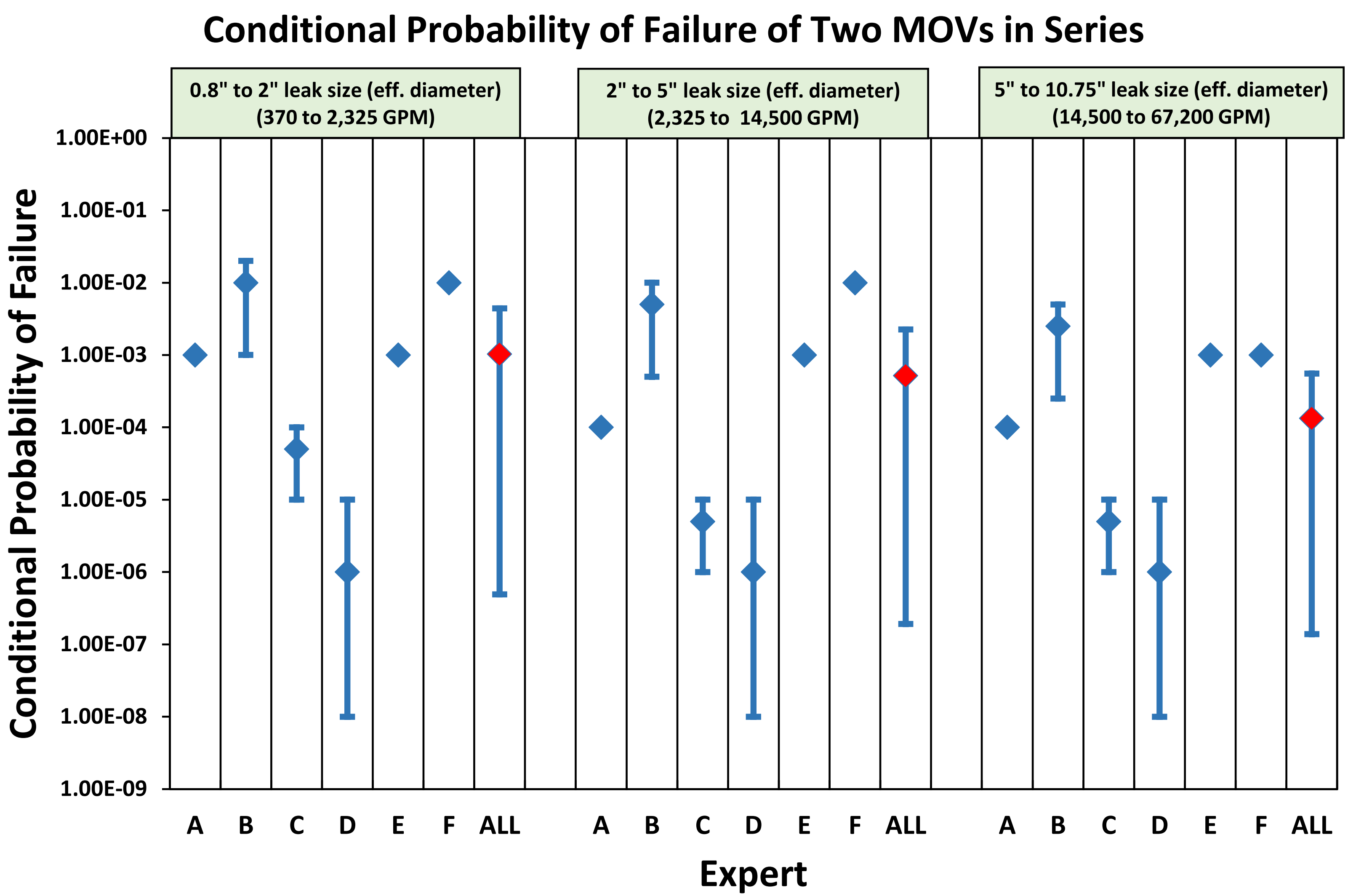
Internal Large Leak Failure Rate



Conditional Probability of Failure of 2nd Valve (downstream and in series with 1st valve)

