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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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JOINT MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

SUBCOMMITTEE ON THERMAL-HYDRAULIC PHENOMENA

AND

SUBCOMMITTEE ON RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

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TUESDAY,

NOVEMBER 5, 2002

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ROCKVILLE, MARYLAND

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The Subcommittees met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 1:30 p.m., Dr. Thomas S. Kress, Acting Chairman, presiding.

COMMITTEE MEMBERS:

THOMAS S. KRESS, Acting Chairman

F. PETER FORD, Member

GRAHAM B. WALLIS, Member

ACRS STAFF PRESENT:

MAGGALEAN W. WESTON, Staff Engineer

ALSO PRESENT:

JACK ROSENTHAL

CHARLES ADER

SIDNEY FELD

CHRIS GRIMES

JOHN LEHNER

JAMES MEYER

ALLEN NOTAFRANCESCO

JACK TILLS

## C O N T E N T S

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

(1:33 p.m.)

ACTING CHAIRMAN KRESS: The meeting will now please come to order.

This is a meeting of the ACRS Subcommittees on Thermal-Hydraulic Phenomena and the Subcommittee on Reliability and Probabilistic Risk Assessment.

I'm Tom Kress. I'm serving as the Chairman of today's meeting mostly because the Thermal Hydraulic Phenomena Subcommittee is normally chaired by Graham Wallis here with me, but this appears to be more of a severe accident issue. So I guess that's one reason I'm doing it.

And the Chairman of the Reliability and PRA Subcommittee is George Apostolakis, and he couldn't be with us today.

The members that are here in attendance are Graham Wallis, as I said, and Peter Ford is expected to join us a little later. His plane was a little late in getting here.

The purpose of this meeting is to discuss the Office of Research's proposed recommendation for resolving GSI 189, which is the susceptibility of ice condenser and Mark III containments to early failure from hydrogen combustion during a severe accident.

Maggalean W. Weston is the cognizant ACRS staff engineer at the meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting, published in the Federal Register on October 28th, 2002. A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice.

It is requested that speakers use one of the microphones available and first identify themselves and then speak up so everybody can hear you.

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

By way of reminding the member that's here, we had a meeting review of this issue back I think it was in June 2002, and in that meeting we suggested to Research that it would be helpful if they had some additional considerations of uncertainties.

So the staff went back and did some reevaluation and determined some uncertainties, and today they're going to tell us about the results of the look and how that factors into their recommendations.

So with that I'll proceed with the meeting and ask Jack Rosenthal if he wants to introduce it.

MR. ROSENTHAL: Thank you.

I just have a few introductory remarks.

My name is Jack Rosenthal, and I'm the Branch Chief of the Safety Margins and Systems Analysis Branch in the Office of Research.

We received the ACRS' letter of June 17 where you recommended that we do additional analyses and pay particular attention to uncertainty analysis, and that's exactly what we've done. We went back and revisited the cost side of the equation, but we also looked at the benefits side, tried to do a combination of uncertainty and sensitivity studies on the benefits; did a fair amount of sensitivity studies to hydrogen phenomenology, which we'll be hearing about; and did a fair amount of our homework.

Based on that, we did send you reports and a cover letter which indicated that we thought it appropriate to move forward on ice condensers, and that we thought that the igniters alone would be efficacious. You'll hear more about that later.

And we were not as clear on Mark IIIs. The Mark III cost-benefit story is not in itself persuasive, and so what we would like to do at the end of the meeting after we've laid out all of the technical information is to discuss other considerations and ask for your advice on how we should treat uncertainties in the decision process.

My last point is that, in fact, these plants are safe, and that this is not in my mind an adequate safety issue, but rather one of a cost beneficial safety enhancement, and that's how we're reviewing it.

With that, I'd like to turn it over to Allen Notafrancesco.

MEMBER WALLIS: Just before we start, I remember the last meeting we had, and we did ask for uncertainty analysis, but I think there was also on the part of several of my colleagues who had experience with real power plants some skepticism about portable generators sort of wheeled into place when needed.

MR. ROSENTHAL: Yes, you'll hear a specific presentation --

MEMBER WALLIS: Well, are we going to hear about that?

MR. ROSENTHAL: -- from Jim Meyer.

MEMBER WALLIS: Because reading the report, it wasn't clear to me whether you were recommending portable or in place, or there didn't seem to be a clear distinction somehow. Maybe that will come clear --

MR. MEYER: We'll talk about that later.

MEMBER WALLIS: -- when you make your presentation. Yes, thank you.

MR. NOTAFRANCESCO: I'm Al Notafrancesco, the task manager for GSI 198.

This is the agenda. The one provided a few weeks ago, we made a change. In this version, the MELCOR analysis will go before the ice condenser combustion issue.

THE REPORTER: Excuse me, sir. It's a little hard to hear you. Would you mind wearing a lap. mic?

MR. NOTAFRANCESCO: I can do this.

ACTING CHAIRMAN KRESS: It would probably help to use that mic anyway, I think. People tend to turn their head, and it gets terrible.

Pin it up close to your throat, and it comes in better.

MR. NOTAFRANCESCO: Is this better?

THE REPORTER: Yes.

MR. NOTAFRANCESCO: Okay. What I'm going to present right now is just a quick overview. We've covered a few of the aspects already, and where we were, why we're here.

And, again, it is a team effort in trying to do the technical assessment of this generic issue. The various components, benefits analysis to cost analysis; the plant analysis using MELCOR; and some hydrogen combustion issues.

And at the end of the day, we're going to summarize it and present our recommendations.

Again, the focus of this generic issue is looking at susceptibility for Mark IIIs and ice condenser containments, early failure due to combustion, in particular, for SBO events. This issue was raised and was borne out from the risk informed 10/50.44 rulemaking on hydrogen control.

As I said earlier, we met with the ACRS June 6th, got a letter June 19th; go back, quantify uncertainties and come back again. And that's why we're here. We have a completed, refined technical assessment that's on the table now, and we're going to present that.

And, again, our plans are to try to submit the technical assessment package to NRR by the end of the year.

Again, just a little bit more background.

The domestic plants that are affected by our analysis, Mark IIIs and ice condensers. There's nine ice condenser plants. There's four Mark III plants.

The common attributes of these plants is low design pressure, relatively low or free volume, and also the key issue that's related to both of these plant, they have igniter systems, they were retrofitted post TMI, and they're hooked up to the off-site power and the diesel generators. So the issue is a SBO sequences in which --

MEMBER WALLIS: Now, these PWRs, I notice there are four joule units, and in your paper there was a discussion of an accident and a containment breach in one affecting the viability of the other plant and whether or not it would be shut down for a long period of time, but that didn't seem to have been taken into account. It was discussed, but then it wasn't taken into account in your costs.

MR. LEHNER: I think we had discussion -- I'm sorry. I'm John Lehner from Brookhaven National Laboratory -- I think we had a discussion of the benefit side, but the averted costs that talked about that, and I can address that in a minute --

MEMBER WALLIS: Well, it disappeared. It didn't seem to be part of your final --

MR. LEHNER: Right. It was not part of the numerical calculation.

MEMBER WALLIS: In fact, it would be a benefit, would it not?

MR. LEHNER: I'm sorry?

MEMBER WALLIS: It would be a benefit. I mean if you're lose a containment and you irradiate the whole site, then you essentially use the other --

MR. LEHNER: Yes, but -- but --

MEMBER WALLIS: -- for quite a period of time, quite a long time.

MR. LEHNER: I guess there were two things, well, a number of things why we didn't actually include it in the numerical calculations. One is that if you lose the containment late, and remember we're talking here about early failures; so if you lose the containment late, you're likely to have the same problem.

So in that sense, the benefit would not be -- the benefit would only really be there for dual units if could avoid late failure as well.

MEMBER WALLIS: If you didn't lose it at all.

MR. LEHNER: Well, at all. Exactly, exactly.

And the scenarios are very uncertain. I mean, it depends on, you know, when the second unit could be brought back. There are just so many uncertainties there that --

ACTING CHAIRMAN KRESS: I guess the assessment is that if you have a station blackout, you're going to have a late containment failure.

MR. LEHNER: Yes. I mean, the igniters, as Allen pointed out, they're really there to avoid the early failure.

ACTING CHAIRMAN KRESS: Let me ask you about this, one of you, about the station blackout. Is the assumption in the sequence that the emergency diesels actually fail to start? Is that why it's a station blackout? When you lose off-site power --

MR. LEHNER: Yes.

ACTING CHAIRMAN KRESS: -- and then the -- so the probability of a diesel failing, the emergency diesels failing to start and pick up the load is part of the station blackout?

MR. LEHNER: That's correct, yes.

ACTING CHAIRMAN KRESS: It's one reason it has such a low --

MR. LEHNER: Probability, yes.

MR. NOTAFRANCESCO: Okay. My last slide

here basically, again, reiterates the objective: looking at early containment failure, SBO due to hydrogen combustion for SBO events. We're doing a cost-benefit looking at different possible enhancements to make sure the combustible gas control system is working early on, looking at the cost-benefits.

In sizing out the benefits part, we're using existing risk studies, 1150, IPEs, and other issues, other risk studies which we'll get into, and we'll go on.

The next guy up is benefits analysis with John Lehner.

MR. LEHNER: I'm John Lehner from Brookhaven National Laboratory.

And we assisted the staff in doing the benefit analysis for Generic Issue 189, and my objective today is to talk to you about that benefit analysis.

So in the benefit analysis, we did not look at the means by which you would achieve combustible gas control. We're just looking at the averted costs that are there if you can achieve combustible gas control during the station blackout sequences.

And of course, the other part of the objective is to address the comments that we heard in June about getting more information about the uncertainties involved in these estimates.

So we carry out the benefit analysis in accordance with the regulatory analysis guidelines and the technical evaluation handbook, and the benefits here consist of the averted risk, which includes the reductions in public and on-site radiation exposure, as well as the averted off-site property damage.

And as Professor Wallis pointed out, we discuss in the report about the on-site property cost, but we did not actually include that in the monetary benefits.

ACTING CHAIRMAN KRESS: It might be of interest to note that ACRS reviewed those documents at one time and decided that they were very appropriate and well done and good guidelines. So if you followed those, why, you did it right.

MR. LEHNER: So as I said, the benefits here are in terms of the averted risk as to risk reduction due to the enhancement, and since we're talking here about the enhancements being combustible gas control during station blackout sequences, one can really break down the risk reduction to using the station blackout core damage frequency times the change in conditional containment failure probability, conditional on-station blackout that the enhancement brings about.

I mean, that's what the enhancement does. It will change the conditional containment failure probability.

ACTING CHAIRMAN KRESS: Now, the station back-up frequency you have there, that includes getting at this core damage frequency?

MR. LEHNER: I'm sorry. It includes?

ACTING CHAIRMAN KRESS: It includes core damage.

MR. LEHNER: This is a core damage frequency. It's not the initiating event frequency but the actual core damage frequency.

ACTING CHAIRMAN KRESS: It's the station blackout core damage.

MR. LEHNER: Yes. The contribution to core damage --

ACTING CHAIRMAN KRESS: It's not the initial --

MR. LEHNER: -- from station blackout sequences.

ACTING CHAIRMAN KRESS: Okay.

MR. LEHNER: That's correct.

And then, of course, you have to include the consequences from an early failure, and the consequences consist of exposure of the population, persons and the surrounding property damage.

ACTING CHAIRMAN KRESS: Those come out of max?

MR. LEHNER: Those come from a Level 3 analysis, which is max in the NRC space.

So since we need a Level 3 PRA to get the consequences, well, we need a Level 3 PRA because we need consequences in terms of person-rem and off-site costs. We used previously existing studies to put the story together on the benefits gained here. We did not conduct a new Level 3 PRA simply to look at this issue.

Now, if you look at the Level 3 analyses that are out there, the NUREG 1150 studies, they are the most comprehensive studies, and we used those to get the details of the accident progression, which of course is important here since we're talking about changes in containment failure probability, and we used the numbers from 1150 to obtain a base case benefit estimate.

And we also used the information from 1150 on timing of sequences and so forth, which becomes important in the cost analysis that you'll hear Jim Meyer talk about later on.

MEMBER WALLIS: This accident progression includes the effectiveness of evacuation?

MR. LEHNER: That's taken into account in the max calculation for the consequences. There are certain assumptions that go into that and basically, well, you'll see later on in the different studies we looked at for the uncertainty, that you get some different results depending on the assumptions you make for the consequences.

ACTING CHAIRMAN KRESS: Well, since this is dealing with early containment failure, assumptions for evacuation there are that they don't have time to evacuate?

MR. LEHNER: No. I mean, early containment failure doesn't necessarily mean -- you know, it's early in terms of vessel breach. So it doesn't necessarily mean early in terms of the start of the accident.

ACTING CHAIRMAN KRESS: It doesn't necessarily mean the same thing as large early release frequency.

MR. LEHNER: Well, no, it is the part of

the large early release frequency. I mean, the early containment failure leads to a large early release frequency, but it's not early in terms of starting of the accident. There could be some evacuation that's taking place, depending on the accident sequence.

I mean, for instance, we're including here what's called fast station blackout and slow station blackout, and the difference there would be the availability of the turbine driven aux feedwater in the PWRs anyway, in the ice condensers.