RHR ISLOCA Elicitation Form										Date: 06/24/2015 Expert: XXXXXXXXXX	
Conditional Probability of Failure of the 2nd Valve in Series for Large Internal Leakage Failure Mode for High Pressure/Low Pressure Isolation Valves							Conditional Probability of 2nd Valve Failure			PNNL Comments	Expert Comments
RHR ISLOCA Scenario	***Component ID Combinations***	***Event Number***	***Scenario ID***	***Internal Leakage Size (effective diameter - inches)***	***Leakage Rate (gpm)***	***Independent Component Failure Rate (failures/hour)***	***Lower Bound (LB)***	***Best Estimate (BE)***	***Upper Bound (UB)***		
RHR Suction from Hot Leg Loop 1	MOVs HV-1, HV-2	1	RHR.HL1.MOV.CCF2.1	very small	5 to 50	1.36E-09 (LB) 5.64E-08 (BE) 3.52E-07 (UB)	No Need to Evaluate				
		2	RHR.HL1.MOV.CCF2.2	<0.8	<370		No Need to Evaluate				
		3	RHR.HL1.MOV.CCF2.3	0.8 to 2	370 to 2325	1.36E-11 (LB) 5.64E-10 (BE) 3.52E-09 (UB)					
		4	RHR.HL1.MOV.CCF2.4	2 to 5	2325 to 14500	1.36E-12 (LB) 5.64E-11 (BE) 3.52E-10 (UB)					
		5	RHR.HL1.MOV.CCF2.5	5-10.75 (maximum for schedule 120 12" pipe)	14500 to 67200	1.36E-12 (LB) 5.64E-11 (BE) 3.52E-10 (UB)					

Conditional Probability of Failure of 2nd Valve (downstream and in series with 1st valve)



MOV Failure-to-Close Probability

RHR ISLOCA Elicitation Form										Date: 06/24/2015	
										Expert: XXXXXXXXXXX	
Failure-to-Close Failure Mode for High Pressure/Low Pressure Isolation Valves				Change in Failure Rate for Fail-to-Close Against Differential Pressure Relative to NUREG/CR-6928			Fail-to-Close Against Differential Pressure (failures/demand)			PNNL Comments	Expert Comments
RHR ISLOCA Scenario	*Component ID*	*Event Number*	*Differential Pressure Across Valve (psi)*	*Lower Bound (LB)*	*Best Estimate (BE)*	*Upper Bound (UB)*	*Lower Bound (LB)*	*Best Estimate (BE)*	*Upper Bound (UB)*		
RHR cold leg injection path Loops 1 and 2	MOV HV-3, Gate Valve	1	600	NA	NA	NA	1.76E-04	8.12E-04	2.27E-03		
		2	1000								
		3	1500								
		4	2000								
		5	2695								