So if you have a fast station blackout, then you can go to core damage in a number of hours, two, three hours, whereas slow station blackout might take eight or 12 hours to actually get the core down.

Now, we also wanted to look at the uncertainties, and there's uncertainties in each part of the analysis. There's uncertainties in estimating the station blackout frequency. There's uncertainty in estimating the conditional probability of early containment failure, given station blackout, and then there's uncertainty in the consequences that result from the release from the accident.

ACTING CHAIRMAN KRESS: Did you do any consequence uncertainty?

MR. LEHNER: We compared some

sensitivities, but as I discuss later on, we got the cooperation from Duke Power. They gave us some results of their recent PRAs for McGuire and Catawba, and they had some consequence numbers that were done with their sets of assumptions and the map code, and that, of course, is a somewhat different sensitivity analysis than if you look at the NUREG 1150 source term code package.

ACTING CHAIRMAN KRESS: I thought those Duke results only dealt with different assumptions in the accident sequence itself and basically used the same source term.

MR. LEHNER: No, the source terms were different. We only saw parts of the results, but the release fractions were quite a bit different from the release fractions that --

ACTING CHAIRMAN KRESS: But once you had a release fraction, then they just had point values for the consequences, the amount of that?

MR. LEHNER: Well, I believe they used max to calculate the consequences once they had the release fractions, yes.

ACTING CHAIRMAN KRESS: That would be a point value to make it.

MR. LEHNER: Yes, yes. I believe that's

right.

So to look at the uncertainties in these various parts of the analysis, we looked at a number of studies where we could get some uncertainty and sensitivity information from. Again, we looked at NUREG 1150 because that had a quite comprehensive uncertainty analysis that looked at Level 1 and Level 2 uncertainties, and so we looked there for station blackout frequency uncertainty, for containment failure uncertainty, and as I just said, I should have consequences here as well because we compared the consequences there with the consequences from the industries that result in the last line.

The industry results refer to the Duke PRAs for Catawba and McGuire, where they also had an uncertainty on the station blackout frequency. They had an estimate of containment failure probability, and they had the consequences.

We also looked at the IPE station blackout frequencies, and finally we looked at station blackout frequencies from the NRC SPAR models.

ACTING CHAIRMAN KRESS: Now, let me ask you about the consequences once again. If the industry results were for Catawba and McGuire and the NUREG 1150 had neither of those plants in it --

MR. LEHNER: No, NUREG 1150 is Sequoyah.

ACTING CHAIRMAN KRESS: Sequoyah?

MR. LEHNER: Right.

ACTING CHAIRMAN KRESS: How does one get a consequence uncertainty out of comparing those?

MR. LEHNER: Well, we didn't get an uncertainty. We just -- those are really sensitivities, and I --

ACTING CHAIRMAN KRESS: How do you even get a sensitivity out of it?

MR. LEHNER: Well, one thing we did was we grafted the Sequoyah consequences onto the Catawba Level 1 and Level 2 results to compare that with the results that were in the Duke information.

ACTING CHAIRMAN KRESS: Let me ask you. The SPAR models were also used to get station blackout frequencies.

MR. LEHNER: Yes, it turned out we really didn't use those in the --

ACTING CHAIRMAN KRESS: Did those enter into the uncertainties or anything anywhere?

MR. LEHNER: Well, it seemed the range f station blackout frequencies were really covered by the other --

ACTING CHAIRMAN KRESS: Okay. So because

the SPAR models may not be as representative as they'd like --

MR. LEHNER: Well, it turns out that the SPAR models that include the information that we're looking at were the three I models, which have been QAed yet.

ACTING CHAIRMAN KRESS: Okay.

MR. LEHNER: So the reason I mention it here is because later on when we talk about the Mark IIIs, there there was no comparable recent industry information available, and therefore, we actually looked at the spar models to get some sensitivity results.

But for the ice condensers we did not consider the -- or we looked at it, but we did not include the SPAR model results in the analysis.

Now, the assumptions that we made was we said that the combustible gas control system is 100 percent effective because, as I said, we're not concerned here with the means of achieving combustible gas control. You know, the benefits would scale directly with the effectiveness of the system. So we had to make various assumptions because it's 100 percent effective.

We assumed that gas combustion was the

principle cause of early containment failure in station blackout sequences. It's a pretty good assumption if you look at the --

ACTING CHAIRMAN KRESS: I think that's a pretty good assumption.

MR. LEHNER: And then we also said that we're not assuming that late containment failures were also averted by gas control, but only the early containment failures.

Of course, you could argue that at some point if you avoid the early failure, then you can get the off-site power back and you will avoid late failure as well, but we didn't include that in our analysis.

We did a sensitivity case, but it's not included in the figures I'm showing here.

So continuing with the assumptions, this is in line with the guidelines in the regulatory analysis that I had mentioned earlier. We looked at public health and radiation exposure and the off-site property damage over a 50 mile radius from the plant.

We used $2,000 per person-rem to convert the exposure to a dollar value. We then a present worth calculation, and that present --

MEMBER WALLIS: But that 2,000 has been

around for some time?

MR. LEHNER: Yes.

MEMBER WALLIS: How long has it been around?

ACTING CHAIRMAN KRESS: It used to be 1,000 until the ACRS complained, and then it went to two.

MEMBER WALLIS: All right. Well, --

MR. LEHNER: In the '80s some time I think.

MEMBER WALLIS: So shouldn't it be up by now to something bigger?

ACTING CHAIRMAN KRESS: They look at it occasionally for reevaluation. It may be time.

MR. ROSENTHAL: Sid Feld, the author, advises me that was 1995?

MR. FELD: Yes.

MR. LEHNER: Oh, '95?

MR. FELD: And the position that we took was it's one significant digit. So that it would require quite a movement in the inflation rate before we would adjust it.

ACTING CHAIRMAN KRESS: Let me ask you about the present worth, maybe you or somebody. You assume 40 years of plant life remaining, and I presume that includes the license extension.

MR. LEHNER: Yes, it does.

ACTING CHAIRMAN KRESS: And to get present worth since this is a probabilistic event, you take the amount of time left and divide it by two?

MR. ROSENTHAL: Jim, you have those --

ACTING CHAIRMAN KRESS: Per the event? When do you decide the event occurs back.

You know, this is not really germane to the discussion, but I'm curious.

MR. ROSENTHAL: We integrate the risk over the entire remaining life. So effectively what we're doing is we're considering the probability of an accident occurring in a given day, and we --

ACTING CHAIRMAN KRESS: Is that the equivalent of using the amount of remaining time divided by two or back in that?

MR. FELD: I'm not sure if that would be equivalent, but the calculation actually involves looking at the risk in each year, and it's a present worth calculation for occurring in that year, and then doing that for each remaining year.

ACTING CHAIRMAN KRESS: Okay, and just adding that.

MR. FELD: And you're looking at the

probability per reactor year. So that when you calculate the sum of those things, you're integrating an OP life.

ACTING CHAIRMAN KRESS: Okay. It sounds like it's a reasonable way to do it.

MR. ROSENTHAL: Excuse me, Jim. You have the numbers for 20 and 40 years.

MR. MEYER: For 40 years the multiplier is about 13, and for 20 years the multiple is about 10.7.

MR. LEHNER: That's with a seven percent discount.

MR. MEYER: With a seven percent discount and start with a three percent discount. So we did our calculation with a seven percent rate and then did a sensitivity with a three percent.

ACTING CHAIRMAN KRESS: And that's called for actually in the --

MR. LEHNER: In the handbook, yeah.

Okay. Moving then to the ice condenser analysis, this just shows the 1150 ranges, giving an idea of the uncertainty ranges. The first row is the percentile values for the station blackout core damage frequency, showing the mean value as well as the fifth and the 95th percentile, and the second row is the same information for the conditional probability of early failure given station blackout.

MEMBER WALLIS: Why does that vary so much, that CPEF? Such a huge range.

MR. LEHNER: Well, really if you look at the distribution in 1150, it's the tail that's very, very low.

ACTING CHAIRMAN KRESS: That's why the mean is way up there.

MR. LEHNER: Yes. As a matter of fact --

MEMBER WALLIS: Isn't it just physics?

ACTING CHAIRMAN KRESS: Oh, no. This was expert opinion.

MEMBER WALLIS: Oh, it's expert opinion.

MR. LEHNER: There's a lot of experts. As a matter of fact, I have this. This is not in the handout.

MEMBER WALLIS: Well, why is it that they claim to be experts if they vary in opinion so widely?

(Laughter.)

MR. LEHNER: This first column here is the conditional probability of early containment failure. This is loss of off-site power, but it's essentially station blackout, and you can see that here's the mean and the 95th way down here.

MEMBER WALLIS: It's a big, big --

ACTING CHAIRMAN KRESS: A big range.

MEMBER WALLIS: Yeah, huge range. There's a huge maximum at the top there.

MR. LEHNER: Yes.

ACTING CHAIRMAN KRESS: That will drive the mean.

MEMBER WALLIS: It drives everything.

MR. LEHNER: Yeah.

MEMBER WALLIS: That's all expert opinion, all of that range?

ACTING CHAIRMAN KRESS: Yes. Expert opinion guided by some calculations that were done, but just the guidance was just to reveal the type of phenomenon that was involved so the experts could look at them and make their own decision.

MEMBER WALLIS: Did people make calculations then?

ACTING CHAIRMAN KRESS: Some of the experts did, and some of them just did this. It depends on the expert.

MR. LEHNER: There was at least one expert that gave it a very, very low probability of failing.

ACTING CHAIRMAN KRESS: There was a mixture of experts from industry and labs and academia.

MEMBER WALLIS: If we had computer codes that varied as much as this, we'd despair.

MR. ROSENTHAL: Let me point out -- and we'll ask for your input on this. At one time we were considering taking the fifth percentile off the charts, and that was because we thought that as a regulatory agency we ought to be dealing with the mean and the 95th in effectively a one-side decision.

We decided to leave the information on the slides to present it to you in order to portray as full a picture of our understanding as we could, but if you have some thoughts on that, we would appreciate it.

ACTING CHAIRMAN KRESS: Well, let me express one right now. I think a one-sided look at the distribution is probably appropriate, but I would look at the other side instead of the high side, and I'll tell you why.

This is an enhancement. It goes beyond adequate protection, and under those circumstances I'd want to be very sure that my benefits were expressed appropriately because I'm imposing added burden in this case, and I'm not in a case where I'm trying to assure safety.

So under those kind of services, I would be on the lower side of the benefit end, and on the costs, the costs I would probably just use a mean or flip it the other way, one or the other. So, you know, there's one opinion that's normally contrary to what you might expect to come out of it, but it's only because of the safety enhancement.

MR. LEHNER: So this gives you an idea of the range in the 1150 analysis.

This next slide shows the range and the results we received for Duke Power for their two plants, and let me explain a little bit what this is.

For Catawba --

ACTING CHAIRMAN KRESS: Now, the 1150 includes thinking of external events.

MR. LEHNER: No.

ACTING CHAIRMAN KRESS: It doesn't?

MR. LEHNER: It does not. So far we --

ACTING CHAIRMAN KRESS: It's all internal.

MR. LEHNER: It's all internal. There were two 1150 plants. I believe it was Peach Bottom and Surry that they did external events for, but not Sequoyah or Grand Gulf.

Now, the results from Duke shown here show, again, fifth mean and 95th, but they also included a point estimate, and they had a point estimate for external events in some cases, and those external events were mainly, I believe, seismic and tornadoes.

ACTING CHAIRMAN KRESS: And let me ask you about this fifth mean and 95th. When I see those, I'm visualizing that they had to have a full distribution. I'm not sure that was the case because I've never seen any of these results from Duke, or was this merely a sensitivity where they estimated the fifth and 95th?

MR. LEHNER: Well, the results that we received from them only included the fifth mean and 95th, but my impression is that they had a full distribution, but maybe there's somebody here from Duke Power that could --

ACTING CHAIRMAN KRESS: Would that not help?

MR. BARRETT: Yes. My name is Mike Barrett from Duke.

We do assign probably distributions to the basic events in the core damage frequency calculation. So the distribution, the results you see there are from a distribution, not just from a sensitivity study.

ACTING CHAIRMAN KRESS: Thank you.

MEMBER WALLIS: So they look roughly

consistent with 1150, at least the first line.

MR. LEHNER: Yes. I mean, the Catawba station blackout frequencies are in what I believe is the current configuration. The next line then was a new RCP seal, which brings the frequency down somewhat.

ACTING CHAIRMAN KRESS: And what's the ranges in the conditional probability? Are those five to 95 or --

MR. LEHNER: I'm talking the conditional probability of containment --

ACTING CHAIRMAN KRESS: Your first line, on your first line there.

MEMBER WALLIS: It's on the left.

MR. LEHNER: On the left? No, those are -- sorry. Yeah, I should explain that. Those ranges are really ranges depending on the plant damage state that's being talked about. Those are not uncertainty ranges.

ACTING CHAIRMAN KRESS: Okay.

MR. LEHNER: Those are ranges, early containment failure associated with particular plant damages. I mean, in actuality, the station blackout isn't the one sequence. It's a number of sequences, and they bend into slightly different plant damage.

MEMBER WALLIS: So they don't have the ten to the minus four in the CPEF.

MR. LEHNER: Right. Well, I don't think that Duke did an uncertainty evaluation of the conditional containment failure probability. It was a point estimate, but it varied depending on the plant damage state that you were in.