MOV Failure-to-Close Probability

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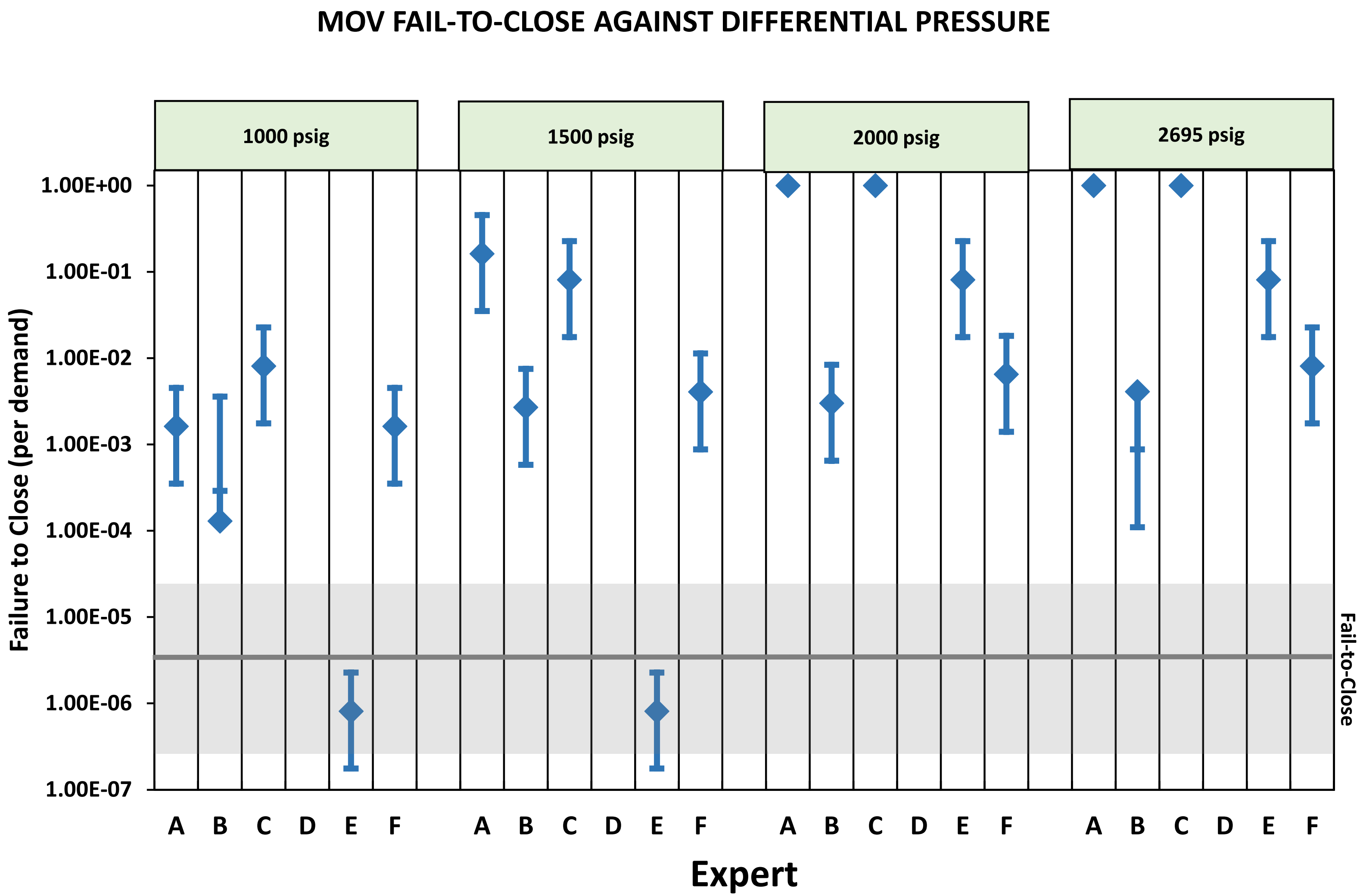

Probability of External Break Location

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RHR ISLOCA Elicitation Form					Date: 06/24/2015 Expert: XXXXXXXXXX	
Line Break from Over-Pressurization				**Characterization of Break Location**	**PNNL Comments**	**Expert Comments**
RHR ISLOCA Scenario	***Event Number***	***Break Location (Component ID)***	***Maximum External Leak Size (effective diameter)***	***Likelihood of Break Location Relative to Reference Location (e.g., 0.1x, 10x)***	***Assumptions and Other Considerations in Developing Rankings***	***Assumptions and Other Considerations in Developing Rankings***
RHR Suction from Hot Leg Loop 1	1	Pipeline Segment immediately after MOV HV-1	12"	1	Reference Location - Pipe location immediately downstream from internal leak; first location to see pressure spike.	
	2	2	12"			
	3	3	14"			
	4	4	12"			
	5	5	12"			
	6	6	8"			
	7	7	8"			
	8	8	8"			
	9	9	3"			
	10	10	8"			
	11	11				

CANDU Owners Group Inc.

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Excellence through Collaboration

Whole-Site Risk Assessment and Safety Goals

Jack Vecchiarelli

Ontario Power Generation

ACRS Meeting, Rockville, MD
March 1, 2016

Disclaimer

The ongoing work described in this presentation is preliminary in nature and does not represent the finalized views of members of the CANDU Owners Group (COG).

Outline

- Background on “whole-site risk”
- Key issues
- Work conducted by COG
- Risk metrics and their role

Background

- Current risk metrics are applied on a per-unit, per-hazard basis (e.g., Large Release Frequency)

- 2013 licensing hold point on Pickering Nuclear Generating Station (6 operating units east of Toronto, Ontario)
  - required a "whole-site PRA" OR a methodology for it

- Intent is to characterize the *overall* risk of the *site* due to the aggregation of risks from:
  - multiple reactor units
  - other on-site radiological sources → e.g., spent fuel bays
  - different hazard types (internal and external)
  - various plant operating modes

Key Issues

- No international consensus on methodology
- Simple addition of all hazard risks (internal events + fire + flood + seismic + high wind…) → can be overly-conservative
  - Also, for given hazard → multi-unit risk ≠ per-unit risk x (# units)
- PRA safety goals are perceived as a hard delineation between safe / unsafe plant design

Role of Safety Goals

- Ultimately, safety goals are intended to ensure risks are kept acceptably low
  - and hence, that nuclear plants are licensable
- PRA, as applied, provides an *indicator* of risk, not a true *measure* of risk
- Need to incorporate broader aspects of what contributes to managing plant risk (i.e., both programmatic and analytical elements)
  - to support the process of communicating about nuclear safety