So, yes, the word "range" here shouldn't -- it's probably a little confusing with uncertainty ranges. It's not meant to imply uncertainty range.

ACTING CHAIRMAN KRESS: Those are fairly consistent with the --

MR. LEHNER: Well, it's not that different from the .15 mean value of 1150.

MEMBER WALLIS: Eleven, fifty was based on another plant, but similar plant.

MR. LEHNER: Sequoyah, another ice condenser, and the ice condensers are actually quite similar in their features. I mean, there's very little variation among the ice condenser plants.

ACTING CHAIRMAN KRESS: So actually if you looked at McGuire, it's quite an improvement in the core damage frequency.

MR. LEHNER: Yes. Well, if you look at the --

ACTING CHAIRMAN KRESS: And have those same fixes been done to Catawba also?

MR. LEHNER: Well, if you look at those three lines for Catawba, the first one is --

ACTING CHAIRMAN KRESS: Oh, yeah.

MR. LEHNER: The third one is also quite low because it turns out in Catawba most of the station blackout comes from flooding, and so once they put in the flood wall, the frequency gets to be quite low.

ACTING CHAIRMAN KRESS: And then it's about the same as the Catawba.

MR. LEHNER: As McGuire, yeah. That frequency --

ACTING CHAIRMAN KRESS: Right.

MR. LEHNER: -- and the McGuire frequency are quite a bit lower than the 1150 frequency.

MEMBER WALLIS: Has the RPC seal been replaced? This is a new kind of seal, isn't it?

MR. LEHNER: It has been replaced; is that right?

MEMBER WALLIS: Improved seal.

PARTICIPANT: Yes.

MR. LEHNER: But the flood wall has not been installed yet.

ACTING CHAIRMAN KRESS: So if you were going to use means, it seems like it was those two bottom means that would be the appropriate ones to use at the current time.

MR. LEHNER: I guess it is for McGuire. I think the flood wall has not been installed for Catawba; is that correct?

MR. BARRETT: That's also correct. And we're planning to do that in the future.

MEMBER WALLIS: They are planning to do that anyway?

ACTING CHAIRMAN KRESS: That brings up an interesting thought. If the plant has a current issue like that, the current CDF, and your analysis is supposed to account for everything going on between now and the end of life and they say they're going to fix it in a year, so which CDF should you use in that analysis?

MR. LEHNER: Well, yes. I mean, you know, when we looked at the risk informing 50.44, one of the means of addressing the issue of igniters during station blackout was obviously to drive down the station blackout frequencies. So that was happening.

ACTING CHAIRMAN KRESS: It was happening.

MEMBER WALLIS: But it seems, thinking

about your range of numbers, it may well be that with the flood wall installed, the cost-benefit analysis would show it's not worthwhile having these diesel generators.

MR. LEHNER: Well, you'll see on the next slide. The next slide then shows the analysis.

MEMBER WALLIS: It does show that?

MR. LEHNER: Yeah. It's a very busy slide.

ACTING CHAIRMAN KRESS: A busy table, yeah.

MR. LEHNER: But essentially what we've done here is --

MEMBER WALLIS: Yeah, that's right. It does. It brings it down below the cost of some of your estimated costs of installing the diesel generator.

ACTING CHAIRMAN KRESS: It brings it down to 500,000.

MEMBER WALLIS: It brings it down 300 --

ACTING CHAIRMAN KRESS: Or 150,000 using the mean.

MR. LEHNER: Yeah, let me spend some time on this. The first three rows here -- can you hear me okay without that?

MR. LEHNER: Yeah.

MEMBER WALLIS: Yeah. I'm not sure that the recorder can hear you, but we can.

MR. LEHNER: These are the Sequoyah 1150 results, and what we've done here is these are the converted costs, the benefits in terms of thousands of dollars.

ACTING CHAIRMAN KRESS: That's the .97?

MR. LEHNER: Yes. The first row is the -- well, these are the station blackout frequencies, fifth, mean, 95th.

ACTING CHAIRMAN KRESS: Right.

MR. LEHNER: Going down here, we have sensitivities with different early containment failure probabilities. So this one is the mean in the NUREG 1150 probability. This is the 95th NUREG 1150 probability, and the .97 is from the NUREG/CR-6427. That's the DCH study for ice condensers that was done failure recently at Sandia where they assigned a very high containment failure probability to hydrogen combustion for Sequoyah. It was .97.

MEMBER WALLIS: If we use the mean, we get 320. Do I see that?

MR. LEHNER: Yes.

MEMBER WALLIS: And if we use the two

means, we get 320?

MR. LEHNER: Yes.

MEMBER WALLIS: And if you go down the other ones, we get even smaller numbers, like 30 or something.

ACTING CHAIRMAN KRESS: These what, five percent?

MEMBER WALLIS: Tiny numbers if you use the means.

ACTING CHAIRMAN KRESS: Oh, yeah, if you use the means.

MEMBER WALLIS: You get 30.

MR. LEHNER: well, if the station blackout frequency is low enough.

MEMBER WALLIS: Well, that's just using the means.

MR. LEHNER: It's using the means, yes.

MEMBER WALLIS: That's a pretty small number. These are Ks?

MR. LEHNER: Yes, these are Ks.

MEMBER WALLIS: Your costs are of the order of hundreds of Ks, your cost of installing diesels.

MR. LEHNER: yes.

MEMBER WALLIS: So the big numbers at the upper bound that you quote in your report is the real upper bound. It's way far away from the mean.

MR. LEHNER: Yes, but, well, what we wanted to do was we realized if you took the 90 -- if you want to consider a combined 95th percentile as an upper bound, that is, a combined Level 1/Level 2 uncertainty, you couldn't just take the 95th percent of the Level 2 and the 95th percent of the Level 1 because that would drive you up beyond the 95th and the combined.

ACTING CHAIRMAN KRESS: Yeah, that does.

MR. LEHNER: So you can't glean directly from NUREG 1150 what the combined uncertainty would be for this particular case, but for other -- there are some numbers in 11th that show you that if you combine Level 1 and Level 2 uncertainty, the 95th percentile with the combined uncertainty is within one order of magnitude of the mean of that combined uncertainty. So that's why --

ACTING CHAIRMAN KRESS: So that's where the numbers come from.

MR. LEHNER: That's right. So this --

ACTING CHAIRMAN KRESS: Multiplying the mean by an order --

MR. LEHNER: -- is 320, ten times, but we said that this would be an upper bound, meaning the 95th percentile of the combined uncertainty.

MEMBER WALLIS: The mean give you a value, but you might say the expected benefit. Now, if you were going to invest in something, you would invest on the basis of an expected benefit, not an amount you might get in some absolutely extreme case.

ACTING CHAIRMAN KRESS: Well, I think one of the things they're asking us for guidance on is how do you use these.

MR. ROSENTHAL: In the cost-benefit guidelines, it says that you should put more weight on the mean values, and then it also says that you should consider the uncertainty.

ACTING CHAIRMAN KRESS: Yeah. That's about all it tells you, too, isn't it?

MR. ROSENTHAL: And so if you have some more guidance, we would appreciate it.

MEMBER WALLIS: I guess if we just looked at some of these means, we might not have a containment at all.

MR. LEHNER: Well, I mean --

MEMBER WALLIS: I don't mean in this case. I mean some reactor types argue that on the basis of cost-benefit you don't need a containment, but we still have a containment.

ACTING CHAIRMAN KRESS: Yeah, that's another argument.

MR. LEHNER: Your core damage frequency blown up.

Okay. So the first three rows are Sequoyah 1150 analysis. This next set of calculations is for Catawba using the three different scenarios that are in the previous slide, and what we've done here is -- here what we've done is we've done a sensitivity on the containment failure probability. That's fixed here. We used the containment failure probability of .29, which by the way, turns out to be the containment final probability assigned in NUREG/CR-6427 to Catawba, but is also similar to containment failure probabilities used in the Duke PRAs themselves. So we felt that was a reasonable number to use here.

But what's varied here is we're using here the results that Duke provided, and we realize that one of the differences, one of the consequences, the relief fractions and so we did a sensitivity where we grafted on the Sequoyah source term, the Sequoyah consequences, and this just -- the 1.8 factor here because of population around Catawba is about 80 percent higher than around Sequoyah, we then multiplied the Sequoyah consequences, at least the person-rem consequences, by 1.8.

MEMBER WALLIS: What's the reason for grafting on a Sequoyah 1150 to a Duke plant?

MR. LEHNER: Simply to get a sensitivity on the consequence.

MEMBER WALLIS: So somebody can compare with their figures?

What does Duke say about -- who has the Sequoyah plant? Who owns the Sequoyah plant?

ACTING CHAIRMAN KRESS: TVA.

MEMBER WALLIS: Do they have an analysis to compare with 1150?

MR. LEHNER: Not that I'm aware of.

ACTING CHAIRMAN KRESS: Well, Sequoyah was one of the 1150 plants.

MEMBER WALLIS: I know it was, but you see, we're sort of getting the impression that Duke's numbers are significantly smaller than numbers that you can get by grafting on the Sequoyah. So the question is: who do you believe?

At least they analyze their own plant. They didn't graft something on.

MR. LEHNER: We have no choice.

ACTING CHAIRMAN KRESS: I think part of the difference is 1150 was a lot driven by expert opinion, whereas the Duke numbers, I'm sure, come right out of the PRA with the uncertainties.

MEMBER WALLIS: They have a good PRA. It's more believable to me than this expert opinion which has a tremendous --

ACTING CHAIRMAN KRESS: Well, these opinions are supposed to take care of model uncertainties as well as parameter uncertainties.

MR. LEHNER: Yeah, I mean, it's not just the expert opinion here. The difference is here that in 1150 the form term code package was used --

ACTING CHAIRMAN KRESS: To get the consequences because you're right. The consequences weren't expert opinion. They actually -- they also went to the Level 2 with expert opinion, and then grafted the consequences onto that from a max calculation

MR. LEHNER: Yes.

ACTING CHAIRMAN KRESS: You're right. I forgot about that. So it is different.

MR. LEHNER: Whereas, you know, I think these were -- the releases he calculated was max.

ACTING CHAIRMAN KRESS: Yeah, the only

difference would be in the source term used.

MR. LEHNER: Yes, and the source term, I mean, it's a question of which source term you pick, as well. I mean, you know, there is -- if you remember the 1150 analysis, the source terms were really -- well, did a lot of parametric studies. So, you know, we pick the source term that was an early containment failure and had some other characteristics that one would expect in this kind of sequence, but there are other kinds of source terms one could pick with less consequences or more consequences.

MEMBER WALLIS: Now, they have replaced the seal. So we should at least consider that.

MR. LEHNER: Yes.

MEMBER WALLIS: Now, the flood wall, I wasn't quite clear. Are they working to install the flood wall or do you think it's going to be done in the future? What's the story?

ACTING CHAIRMAN KRESS: Is there a commitment?

MR. GILL: Yes, sir. This is Bob Gill with Duke Energy.

Both McGuire and Catawba filed letters back in August with the staff, and I have copies of the commitment for the committee, and Catawba committed to complete it by early 2005, which is roughly three years from now. There's a transform in the base of the turbine building which is susceptible to flooding, and for the committee, those are public record letters and contain those commitments.

MEMBER WALLIS: So if you installed the emergency diesel, it would probably only work for a year and probably be valuable for a year. Then it wouldn't be needed essentially based on this analysis.

ACTING CHAIRMAN KRESS: Because you've got this.

MEMBER WALLIS: Because you've got the flood wall.

MR. GILL: The flood wall is a very cost effective modification, cost beneficial.

ACTING CHAIRMAN KRESS: What are the consequences if you don't meet such a commitment?

MR. GILL: There's a process with the staff on revising commitments, and we would have to negotiate with the staff on that, but as it stands now, there's no intentions to change that commitment. It's in the budget plan to do that.

It's a relatively simple mod., too. It's concrete and steel and rebar. No moving parts.

ACTING CHAIRMAN KRESS: No real difficulties that --

MR. GILL: No, sir.

MR. LEHNER: And here are some benefits in terms of some of the point estimates for external events on the very extreme right.

ACTING CHAIRMAN KRESS: Now, let me ask you about external events, particularly seismic. Does that not drive the estimated initiating event frequency for loss of off-site power? I mean, isn't that implicit in there or not?

MR. LEHNER: Well, it's not implicit in those. The numbers I showed before were -- well, the 1150 numbers were internal event frequencies only.

ACTING CHAIRMAN KRESS: Yeah, but you know, I don't understand, an internal event frequency for loss of offset power, because that's an external like thing, and it's a frequency that comes from experience or something.

And I assuming that might implicitly assume seismic events.

MR. LEHNER: No, it doesn't.

ACTING CHAIRMAN KRESS: It doesn't?

MR. LEHNER: No. I mean, that's one of the --

ACTING CHAIRMAN KRESS: Okay. That was one --

MR. LEHNER: -- conventions, I guess, that, you know, loss of off-site power is considered an internal initiator.

ACTING CHAIRMAN KRESS: I guess that seismic events are probably such low frequency anything that it might not add much to the frequency, do you think?

MR. LEHNER: Well, it depends on the location of the plant. It could be comparable to the internal event frequency in some cases.

ACTING CHAIRMAN KRESS: It might double it then?

MR. LEHNER: It could, yes.

ACTING CHAIRMAN KRESS: Which in my mind is no consequence in terms of this. Doubling is not a big -- unless it increases it a factor of ten, it's not a big deal in this.

MR. LEHNER: In terms of station blackout, you know, the seismic event would usually -- one would expect a seismic event to lead to station blackout.

ACTING CHAIRMAN KRESS: That's right.

MR. LEHNER: Yeah. But, of course, you

know, from the other end, Jim Meyer will represent the -- if you want to have combustible gas controlled system that will work under seismic conditions, then it will drive up the cost.

ACTING CHAIRMAN KRESS: Yeah, there's lots of other things. Yeah, you're right. It's probably not worth it.

MR. ROSENTHAL: Just before we leave this slide and we intentionally wanted to dwell on this because even though it's a busy slide, it really encompasses much of what was done. You run into the issue of you can always add another diesel, another diesel and drive down the frequency of station produced blackouts. So that's on the prevention side when considering a mitigation fix.

And so another decision question really is -- and it's a policy issue -- is should you take however many preventive fixes are needed to drive the numbers sufficiently low where at some point you require some degree of mitigation.

ACTING CHAIRMAN KRESS: Kind of a defense in depth indication.

MR. ROSENTHAL: Right, and we don't have numbers for that. So again, we recognize that, and that in my mind is a policy issue. We want to trade here, and they'll contend ten to the minus five to ten to the minus six. Well, could you drive it an order of magnitude lower yet? At what point do you believe it has mitigation?

And again, just before we leave this slide because I'm sure that not everybody in the room has read all of the reports, the cost of a fix is about two to $300,000. So at least in my mind, I look at those numbers that are within on the order of two or 300,000 or greater. Some decision guidance.

ACTING CHAIRMAN KRESS: Right. One of the gray areas where it's near the line.

MR. ROSENTHAL: Right. Actually, Charlie Ader, my Deputy Division Director, has pointed out to us that we had an opportunity when we looked at the IPEs to think about this issue, and then there was the containment performance improvement program, and there was another opportunity to revisit the issue.

And when we did the DCH report, that's sort of new information that. So effectively we've been working these issues with low core damage frequency and trying to decide if it was worthwhile or not for at least 20 years.

ACTING CHAIRMAN KRESS: A tough decision.

MEMBER WALLIS: Well, maybe if it's a

tough decision it simply means that it doesn't matter too much which one you make. It's up in the air.

ACTING CHAIRMAN KRESS: That's sometimes a characteristic of tough decisions.

MEMBER WALLIS: What should we think about D.C. Cook?

ACTING CHAIRMAN KRESS: D.C. Cook?

MEMBER WALLIS: Yeah. You don't have something like this for D.C. Cook?

MR. LEHNER: No.

MEMBER WALLIS: Should we assume it's similar or very different?

MR. LEHNER: Well, interesting question. I mean, as I said earlier, there are some differences, and you always can come down through, but they are very similar plants. The only information that we had from D.C. Cook was based on the IPEs, and in the IPEs, the Level 2 analysis for the ice condensers all resulted in very low containment failure probabilities, lower than large dry containments in most case.

So I guess the answer is we don't have similar information.

ACTING CHAIRMAN KRESS: What's the site like at D.C. Cook? Where is it located? I've forgotten?

MR. LEHNER: It's located down South, right?

MR. MEYER: No, it's up at the Great Lakes.

MR. LEHNER: Oh, that's the one.

PARTICIPANT: I think it's Lake Michigan, but I'm not sure.

ACTING CHAIRMAN KRESS: Likely they have a fairly low population.

MR. MEYER: One whole side would be the lake.

ACTING CHAIRMAN KRESS: Yeah, and the wind is always blowing the other way, except at night, and then it goes the other way, and that's when all of the accidents are.

MEMBER WALLIS: So we should think of Cook as fitting into this same sort of pattern, roughly speaking?

MR. LEHNER: Well, I would think so. Like I said, certainly in -- you know, the plants are very similar, and so at least from that consideration --

MEMBER WALLIS: So why does it have a very low containment failure probability?

MR. LEHNER: Which?

MEMBER WALLIS: D.C. Cook. I thought you said it was lower.

MR. LEHNER: Actually in the IPEs, all of the ice condenser containments had very low failure probabilities. So I wouldn't assign --

MEMBER WALLIS: It's not unusual in this class.

MR. LEHNER: Yes. I would not think that D.C. Cook was any lower than the other plants because of the IPEs. But we were fortunate to get this information from Duke Power so we could get some updated values for Catawba and McGuire.

(Pause in proceedings.)

MR. LEHNER: If there are no other questions on this, I'll move on to the Mark III.

MEMBER WALLIS: That's a very useful, useful diagram.

MR. LEHNER: For the Mark III plants, there's a couple of things to consider. First of all, because of the Mark III design, you need to fail both the containment as well as the drywell in order to get a significant release.

I don't know if you have a picture of the Mark III containment.

ACTING CHAIRMAN KRESS: We have it in

mine.

MR. LEHNER: Okay. So that's an important factor to consider.

ACTING CHAIRMAN KRESS: There's little, very little bypass.

MR. LEHNER: Yes. BWR is just --

ACTING CHAIRMAN KRESS: And they were designed to get rid of the bypass.

MR. LEHNER: Yes, yes.

The other thing is that if you look at the 1150 accident progression analysis, it indicates that the igniters really are only effective for sequences with low RCS pressure; that they're not going to alleviate the containment failure with sequences of high RCS pressure.

ACTING CHAIRMAN KRESS: That's because it failed anyway or --

MR. LEHNER: Yes, the vessel breach. They fail anyway.

And the third thing is that the Mark IIIs really don't have anything comparable to what I shoed for the Duke plants. We only have the 1150 analysis, and we have some IPE results, and then we have the more recent SPAR models.

I don't think there's even any license

renewal SAMDA analysis from the Mark IIIs.

ACTING CHAIRMAN KRESS: How many Mark IIIs did we say were out there?

MR. LEHNER: Four.

ACTING CHAIRMAN KRESS: Four?

MR. LEHNER: All single units.

ACTING CHAIRMAN KRESS: All single units?

MR. LEHNER: To return to the 1150 study for Grand Gulf, we see that, again, station blackout core dynamic frequency, the mean values here are lower than for the ice condensers.

The conditional probability of early containment failure is relatively high, but remember that you have to fail both the containment and the drywell, not just the containment here to get significant release.

The bottom here shows the SPAR model station blackout ranges.

ACTING CHAIRMAN KRESS: Oh, I'm not able to just multiply this by the SBO CDF frequency then to get the consequences?

MR. LEHNER: No. You mean the -- oh, you mean --

ACTING CHAIRMAN KRESS: The .5 times --

MR. LEHNER: The .5? No.

ACTING CHAIRMAN KRESS: Because that's just the conditional probability of early failure --

MR. LEHNER: Yes.

ACTING CHAIRMAN KRESS: -- of the containment?

MR. LEHNER: Right, right, right, yeah.

ACTING CHAIRMAN KRESS: I didn't realize that before. So actually --

MR. LEHNER: It turns out that --

ACTING CHAIRMAN KRESS: -- actually the Mark IIIs are even more beyond the cost benefit analysis because of this?

MR. LEHNER: There's lower benefit for Mark IIIs in general.

ACTING CHAIRMAN KRESS: I mean even lower than -- the numbers we have, do they include your combined failure of the --

MR. LEHNER: Yes, yes.

ACTING CHAIRMAN KRESS: Oh, the numbers have already got that --

MR. LEHNER: Yes, yes.

ACTING CHAIRMAN KRESS: -- picture in? Okay. I'm sorry.

MEMBER WALLIS: The next one.

ACTING CHAIRMAN KRESS: Oh, here. Yeah,

I see.

MR. LEHNER: I just want to mention again that the SPAR three I models have not been QAed, and so these frequencies may change quite a bit. As I said, we really had very little information for the Mark IIIs, and as you can see, the station blackout frequency for River Bend there, one times ten to the minus five is actually quite high for a Mark III BWR plant.

And I think it's fair to say that in the IPEs, that frequency was quite a bit lower, but the SPAR models so far have assigned that frequency. So we're using this as sort of to get a maximum estimate, an estimate of what the maximum benefit could be.

Okay. This indicates the what I had mentioned earlier, the fact that the igniters really only benefit you during low pressure sequences, and if you look at the 1150 study, you see that while the containment failure probability is about .5 for high pressure sequences across the Board, the containment and drywell failure probability, that it's the probability of both of them failing is about .2 across the board, whereas for the low pressure sequences, the containment failure and drywell failure probability during station blackout sequences is still .5 and .2, but if you have the igniters available, then the containment failure probability and the drywell failure probability become very low.

MEMBER WALLIS: There are technical analyses or are these expert judgments?

ACTING CHAIRMAN KRESS: An expert.

MR. LEHNER: There is expert judgment in here because, you know, you're talking about combining severe accident loads, which are very uncertain, with --

ACTING CHAIRMAN KRESS: With fragilities.

MR. LEHNER: Fragilities, and while the fragilities --

ACTING CHAIRMAN KRESS: And actually the overlap between the two --

MR. LEHNER: Between the two, yeah, yeah, and I guess, you know, the fragilities we can get a reasonable handle on, but the loads --

ACTING CHAIRMAN KRESS: The loads are what's driving uncertainty.

MR. LEHNER: -- are very uncertain.

ACTING CHAIRMAN KRESS: Even the fragilities have a lot of uncertainty.

MR. LEHNER: Yes, yes. But they're certainly tighter than a load part.

ACTING CHAIRMAN KRESS: Yeah.

MEMBER WALLIS: Well, is there a tendency to be conservative in estimating fragility?

ACTING CHAIRMAN KRESS: Well, the NUREG 1150 was supposed to get a distribution.

MR. LEHNER: Yes.

ACTING CHAIRMAN KRESS: Not to have any fast --

MEMBER WALLIS: It was supposed to be realistic.

ACTING CHAIRMAN KRESS: Yes.

MR. LEHNER: Yes.

ACTING CHAIRMAN KRESS: That was the idea.

MR. LEHNER: Yes.

ACTING CHAIRMAN KRESS: But it was supposed to incorporate model uncertainties.

MR. LEHNER: So given -- oh, sorry. This slide says PWR. Obviously it should be BWR Mark III.

ACTING CHAIRMAN KRESS: I'd like to see one those PWR Mark IIIs.

MR. LEHNER: So this then shows the averted costs for Mark IIIs, and as you can see, they're substantially less than they were for the ice condensers.

Here we've done some sensitivity

calculations where the first row across for Grand Gulf uses the mean NUREG 1150 probability of early containment failure.

The second row uses the 95th NUREG 1150 probability of early containment failure.

The third row says let me assume that I have half of my sequences at lower pressure and my drywell always fails if the containment fails.

By the way, let me back up for a minute. If I look at this slide, since my containment failure is .5 and my combined containment and drywell failure is .2, I can infer that the conditional probability of the drywell failing if the containment fails is .4.

ACTING CHAIRMAN KRESS: Yeah. So you used one.

MR. LEHNER: So we used one here instead of .4.

ACTING CHAIRMAN KRESS: That lets you divide the sequences in half.

MR. LEHNER: Well, but the first two we said there's only 40 percent of the sequences are low pressure. So we've actually increased the lower pressure sequences.

ACTING CHAIRMAN KRESS: Oh, I see. The first two have --

MR. LEHNER: Yeah, yeah.

ACTING CHAIRMAN KRESS: I didn't realize that.

MR. LEHNER: Sorry. One of the earlier slides, yeah, I should have pointed out that in general it looks like 40 percent of the sequences would be at low pressure. So we try to get a handle on the maximum benefits by taking a relatively -- at least from trying to maximize the benefits from a conservative view of the accident progression here.

And then the next two -- that's the first three rows, and then in rows four, five, and six, they're just for Grand Gulf with the SPAR model station blackout frequency, and then we have the last three rows there at the bottom for River Bend with the station blackout frequency, which is, as I pointed out --

ACTING CHAIRMAN KRESS: It's interesting.

MR. LEHNER: -- was quite a bit higher.

ACTING CHAIRMAN KRESS: The SPAR models are not too far off from NUREG 1150.

MR. LEHNER: Well, the River Bend one is quite a bit higher because --

ACTING CHAIRMAN KRESS: Oh, yeah, the River Bend.

MR. LEHNER: -- they assigned this high core damage frequency.

So finally, we wanted to look at some of the reasons why there is such a difference between the Sequoyah benefits and the Grand Gulf benefits, and this slide tries to illustrate that.

If you look at the mean values for Sequoyah from 1150 and the means values from Grand Gulf for 1150, you get a factor of roughly 30 between the benefits for Sequoyah and the benefits for Grand Gulf.

And this slide tried to show where that factor comes from. It's about a factor of four in the station blackout frequency, and Sequoyah's value is higher.

The averted conditional containment failure, there's about a factor of two there, and then there's also a big factor due to the population around the different plants. Grand Gulf has a very low population density around it.

So we also looked at population densities around Mark IIIs, and I think Perry has the highest population density. It's about five times higher than Grand Gulf.

So that factor of five would be one for

Perry. But anyway, that's how you get the factor of 30 between Sequoyah and Grand Gulf.

So that concludes my presentation.