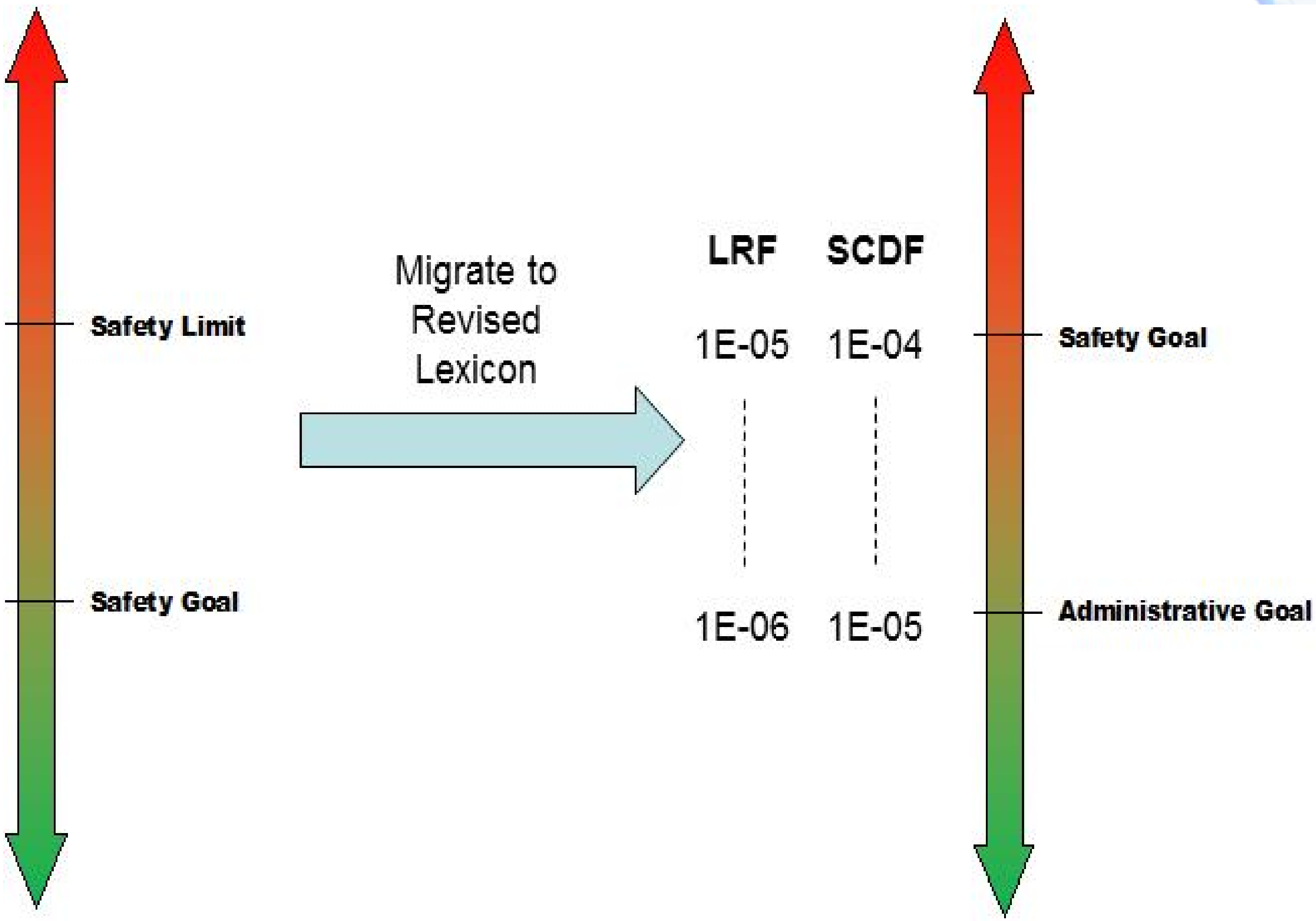
COG Work

- Hosted international workshop (2014)
- Issued concept-level paper on whole-site PRA & safety goals
- Initiated COG Joint Project:
  - Phase A - Safety goals framework → public communication tool
  - Phase B - Risk aggregation studies → quantify whole-site *risk*
    - Identify risk sources and reactor operating states
    - Risk assessment methods for non-reactor sources
    - Consider habitability effects in PRA modelling
    - Trials of different risk aggregation methods
    - Consider other risk assessment approaches
  - Phase C - Pilot whole-site PRA for Pickering (2017)

Risk Metrics

- A primary focus of safety goals should remain the protection of the life and health of the public
- Where surrogate risk metrics are used, show that they represent an equivalent or more limiting criterion than the underlying health-related goals
  - e.g., Large Release Frequency (LRF):
    - Based on sum of frequencies of event sequences that can lead to an off-site release of more than 10^{14} becquerel of cesium-137
      - *a greater release may require long term relocation of the local population* (CNSC Regulatory Document 2.5.2)

Risk Metrics for Existing CANDUs



Other Considerations

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Key Messages

- PRA is *part* of the safety story
- PRA safety goals are “targets” , not hard “limits”
- The main benefits of PRA are in identifying risk insights to improve plant design and operation

- *Existing* PRA safety goals (per-unit/per-hazard) AND *Existing* Programs → confidence that *site* risk is low

Preliminary Assessment of Risk Metrics

- Assess margins to possible QHOs for range of large release frequency (LRF) and consequence assumptions
- Total LRF of ~1E-05/yr would provide margin to possible QHOs for a wide range of accident consequences, whilst serving as a reasonable basis for practical elimination of the potential for long-term relocation
- Recognizing that, in terms of the acceptance criteria for risk metrics, the issues are "trans-scientific"

Summary

- Nuclear safety (low risk) is assured through a collection of safety goals and objectives, not necessarily by a single numerical value (risk metric)
- A hierarchal framework of safety goals can be constructed
  - Consisting of a mix of qualitative and quantitative safety goals in different levels and logically inter-related
  - Such that the over-arching safety goal (health objective) is met whilst also adequately addressing other important considerations (long-term relocation)
  - May be used a basis for public communication
- There is flexibility in acceptable values of total calculated LRF
  - LRF risk metric is not limited to addressing health objectives
  - Whole-site risk can be managed via compliance with current per-unit based LRF risk metric and programmatic measures