MR. NOTAFRANCESCO: Okay. The next person on the agenda is Jim Meyer who has done the cost analysis.

MR. MEYER: Thank you, Allen.

Jim Meyer from ISL.

MS. WESTON: Jim, do you need the body mic? Do you need the body mic?

MR. MEYER: I don't think so. Let's see how this goes, and I'll be happy to use it if needed.

ACTING CHAIRMAN KRESS: Are you going to tell us what ISL is?

MR. MEYER: I'm sorry. What?

ACTING CHAIRMAN KRESS: Are you going to tell us what ISL is?

MR. MEYER: Information Systems Laboratories. We do consulting work for NRC.

ACTING CHAIRMAN KRESS: Are you located here at in Washington?

MR. MEYER: Yes, our office is just right down the street across from Mike Flynn.

I'll tell you what I plan to discuss this afternoon. I wanted to spend a few minutes going through the actual cost assessment process, how we get to the final bottom line numbers, and also go over some of the assumptions that went into that determination, and then talk for a few minutes about the actual cost analysis results themselves.

It was clear from the previous discussion that uncertainty was important. So we put an uncertainty perspective on the cost estimates, and then there's some comments about the implications of system reliability, an issue that also came up at the previous meeting.

This figure was in the report that you received, and it allows for an overview of the --

ACTING CHAIRMAN KRESS: Now, did you interface with the various licensees to get this information?

MR. MEYER: Yes, we did. We gathered information from a number of sources, from the staff, from the licensee information, in particular, the SAMA process, the severe accident mitigation alternative --

ACTING CHAIRMAN KRESS: Oh, yes.

MR. MEYER: -- process as part of license renewal.

There are, I guess, now about ten of those that have been submitted that we looked at, and for each one, they propose severe accident mitigation alternative type fixes and do a cost-benefit analysis associated with that.

The Duke analysis, in particular, was very helpful in providing us with cost estimates for the back-up power.

And this figure does give a breakdown of how we determined the total cost, and again, it is completely consistent with the guidelines that we referred to earlier, the regulatory analysis guidelines.

We address four impact attributes: the industry implementation, industry operation, and then the counterpart for NRC, the implementation for NRC, and the NRC operation.

On the far left, you see the breakout of the industry implementation. We'll talk about that in a little more detail in a minute or two, but it's the actual hardware, the installation of that hardware, the engineering associated with that, the dollar equivalent of the worker dose when it involves exposure to radiation to install the device, the emergency procedures, preparation, and then the licensing costs.

Over the 40 year assumed remaining life of the plant, the industry operation aspects are the surveillance costs, the maintenance costs, and the testing costs for the back-up power system.

ACTING CHAIRMAN KRESS: Would this be assumed to be a safety system?

MR. MEYER: I'm sorry. What?

ACTING CHAIRMAN KRESS: Would this -- if this were in, would it be assumed to be a safety system, SSC?

MR. MEYER: This would not be a safety system in terms of the normal, what you normally think about as a safety system.

ACTING CHAIRMAN KRESS: Yeah, but still there would be certain surveillance and testing required.

MR. MEYER: Yeah, it would have surveillance, maintenance, and testing consistent with systems appropriate for accident management and for beyond design basis type accident accommodation.

ACTING CHAIRMAN KRESS: Okay.

MR. MEYER: The NSC implementation costs or the consideration of rulemaking and the NRC review costs and --

ACTING CHAIRMAN KRESS: We don't count what's going on right now as far as that cost.

MR. MEYER: Do you mean the rulemaking, the 50.44 rulemaking?

ACTING CHAIRMAN KRESS: No, I mean the study that research has done to produce this report.

MR. MEYER: No. No, that cost is not included.

ACTING CHAIRMAN KRESS: Okay.

MR. MEYER: And then --

MEMBER FORD: Of all those costs, does anyone predominate or are they --

MR. MEYER: I'd have to -- do you mean among the various studies?

ACTING CHAIRMAN KRESS: I would guess the installation.

MR. MEYER: Oh, among these costs, the industry implementation is the biggest cost.

MEMBER FORD: By a large factor?

MR. MEYER: By a considerable factor, and we can get into that in a few minutes.

MEMBER FORD: Okay.

MEMBER WALLIS: Well, the cost of the diesel itself is --

ACTING CHAIRMAN KRESS: Is probably not even on the map.

MEMBER WALLIS: -- a few percent of the

total cost.

MR. MEYER: Yes, as it turns out, whether you're talking about a portable diesel or a pre-stage diesel, it's a small percentage of the total cost even for the industry implementation.

MEMBER FORD: Is that because they're safety related?

ACTING CHAIRMAN KRESS: No.

MEMBER FORD: No? Okay.

MR. MEYER: Well, there are a variety of reasons for it that we'll get to in a few minutes.

MEMBER FORD: Okay.

MR. MEYER: We've already touched on a few of these, but I'll go through them and answer any questions relative to them.

We're going to be actually talking about the actual costs in a few minutes, but under the industry implementation, the materials and equipment covers all of the hardware aspects, and in this case the cost of the diesel generators, the conduit and cabling, the electrical panels that are required.

Installation is mainly a labor matter, the cost of installing the device. Engineering I think is obvious. It's the cost of doing the engineering preparation.

Occupational exposure we made an estimate of and translate that into dollars using the 2000 dollars per person-rem, and then we also include emergency procedure preparation and then the licensing costs, for example, changes to the UFSAR.

For the industry operation, and again, it's over 40 years consistent with the benefits analysis, we include the maintenance, testing, and the surveillance of the back-up power system.

NRC implementation and operation, as I said earlier, include the items listed here.

MEMBER WALLIS: These four kilowatt diesels, is that something like what are used on construction sites?

MR. MEYER: The portable diesels?

MEMBER WALLIS: They're a standard item that are used on construction sites, aren't they?

MR. MEYER: The portable diesels?

MEMBER WALLIS: Yeah, you're going to have --

MR. MEYER: Yes.

MEMBER WALLIS: -- just put this in the back of your pickup truck and drive off.

MR. MEYER: Right.

MEMBER WALLIS: It's a very standard item.

MR. MEYER: This is a very standard item. There's a large variety of portable diesels available with considerable power ranges. You can have portable diesels to accommodate the power requirements you know, for the igniters if you would choose that option.

ACTING CHAIRMAN KRESS: There's no consideration of the diesel reliability and the benefits of miscalculating?

MR. MEYER: Yeah, the benefit analysis assumes 100 percent reliable system, and I will speak to that in a few minutes, but --

ACTING CHAIRMAN KRESS: Do you have to pay more for that reliability?

MR. MEYER: You have to pay more, and in fact, we did take that into consideration based on some comments from the previous meeting in terms of costs, operational costs, as well as costs for hardware.

MEMBER WALLIS: Why do they have to be diesels?

MR. MEYER: They don't have to be diesels.

MEMBER WALLIS: High powered gasoline powered.

MR. MEYER: They could be gasoline

powered. In fact, some licensees are considering gasoline powered back-up capabilities.

We chose diesel for a number of reasons. Their reliability, a well known commodity, and that the utilities are familiar with, but there are those other options.

I want to just touch briefly on the physical modifications that we considered. As our base case, we considered the pre-staged diesel to power the igniters, and then as an alternative we considered the portable diesel. The pre-stage diesel, everything is set up ahead of time so that the only thing that the operator would really have to do is go to the diesel, start it up, and then make sure that there was power applied to the igniters.

In the case of the portable, it's more complicated in that the portable diesel would be stored at a location probably away from the auxiliary building. It would have to be physically moved to a panel. We were thinking of being close to the auxiliary building, and then the igniters activated that way.

MEMBER WALLIS: The igniters all have to be on at the same time? I mean your power requirement is based on having all of the igniters on all of the time?

MR. MEYER: Yes, that was --

ACTING CHAIRMAN KRESS: I think that's the only way.

MR. MEYER: -- that's an assumption that we made, that for a variety of reasons we determined that one train of igniters was a necessary and sufficient condition for effective operation.

MEMBER WALLIS: Because the actual ignition takes very little energy. It just it's -- what takes the energy in an igniter?

ACTING CHAIRMAN KRESS: There's not much energy involved, but --

MR. LEHNER: The igniter energies vary. The igniters that are used for Duke, for example, require about five kilowatts, while the igniters for TVA require about 20 kilowatts.

MEMBER WALLIS: Yeah, but that's not the ignition problem. The ignition probably takes a very small amount of energy, but it's all of the equipment.

ACTING CHAIRMAN KRESS: Well, they have to be at the right temperature, and they have to be where the hydrogen in there are.

MR. NOTAFRANCESCO: Each igniter is 100 watts.

MR. MEYER: Right.

MEMBER WALLIS: And so it's the heat loss from the thing which is taking most of the energy?

ACTING CHAIRMAN KRESS: Yeah.

MR. NOTAFRANCESCO: The igniter is about 1,700 degrees Fahrenheit.

MEMBER WALLIS: All right. So it's the heat losses which are taking the energy. Okay. So it's not just a spark. It's something which is on all the time.

ACTING CHAIRMAN KRESS: There are spark igniters, but I don't think anybody uses them.

MEMBER WALLIS: With a spark igniter, you could probably use sort of 100 watts and just charge up some condenser and go bang.

ACTING CHAIRMAN KRESS: Yeah, but you have to know when to spark it.

MEMBER WALLIS: Yeah, that's right. You've got to have some intelligence system.

MR. MEYER: Another modification that will be considered was having a prestage that would accommodate both the power to the igniters and the air return fans, and the subject of the role of the air return fans will be part of a later presentation.

Then we also considered passive water

catalytic recombiners as just another alternative to the back-up power to the in place igniters.

The assessment was differentiated in a number of respects. We considered reactor types, containment types, and also balance of plant.

Also, it turns out that the number of reactors at the site is important. With dual unit sites, you can share some of the costs and keep the costs down compared to the single unit sites.

ACTING CHAIRMAN KRESS: Is that a big deal? Could you use the same portable diesel, say, for both sites?

MR. MEYER: Well, that had more of an impact for the pre-staged --

ACTING CHAIRMAN KRESS: Oh, it did?

MR. MEYER: -- diesel, but you could share in the preparation of procedures and allow the paper work. There's a lot of cost cutting, you know, from that standpoint.

And also differentiated by the power requirements. I mentioned that the TVA power requirements were considerably larger, 21 kilowatts compared to the Duke and the D.C. Cook.

ACTING CHAIRMAN KRESS: Why are they so much higher requirement of power?

MR. MEYER: They just have a different glow plug type.

ACTING CHAIRMAN KRESS: Just different blow plug.

MR. MEYER: Finally, we --

MEMBER WALLIS: You say in your report that there's a distinction between having a prestage and a portable diesel. The tables seem to be independent of that.

MR. MEYER: I'm sorry?

MEMBER WALLIS: I couldn't see a distinction made between the prestage an the portable diesel costs. The tables that are in your report don't seem to make a distinction between whether it's a portable diesel or prestaged.

MR. MEYER: We had a separate case that was --

MEMBER WALLIS: You have a separate case?

MR. MEYER: -- dedicated to the --

MEMBER WALLIS: Okay. So you have to go all the way through, and then you find the other one.

MR. MEYER: Yeah, I believe it was case two.

MEMBER WALLIS: Okay. I'm sure you'll get to it. But the costs of the hitch-up and everything and all of the cables and circuit breakers is presumably the same whether it's portable or not.

MR. MEYER: The costs, there's a prestage part to the portable diesel, and it's the prestage part, the part that you're wiring into a safety grade system, and it's those costs and the panels and the cabling associated with that that are common to both and --

MEMBER WALLIS: They're much bigger than the cost of the diesel.

MR. MEYER: And they're bigger than the cost of the diesel, correct.

We also performed some sensitivity analyses. External event qualification was one of those. Here the external event characterization varies from site to site, as I'm sure you're aware, and also much of the external event is not quantified. Seismic margins are used for most of these plants.

And so we did a rough estimate of the cost of including external events, and it's about a doubling of the overall costs.

We also considered the sensitivity of extended outage, and we based this on $300,000 per day, cost to the utility if they would have to extend their outage in order to install the back-up power.

ACTING CHAIRMAN KRESS: If it about doubles the cost and it about doubles the frequency, is it a wash?

MR. MEYER: I'm sorry?

ACTING CHAIRMAN KRESS: If seismic external events double the costs but also double the frequency, then it's a wash?

MR. MEYER: Yeah, it would be. It probably would be pretty close to a wash. That's correct.

MEMBER WALLIS: How long does it take to -- what is the effect on outage typically?

MR. MEYER: Well, the effect on outage, you can assume any length of outage.

MEMBER WALLIS: I don't want to assume anything. I want to get a real good estimate of how long it takes.

ACTING CHAIRMAN KRESS: The outage is to still this --

MR. MEYER: Well, in this case, we're assuming that you don't need any extension to the outage.

MEMBER WALLIS: I don't see it in the table, or is it part of something else in the table, like installations? Is it part of the installation cost?

MR. MEYER: No, we looked at the cost of an extended outage, and it's based on $300,000 assumed for a day. Our base case assumed that there would be no extended outage, that it could be performed within the normal --

MEMBER WALLIS: You say it might be a day or something?

MR. MEYER: No, for our analysis, we assumed eight hours, a third of a day or $100,000 addition.

ACTING CHAIRMAN KRESS: Okay.

MEMBER WALLIS: Oh, you assumed eight hours.

MR. MEYER: Yes.

MEMBER WALLIS: As the sensitivity. Okay.

MR. MEYER: But it was only just to get an idea of how that would affect the overall number.

MEMBER WALLIS: So the mean would be four hours?

MR. MEYER: It could be four hours.

ACTING CHAIRMAN KRESS: It could be a real driver.

MEMBER WALLIS: It could be a real driver. That's right.

ACTING CHAIRMAN KRESS: Three hundred K a day.

MR. MEYER: It could be a driver. That's the main reason for raising the issue, but we did assume that it could be accommodated within the normal shutdown period.

And then consistent with the regulatory analysis guidance, we did a three percent to seven percent discount rate to see what the impact of that would be.

MEMBER WALLIS: Is it ever going to go to ten percent?

ACTING CHAIRMAN KRESS: No. Seven percent is too high.

MR. MEYER: Well, you know, seven percent is recommended as being the base percentage. Ten percent would be pretty optimistic in terms of economic growth.

Some of the key assumptions. As I said before, the prestage diesel generator is located near the auxiliary building. Its activation is remote. That is, it would be located at the diesel generator, and it would be manual. It would not be automatic.

All of our costs are consistent with the benefit costs. They're in 2002 dollars with four years of operation, and we're assuming that, like we mentioned a minute ago, that the back-up power supply need not be safety grade, and that one train is necessary and sufficient for our purposes, for mitigation of the consequences of the station blackout.

MEMBER WALLIS: How thick are the diesel generators that people buy for their houses for back-up power?

MR. MEYER: How large are they?

MEMBER WALLIS: Yeah.

MR. MEYER: Well, the catalogues have --

MEMBER WALLIS: A few kilowatts presumably?

MR. MEYER: Yeah, two to 20 or 30 kilowatts.

MEMBER WALLIS: They're in the range. The kind of thing that you just stick on your house in case of a blackout?

MR. MEYER: Well, that's what people buy them for.

MEMBER WALLIS: What do they cost?

MR. MEYER: What do they cost?

MEMBER WALLIS: What do they cost installed?

MR. MEYER: They cost $2,000.

MEMBER WALLIS: Installed?

MR. MEYER: I don't --

MEMBER WALLIS: Is that something you can buy for your house that's 2,000 and when you put it in a nuclear power plànt it's 200,000?

MR. MEYER: Yeah, I don't know. For home use, I don't know what the installation charges are.

MEMBER WALLIS: No, okay. I was trying to get the overall costs, not just the hardware, but the overall.

MR. MEYER: For home use I don't know what they would be.

Another assumption, too, is that the worst case scenario, we have three hours from the start of the station black-out accident before these igniters would have to be activated, and that was an important assumption for a better understanding of what kind of flexibility we had in considering the options,

Well, these are a summary of the results for the best estimate results that we determined. The first line is the --

MEMBER FORD: Excuse me. Would you mind just going back to the previous graph?

MR. MEYER: The key assumptions?

MEMBER FORD: Yeah.

MR. MEYER: Yes.

MEMBER FORD: Could you explain to me why it doesn't have to be safety grade? I mean, if it's something that you did -- if you could buy it out of Ace Hardware, that would not be safety grade.

MR. MEYER: That's correct, yes.

MEMBER FORD: But it's not saying anything at all about its reliability on this. Doesn't it have to be really reliable?

MR. MEYER: Yes, and that's why we've steered away from the home use type of diesel generators.

MEMBER FORD: Because it's not safety grade.

MR. MEYER: No. We've looked at it from a standpoint of the reliability of these systems.

MEMBER FORD: Right.

MR. MEYER: And for the purposes of the cost-benefit analysis, we feel very confident that you can have functional reliabilities in the range of 95 percent or better, and with those kind of reliabilities, it's not going to perturb the cost-benefit analysis whether you assume a perfect system or a more realistic, 95 percent reliable system.

So we --

ACTING CHAIRMAN KRESS: Besides that, if you did the Option 2, this would never show up as a risk significant item.

MEMBER FORD: It wouldn't? Okay. It's just that I seem to remember now the last meeting we had on this subject, this very point came up. In fact, you brought it up, Graham, this question of Ace Hardware showing on the back of your truck and bringing it in.

MEMBER WALLIS: Right.

MEMBER FORD: And I thought it was rejected because it was not safety grade. That's why it was not bringing it back.

MR. MEYER: That was not the reason. We're talking about actions beyond the design basis, and so there's a lot more flexibility in the kind of systems that we can consider.

MEMBER FORD: Okay.

MR. MEYER: For the purposes of the backfit analysis, we determined that these systems could be made sufficiently reliable that they wouldn't impact on the cost-benefit decision.

MEMBER FORD: Okay.

ACTING CHAIRMAN KRESS: Regardless,

they're both assumed to be on site. You don't go out to the hardware and buy it when you need to --

MEMBER WALLIS: I think the hardware one is 90 percent reliable, too. Otherwise people wouldn't buy them.

MR. MEYER: The hardware one is --

MEMBER WALLIS: So it doesn't really affect your cost benefit once you get up in that kind of reliability range. It doesn't matter.

MR. MEYER: No, diesels are very reliable, and the home use ones are very reliable, too.

In our cost analysis, we did assume on the lower end of our cost analysis a $2,000 type home use type diesel generator. However, we thought that for our base case it would be more appropriate to assume an industrial qualified standard diesel.

This viewgraph displays the cost for both the ice condenser and the Mark III, and these are out best estimates. We'll get into the uncertainties in a minute, but they're our best estimates, and I can go through all of these, but you can get a pretty good feel just from looking at the various options that we considered that the costs for the ice condenser back-up diesels range from $200,000 to, if you include the air return fans, $590,000.

They're a bit larger for the Mark IIIs because the Mark IIIs are single unit sites and don't have some of the benefits of shared costs. The PARS (phonetic) are, as you can see, considerably more expensive than the back-up diesel to the igniters.

ACTING CHAIRMAN KRESS: When you talk about PARS, did you include all of the just same elements that add back here on this chart, installation, engineering --

MR. MEYER: Yes.

ACTING CHAIRMAN KRESS: -- materials and equipment?

MR. MEYER: Yes. Yeah, well all of these were analyzed with all of those cost elements considered.

We performed an uncertainty analysis using a Monte Carlo simulation software, and for each one of those cost elements that went into the roll-up of the total cost --

ACTING CHAIRMAN KRESS: Yeah, now on this uncertainty analysis, your input was a high, most likely. Now, where did you get those numbers, those values?

MR. MEYER: Okay. Those numbers were gleaned from input from staff, from the industry, and from engineering judgment.

ACTING CHAIRMAN KRESS: And you do a triangle between --

MR. MEYER: We did a triangular --

ACTING CHAIRMAN KRESS: And then did a Monte Carlo uncertainty?

MR. MEYER: And did a Monte Carlo uncertainty analysis. Some of the industry analysis actually provided a minimum, maximum costs, and their best estimate costs, and we tried to use those as much as possible.

MEMBER WALLIS: Well, for instance, you have this engineering. I see you have estimate engineering cost for similar modifications were between 50,000 and 175,000, and you chose to use 50,000 for your estimate.

MR. MEYER: Correct.

MEMBER WALLIS: You have chosen the lowest value of the range rather than some mean.

MR. MEYER: We chose -- this is for the engineering?

MEMBER WALLIS: Yeah.

MR. MEYER: Yeah, we chose the 50,000. The input we got that it would go as high as that 100 --

MEMBER WALLIS: One hundred seventy-five thousand.

MR. MEYER: That number, but we were also provided input that it would be as low as $5,000. So we used that as the lowest engineering number.

MEMBER WALLIS: It's amazing there's such a range on something that --

MR. MEYER: It's a very large range, and --

MEMBER WALLIS: If I were building a house, I wouldn't accept bids that went from a factor of ten, low, to a factor of --

MEMBER FORD: This is the as installed cost; is that correct?

MR. MEYER: We're talking about the engineering costs now.

MEMBER WALLIS: No, but even so --

MEMBER FORD: Well, gosh.

MEMBER WALLIS: -- you would think they could do a much better job of estimating cost than 5,000 to 175,000.

MR. MEYER: What we wanted to do was make sure that we picked up the full range, and we felt comfortable with the $50,000 as being the robust value.

We did the uncertainty analysis for the prestaged and the portage options, and we also did an uncertainty analysis with and without accounting for the air return fans.

MEMBER WALLIS: How do you know that these guys aren't making it appear expensive because they don't want to do it?

MR. MEYER: That was taken into consideration. We were able to get information independently from manufacturers. We talked to the staff about their thoughts on these costs, and we tried to weigh that appropriately.

This is the results of the uncertainty analysis.

MEMBER WALLIS: There's another thing. You said it cost you 50,000 to train people to use this thing?

MR. MEYER: Yes. We originally had a considerably lower number than that. Those are not dissimilar from the assumed numbers for developing the procedures and doing the training that we've seen for other like fixes.

MEMBER WALLIS: So it's not something that automatically comes on when needed so there's no training required?

MR. MEYER: Well, you need training. You need to develop procedures, and you need to train the staff in how to carry out those procedures in terms of --

MEMBER WALLIS: So you don't train the homeowner on his emergency diesel generator. It just comes on when required.

MR. MEYER: No. No, it's a manual start.

MEMBER WALLIS: Manual start?

MR. MEYER: Even the current activation of the igniters is manual. It's from the control room, but it's a manual operation.

For the prestage, the differences here is that it would be manual, but it would be a local start at the site of the prestage diesel.

MEMBER WALLIS: Someone has to go to it and pull a switch?

MR. MEYER: And, again, these are assumptions that we made. An individual utility could design it differently, but we had to establish a basis for the cost, and this was another way to keep the cost from being excessive. To have it powered from the control room would be an additional cost that we felt was not necessary for this application.

Well, here we see the results of the

uncertainty analysis, and it shows the five percent, the mean, and the 95 percent values, and I think it's pretty much self-explanatory as to what that is.

For the --

ACTING CHAIRMAN KRESS: Now, why isn't -- I see. These are the same mean and the low and high that you had on the previous chart, the ones on the graph. They're the same ones.

MR. MEYER: Yes. Yeah, well, the differences between the number here and the number of the graph --

ACTING CHAIRMAN KRESS: Yeah. Because, for example, looking at the 95 percentile on this one, there's 375, and on this one you have 460.

MR. MEYER: Yeah, the reason for the difference is that this is for the dual unit sites, Catawba, Cook, and McGuire.

ACTING CHAIRMAN KRESS: The previous chart was sort of an average for --

MR. MEYER: Yes, it's an average. It's a weighted average for all of the --

ACTING CHAIRMAN KRESS: I see.

MR. MEYER: -- for all of the ice condensers.

MEMBER WALLIS: I'm really impressed with the accuracy with which you predicated your mean.

(Laughter.)

MR. MEYER: You're impressed with the accuracy on --

MEMBER WALLIS: Accuracy with which you predicated the mean.

ACTING CHAIRMAN KRESS: He's talking significant figures.

MR. MEYER: Oh, yeah.

PARTICIPANT: Go to the next slide.

MR. MEYER: No, you can disregard those significant figures.

ACTING CHAIRMAN KRESS: But this just reflects your triangle really.

MR. MEYER: Yes.

ACTING CHAIRMAN KRESS: Which the low was this bottom one, and the high was this top one, and then the mean point was in the middle.

MEMBER WALLIS: It looks like a Gaussian.

ACTING CHAIRMAN KRESS: Well, it does, but it just reflects a triangular distribution of the input.

MR. MEYER: And finally we have been talking about this this afternoon. This summarizes the implications of the back-up power system reliability on the cost-benefit assessment, and as was said earlier, the benefit assessment assumes that the systems are 100 percent reliable, that is, they're perfect systems.

And obviously no system has 100 percent functional reliability. So the impact of this assumption on the cost-benefit assessment was addressed and determined to be insignificant. Why is that the case?

Well, our studies indicate that we feel that functional reliabilities can be achieved greater than 95 percent for both the portable and the prestaged --

MEMBER WALLIS: That includes the operator action?

MR. MEYER: Yes.

MEMBER WALLIS: And reliability?

MR. MEYER: That includes the operator actions. And if that's the case, then it's not going to have much impact on cost-benefit.

That doesn't mean it's not important in other contexts, but for our purposes here, we've determined that it won't have an impact on the cost-benefit determination.

The fourth bullet points out that a

similar back-up system has recently been evaluated with the paper referenced in the footnote to have a functional reliability in the range of 97 to 98 percent, and that's for a portable, gas powered back-up system.

So our conclusion regarding reliability is that the back-up power system functional reliabilities have a negligible impact on the cost-benefit assessment.

And also, variations in the functional reliabilities between systems also have a negligible impact.

MR. ROSENTHAL: From the presentation, what I'd like you to come away with the idea is that a back-up fix would be two, three, 400,000, and I don't know that we know it necessarily would be better. And two, three or 400,000, although it's a lot of money in our normal lives, really is not a big difference within the scope of the study.

But it does point out that if at one time we were thinking of a really cheap fix because you could get something off the shelf, by the time we realized that you had to carry it in and have some sort of procedures and put in breakers that interface with safety related equipment and whatnot, you realized that the costs would be hundreds of thousands, you know, two, three, 400,000 and not 2,000, 3,000 and 4,000.

I think that that's a lesson learned from this.

The next thing is that we are not designing a system. You have to do a conceptual design and go to some catalogues and look up real costs of real things in order to do some scoping analysis for the purposes of coming up for the cost compared to some benefits, but this is not the design that a licensee would do.

And it's very likely that we would recommend that NRR -- we would finish our work and recommend that NRR take the next step and back the process.

And in today's time, it's very likely that as the agency moved forward, it would probably go to some sort of functional requirements. So we're not trying to pick here would it be portable or fixed or welded in or whatnot, but rather, we would have some sort of -- what we envision is that the agency would come out with some sort of functional requirement, and the implementation of that would be of the order of the kinds of things that you've been presented today, but not specifically this fix.

So we don't have to worry about the gruesome details.

Dr. Kress, we're about to take a major shift now into phenomenology.

ACTING CHAIRMAN KRESS: Yeah, I think maybe this might be a good time for a break. What does everybody think? Why don't we take just a ten minute break since we're running behind and come back at 3:30?

MEMBER WALLIS: Could you tell us why we need to know any more?

ACTING CHAIRMAN KRESS: Oh, well, there's the question of

ACTING CHAIRMAN KRESS: We are now talking about the business of hydrogen control and calculations. I wonder if I could ask the presenter to maybe save us a little more time and cover this pretty briefly, if you could. I don't know what that means.

MR. NOTAFRANCESCO: Yes, we'll try to do that, but I just wanted to -- I took a slide out of my presentation to give some background before we go into MELCOR.

ACTING CHAIRMAN KRESS: Okay.

MR. NOTAFRANCESCO: The thrust of why we are doing this is recent positioning by several licensees that, if we provide back-up power to igniters, it should also go to the air return fans. So we did some MELCOR analysis, and when I get up, I have done other evaluations, but I am trying to give you a snapshot that we believe current evaluations reveal that igniters alone are sufficient and there is a downside of air return fans.

They would tend to melt out the ice chest quicker. Plus, if one includes the air return fans in the cost/benefit, the cost goes up significantly, at least doubles. So that is why this is pivotal in the ice condenser area.

ACTING CHAIRMAN KRESS: Let me ask you a simple question maybe one way or the other. If you didn't have igniters available, would it be important then to have air return fans?

MR. NOTAFRANCESCO: If I didn't have igniters? Air return fans alone?

ACTING CHAIRMAN KRESS: Yes. I mean, what you do, would you still mix up the hydrogen and air with just natural convection processes? It is going to reach detonation then. Mixed, it is going to reach detonation composition, but the question is, would it be early in one spot due to stratification and likely be in a location where the shockwave would tell containment or would it be all mixed up and occur randomly in locations whether or not the igniters or it might be random igniters?

The question is, would it be important to have air return fans even if you didn't have igniters or if the igniters failed for some reason?

MR. NOTAFRANCESCO: Well, anything is better than nothing.

ACTING CHAIRMAN KRESS: I guess it is really a non-question.

MR. NOTAFRANCESCO: Anything is better than nothing.

ACTING CHAIRMAN KRESS: Yes.

MR. NOTAFRANCESCO: Maybe the air return fans could induce some random ignition, too. I just think we want to take the position of optimizing the configuration the best --

ACTING CHAIRMAN KRESS: Yes.

MR. NOTAFRANCESCO: -- have a potential backfit. That is what matters.

MR. TILLS: My name is Jack Tills. I served as a contractor on this project to Sandia Laboratories for the purpose of doing the containment portion of the analysis.

Most of my time is spent as a consultant to the NRC, basically, for the purposes of looking at codes like lump parameter CONTAIN code, and that has been for assessment purposes primarily. That means that most of my time is spent in looking at experiments versus lump parameter results, both thermal-hydraulics and the hydrogen.

I have also sat on the boards of international writing groups where people that have represented the CFD codes have been present, and so have some understanding of where the CFD people come in line. So I have an understanding at least of some of the issues.

I first wanted to talk a little bit, before we get too far into this, about expectations. The intent of these calculations were primarily scoping in nature. We weren't reopening issues of severe accident to look at absolute certainties or accuracies of hydrogen distribution within the ice condenser-type deal.

We had a number of options to look at: power to igniters, power to igniters and fans, or nothing. We looked in a comparative sense, a relative sense, to what that means in terms of the response of the containment.

We have done experimental analysis or experimental assessment of lump parameter codes for ice condensers, but it is mainly for DBA, in other words, strong sources for short periods of time, and not for hydrogen. The data that has been gathered for ice condensers reflect that. There is not any concentration data in ice condensers that have been measured to allow you to do an accurate validation.

So I just wanted to mention that because I know there was a concern of the Committee about lump parameter. I will discuss some of those issues, but it is going to be more from the scoping analysis as opposed to being a detailed analysis.

However, we did follow all of what we consider reasonable guidelines for applying the lump parameter analysis to this ice condenser.

MEMBER WALLIS: Does this change any of the conclusions we heard earlier? We were given some estimates of benefits, and so on. How does your work fit in with that?

MR. TILLS: Well, you notice that in one of the slides at the beginning the assumption was that the hydrogen control was 100 percent effective. Once that statement is made, anything that I do, basically, doesn't have any bearing unless it indicates or shows that there is a major difference between that statement and what actually could occur type deal. So that would be one point.

The other point is that the discussion in terms of whether or not you are going to apply power to igniters or fans, if there was a major benefit phenomenologically in terms of concentrations in the containment that might lead you to expect a worse condition, then that may, you know, it has a possibility of overriding the decision that would be made.

There was a number of issues that were addressed. The first one I have already really talked about a little bit about the --

ACTING CHAIRMAN KRESS: You didn't use the MELCOR hydrogen generation capability? You just used this containment?

MR. TILLS: No.

ACTING CHAIRMAN KRESS: Is that what that --

MR. TILLS: No.

ACTING CHAIRMAN KRESS: That is not what that first bullet means?

MR. TILLS: No, the first bullet means

that the multicell analysis was done using the MELCOR code for the containment. Now the MELCOR code was also used for the primary system to generate the hydrogen sources.

One of the things that is different a little bit in this analysis than previously had been done in, say, CONTAIN analyses or other analyses that were done earlier was the disconnect that appeared when you had SCDAP RELAP people providing input that may have not been sequenced correctly for the event that you are looking at and putting it into a code like CONTAIN, for instance.

In this case we had similar --

ACTING CHAIRMAN KRESS: This is a completely integrated analysis.

MR. TILLS: -- integrated-type deal. Although we used the sources that were generated by the MELCOR code in a separate fashion, in other words, we decoupled it for the purposes of doing this analysis because we wanted to look at a large number of uncertainties and do a similar uncertainty study of the containment, and the MELCOR code calculations take, you know, two to three days to complete a calculation on a workstation. These containment calculations take about an hour to do. So that is how it was done.

But the sequencing of the sources was important. MELCOR was used in the primary side to generate uncertainties in the sources. So one of the issues was to select representative sequences of injections that were either high or low in terms of what the injection total was to the containment as well as the actual signature that would drive the worse condition in the containment.

The other bullet, the third bullet here, that talks about relative comparisons, that is what I just mentioned in terms of how the scoping analysis was done to look at three different possibilities of either no power or power to various control areas.

The final bullet was an uncertainty analysis that was done primarily just for the containment. This was really for the burn parameters associated with deflagrations, propagation, initiations, and an inertian. Then there was some uncertainty or sensitivity analysis that was done on the modeling, the containment, what paths might be open and what might be closed.

I will go quite quickly through the next three slides here. This is just a sketch of what the ice condenser looks like as it nodalized. There was a total of 26 cells nodalized in the containment. Most of the time we follow the general rule, which is you use a lump parameter or you use one node per room and you try to minimize the number of nodes that you might have in open regions that might have circulation.

ACTING CHAIRMAN KRESS: And you used Sequoyah for --

MR. TILLS: This is Sequoyah.

ACTING CHAIRMAN KRESS: You figured it would be representative of the other ice condensers?

MR. TILLS: Right.

ACTING CHAIRMAN KRESS: There's not that much difference in their margin --

MR. TILLS: No, there is not. The lower part of a containment, where there was sources injected -- this slide just kind of indicates that we did take knowledge of where the sources were going to be injected in the containment, because this is not going to be a symmetric-type source that is going to feed the ice chest. It is very non-symmetric because of the offset of the pumps and the hot legs, and so forth.

The next slide just shows the ice chest as it is nodalized. Because of the asymmetric sources, to try to capture some of that in the analysis, four asymmetric cells were included for the ice bed. There was not any vertical stratification for those ice beds used.

The reason is a number of reasons. One is that this is an accident where there are sources continually going into the ice chest throughout the scenario. This is a pump seal failure event. So we still have sizable sources going into the ice chest which are, as I mentioned, asymmetric.

In addition, there is a substantial amount of ice melt during this period of time. Somewhere between 40 and 60 percent ice melt, depending on whether or not you have fans on or not, occurs. That amount of ice melt with that amount of water falling down creates its own turbulence.

Second of all or third of all, I should say, in an ice chest environment it is almost impossible to get a situation of no mixing because the gases come in; they rise just because of the momentum of carrying them in; they cool off; they're stripped of steam; they become heavier. As they become heavier, they circulate back down and then are disturbed again by the source that is coming up through them.

So there's a number of reasons for that. The fourth reason would be relationship to if you are doing burns in an ice chest. Most or practically all our correlations are based on single-compartment or single-room propagation correlations. There is no correlations that have been developed to put in this code, the MELCOR code, to treat a series of cells that are linked together. So from consistency reasons, that seems to be appropriate to nodalize like this.

Now to address other situations, though, we did do sensitivities. We did stacked cells with no mixing. We did look at nodalizing this configuration with stacked cells, so that there was a number of cells in the ice condenser and our best estimate as to what the circulation would be. We did not get, we could not maintain any sizable density profile or concentration profile in the ice chest. So that just gives you a little background of what the nodalization is, used and picked.

The next slide goes on to the uncertainties of the source terms that were put in there. I mentioned that we picked representative source terms that came out of the MELCOR RCS analysis.

What is shown up here in the dark lines are the three representative curves that we picked.

Now the failure of the containment, actually the early failure, comes anywhere between six to seven hours. Now this is either by a hot leg or by a vessel head failure.

We are only going to do the analysis -- I won't even show you the analysis today of just the early failure because that is what they were mostly concerned with, was early failure. So this is an analysis up to and including RCS pressure boundary failure, either by a hot leg or a vessel breach.

The variation in here is about 15 or 16 plus or minus percent with total injection hydrogen. The average is about 450 kilograms. So it ranges plus or minus 16 percent.

The curve in the dark line is what I used as a reference injection because it gave the highest rate of injection of hydrogen at the time when the actual pump seals were considered to fail. So you will see that as a reference case. But the other cases, I will show one case which is the low case, to give you an idea of what the variation might be and the sensitivity.

The next table just outlines the important parameters of those three runs, both in terms of when the pressure, the RCS failed, either by lowering another hot leg and then how much relative hydrogen was generated in-core and where that injection came from in terms of the containment. You see that most all of the injection comes out through the pump seals in these three cases.

That was the case for, I think, all the cases. Of the 40 runs that were made by Sandia, and this was 40 runs made to do a Latin Hypercube analysis, all of the failures were either hot leg or lower head failure.

The next slide gives you a little bit of a picture of what those sources look like. What is shown here is a rate profile of hydrogen that comes into the containment through the pump seals. You can see that the rates are a few tenths of a percent when the seals start to deteriorate and fail and then drop off after that period of time.

So the critical point of time to do the analysis here is that period of time when you are between three-and-a-half and four hours for this scenario, and you know that it is going to probably be a fairly small spike increase in hydrogen.

The next slide is just for information. It just shows the default ignition levels that were used, the propagation levels that were used, as the default in the MELCOR code. These were then varied later, and then uncertainties, you started to see what sort of nonlinear effects would be picked up in the uncertainty study.

The igniter locations are shown based on general locations. You will notice that there are igniters practically everywhere in the containment except in the lower plenum of the ice chest and in the ice chest proper.

ACTING CHAIRMAN KRESS: Now when you do such an analysis like this, you look to see where these ignition limits are reached first and then you say that's where the ignition starts?

MR. TILLS: Yes, and so the code, I mean the code doesn't predict these. The code just uses them as its input. So it's input based on experiments --

ACTING CHAIRMAN KRESS: Yes, these limits are just input?

MR. TILLS: That's right.

ACTING CHAIRMAN KRESS: But the code calculates?

MR. TILLS: They do. That's right.

ACTING CHAIRMAN KRESS: Where the limits are reached, then that's where the ignition starts.

MR. TILLS: That's right, it burns. That's right, and then it looks at adjoining cells to see what the condition is there. If the condition is right, it propagates --

ACTING CHAIRMAN KRESS: It propagates --

MR. TILLS: -- based on an algorithm that has been checked with experiments.

To give you just a baseline of what we are looking at in terms of pressure, if there is no power to the igniters in a station blackout, what is calculated here is for that reference case of Run No. 21, which was that high-injection case. What you are looking at is a pressure profile where at the time of vessel breach we assume that we can have deflagration, based on these limits.

So at the time, basically, the code was precluded from doing any burn, and we accumulated hydrogen as it would mix it and turn it around in the containment. Then at the time of vessel breach, when we had the hot material coming out, we assumed that we had ignition right there.

ACTING CHAIRMAN KRESS: This is like the case where you have igniters?

MR. TILLS: No igniters. If you didn't do anything, this is the best estimate of what would happen.

ACTING CHAIRMAN KRESS: This 10 percent containment probability failure, that is the fragility curve?

MR. TILLS: That's right.

ACTING CHAIRMAN KRESS: That's the 10 percent formula?

MR. TILLS: Right, and actually the fragility curve that we looked at for seven atmospheres would almost be a 95 percent failure. So, I mean, it is a very steep curve. I just show it as 10 percent, but really here we are looking at about a 95 percent failure rate.

MEMBER WALLIS: I'm surprised it is so steep, but I guess it is.

MR. ROSENTHAL: Jack, we brought up this static or dynamic. Do you just want to flip back to the slide to answer Professor Wallis' question?

We are looking at a hydrogen burn on a scale of hours. So, in fact, that is a quasi-static.

ACTING CHAIRMAN KRESS: I see.

MR. TILLS: One of the things in doing this comparative analysis is to look at different regions in the containment where we predict the hydrogen concentration.

This is just showing you a comparative prediction in the upper containment. Now this is a critical area where you want to burn out hydrogen before you get into the upper containment.

The top curve in red is showing you that that curve is in the neighborhood of 14 percent, which is a bad news type of concentration. But what is interesting in this slide is the relative insensitivity of two different options of being power to the igniters or power to the igniters and fans. The fans bring you up a little bit quicker, but as long as the igniters are operating, there isn't much sensitivity in the upper containment. Now that gets a little bit more dicey as you move into other regions that are more difficult to calculate.

This next slide is showing you concentrations in the ice condenser. You remember there was this large injection right at the time of pump seal, and that is what you are seeing here, is a fairly large increase in the concentration of hydrogen as you are in the ice condenser.

This is without any power to the igniter. So this is, again, a baseline type of a calculation, so the worse condition occurring just after you have that pump seal break.

ACTING CHAIRMAN KRESS: Now you've deduced that, although these are very high concentrations, that this did not get into a detonable configuration?

MR. TILLS: Well, the case without power on that previous slide here --

ACTING CHAIRMAN KRESS: This is without power, too? Okay.

MR. TILLS: Without power, you are again in a detonable-type situation in most cases.

Although I think Allen is going to talk a little bit about combustion, obviously, you know, there's a lot of uncertainties with detonation and transitions, and the ice condenser is a pretty complicated deal. There is some information that Allen is going to share with you on that, but to say that we are in a detonable deal is also very uncertain.

The next curve, figure, here is just showing you what happens in the case when you just have power to igniters. Now the propagation limit, you know, there's no igniters in the ice chest. What you are seeing is the maximum concentration of hydrogen getting up to almost 9 percent. That 9 percent is the propagation limit for propagating down from the upper plenum region when you have ignited up there and you burn down.

Now we could have done continuous burning, but we decided to just do deflagration-type burning because that would give us a higher spiking in terms of what the hydrogen might get to, rather than continuously starting to burn and letting it burn all the way out.

ACTING CHAIRMAN KRESS: What are the different curves?

MR. TILLS: The different curves are the different -- there's four cells in the ice condenser, four asymmetric cells. What you are seeing in the variation is the slight variation in the concentrations as a result of the source asymmetric behavior.

ACTING CHAIRMAN KRESS: So what is happening here is you build up to this downward propagation --

MR. TILLS: Right.

ACTING CHAIRMAN KRESS: -- and that's already ignited?

MR. TILLS: That's right, it is already ignited at the top.

ACTING CHAIRMAN KRESS: And it burns down, and then you've got to build up the concentration, and then it burns down --

MR. TILLS: That's right. That's right.

Now you can compare that to another case that was run where power was put to both igniters and fans. In this case the concentration in the ice bed is dropped. The reason is because now, once you have the fans on, the burn behavior in containment is more characterized as being generated or burned out by areas where there are igniters, because now you have put in more oxygen. You have taken the steam concentration down. So most of the burn is going to occur where there is an igniter, as opposed to propagating. So now the concentrations go down. So this is kind of a reasonable thing that you would expect.

But the difference between the other one and this one going from 9 percent to 6 percent is totally controlled by the input that you put in the code. The next table just kind of emphasizes that, and it shows the total amount of hydrogen burned in different regions of the containment up to the time of vessel failure.

The one thing that is interesting about this, and what was pursued as a result of this type of an analysis, was that there's a large amount of hydrogen being burned in the lower compartment. Now most people in the past have questioned how much hydrogen would burn in an area where you have injected a large amount of steam. You have evacuated a portion of it, of oxygen, during the accident. And, also, if you had a burn, you exhausted a number of moles of oxygen as a result. So you would starve off any continued operation of the igniters.

So we looked at what was really occurring here. I will talk about that in the next slide or two.

The next slide just shows you a sensitivity based on those injected variations that we received from the hydrogen RCS calculations. Run No. 35 was the low injection rate curve on that figure that showed 21 through 40 at --

ACTING CHAIRMAN KRESS: Where you had those three curves?

MR. TILLS: That's right, three curves, and this is the low one, which has the lowest injection rate. It was about 400-and-some kilograms.

Again, when you first inject, it looks just about like the other one because most of the falloff in the total amount of injection occurred after the initial burst of hydrogen in the containment when the pumps had failed. So you see a very similar behavior.

So one of the conclusions out of this is that, basically, the source uncertainty that is generated by the primary code is not propagated in the same fashion in terms of uncertainty in what the containment, how the containment responds. Because once you've got the igniters going, you'll burn irrespective.

The question of how much hydrogen burns out, depending on how you model circulation in the ice condenser, was a concern based on what we were seeing in terms of how much was burning out in the lower compartments. Now normally, as I mentioned, you would be starved by oxygen in the lower compartments.

However, for the ice condenser, there is a fairly well-defined refueling canal or drains that in a station blackout we would normally expect to be open, because they are not flooded by sprays. So that path in the previous calculations was open. As a result, there is a growth circulational behavior that occurs during the accident, bringing in oxygen into the lower compartments.

To look at the sensitivity of that, we went ahead and shut those paths off. So what you are seeing in this table here on slide No. 17 is the comparison again with igniters, power to igniters, and igniters to fans, assuming that there is no circulation that is coming back down from the upper containment through the refueling drains.

What happens is that, when you only have the igniters on in this case, it cuts the amount of hydrogen being burned there by almost about half. So it is a very significant amount.

You are still getting some burn because, first of all, there was some initial hydrogen or oxygen in there when you started the burn, but also it is very hard to seal these doors on the ice chest. So there is some circulation that is going on because of the dynamic behavior of the doors.

Again, these are scoping calculations, but it just kind of gives you --

MEMBER WALLIS: Does it matter where it is burned?

MR. TILLS: Well, one of the concerns was that, if you don't burn in the lower compartment, it shifts where you are going to burn to only two places after that: the ice chest or the upper plenum primarily, where the hydrogen is going to come through.

As a result of that, you get higher concentrations in the ice chest potentially, because you are feeding it without having the benefit of burning some of that hydrogen before it has gotten into the ice chest.

MEMBER WALLIS: But what is the consequence that matters?

MR. TILLS: Well, it was primarily just the consequence of being concerned that --

ACTING CHAIRMAN KRESS: It was a perception if you got a lot higher concentrations you could detonate --

MR. TILLS: That's right. That's right.

MEMBER WALLIS: So you're trying to avoid detonation?

MR. TILLS: Right.

MEMBER WALLIS: But you are saying here it burns anyway?

ACTING CHAIRMAN KRESS: Right.

MR. TILLS: The other concern that we had when we were looking at different options like the fans, for instance, was if you provide power to the fans, what are you going to do to the ice melt? You are going to increase the ice melt. Is it going to be significant, enough significant that you may jeopardize later some analysis that would occur for late accident behavior?

ACTING CHAIRMAN KRESS: Now you burn less in the ice compartment itself, but more in the lower compartment? Is that where the ice melt comes from, because you are burning more in the lower compartment?

MR. TILLS: Well, I mean, both because of the energy, just of the thermal-hydraulic energy of the source of the steam going through there, it is a melting-off-the-ice-type deal. I did not do the partitioning of how much is affected by the burning-type deal, except, as you will see here, that there is a sensitivity --

ACTING CHAIRMAN KRESS: This just comes right out of the MELCOR calculation is what you're saying?

MR. TILLS: That's right. But what is shown here is that there is some sensitivity, obviously, to having the fans on or not having the fans on. Something like about 30 percent more ice is taken out at the time of vessel breach.

MEMBER WALLIS: So that would reduce the pressure?

MR. TILLS: The pressure is pretty much a no -- you know, it doesn't matter here.

MEMBER WALLIS: It doesn't matter?

MR. TILLS: If the thing is operating as an ice condenser --

MEMBER WALLIS: It would condense more steam?

MR. TILLS: It is condensing more steam and it is melting more out.

MEMBER WALLIS: You would think the pressure would go down.

MR. TILLS: It does go down, but it is not a significant --

MEMBER WALLIS: It is not significant?

MR. TILLS: It is not significant.

The other interesting thing here, as you mentioned, in terms of burn-type deal, the actual injection, just due to the sensitivity of the sources here, gave you almost the same type of uncertainty or sensitivity as whether or not you had the fans on.

MEMBER FORD: Could I just ask a question? All the conclusions you have made so far assume that MELCOR is correct within the certainties that you are talking about, the ranges that you are talking about there. We are quite sure that MELCOR is correct against data?

MR. TILLS: When you say, "against data," the problem is we don't have data really that would allow one to make a definitive statement on something like concentration on the ice chest of hydrogen. However, in terms of thermal-hydraulics, when we were doing the analysis of CONTAIN, which is basically a sister code of MELCOR in terms of the lump parameter containment models, we did analysis of ice melt based on the experiments that were conducted by Westinghouse.

We did them both in short term -- this is during the blowdown -- but we also did, they had a few tests that were done long term, hours, where we did complete meltout of the ice in the ice chest. In both the short term and the late time, we did very good ice melt calculations. We also matched pressures very well.

Now the ice melt gives you a pretty general idea of how well you are doing hydraulically in terms of taking the ice out. The pressures also give you a pretty good idea of how well you are doing in terms of modeling the mixing that is going on in that compartment-type deal. Because if it would not have mixed, you would get excursions in the pressures typically.

So there is some data. Has MELCOR been

validated directly with ice, new condenser experiments? No, not directly. I mean in terms of this type of detail of concentration.

MEMBER FORD: So it is almost, I was going to say, "engineering judgment," but that's not true. You mentioned a few tests.

MR. TILLS: It is better than engineering judgment, and it is based on thermal-hydraulic calculations that we have no reason to believe that there is anything occurring here that would invalidate completely this for a comparative purpose, scoping-type purpose.

Obviously, if we were going to do something more detailed in terms of absolute numbers-type deal, we would approach this completely different. There may be additional experiments we either would want to have conducted or seek out more detail.

But, again, I just wanted to kind of mention that upfront in the presentation to just kind of sensitize you to that, that this is scoping and it gives you kind of a general idea.

I feel pretty good about the ice melt calculations. I think most people would, when they look at what the utilities have done -- and I haven't got those results with me -- type deal, but this is well in line with what most people think how the ice would melt out.

MEMBER FORD: So the best thing you could say is that the trends are correct?

MR. TILLS: Yes.

MEMBER FORD: But the absolute values may be questionable?

MR. TILLS: That's correct.

MEMBER FORD: Okay.

MR. TILLS: There was some interest to do uncertainties of the containment analysis, and one of the areas, of course, was the parameters that initiate the burns and the propagation. There's a number of ways of approaching the uncertainty.

One would be to look at the analysis and try to pick the worse case and the best case in terms of these parameters, but that is almost impossible when you have something this complicated, where you have burns occurring in all different types of compartments and propagation conditions changing. So the only thing that made reasonable sense was to go ahead and do a Monte Carlo calculation where all the parameters where varied randomly, and then you did a statistical analysis. So that was what was done for the MELCOR and the containment part of it.

In this case, a direct statistical analysis was made, varying the ignition limits, and propagation is shown in terms of low and high. These, again, were just -- I won't say they were pulled out of the air, but they were just kind of best estimates as to what those variations would be.

The main interest here was to see whether or not there were strong nonlinearities that were occurring as you varied these parameters over reasonable ranges. A hundred calculations were run to give a two-sided tolerance band of 95 percent confidence and 95 percent probability.

So the results that are shown here look at the two critical regions for early failure. One is the period of time where the pump seal is occurring --

MEMBER WALLIS: What do you mean by "two-sided"?

MR. TILLS: "Two-sided" meaning we were looking at minimum and the maximum --

MEMBER WALLIS: The minimum and the maximum.

MR. TILLS: -- of the hydrogen concentration, and we were trying to find what that bounce was.

So the first column gives you that period of time when the pumps are failing, seals, and the last column is just before vessel breach.

The biggest uncertainty here, obviously, which we expect, occurs in the ice bed because of its being affected by propagation. So you see about a 5 percent variation in hydrogen concentration for a case when you had the igniters on, as a result of varying those parameters.

MEMBER WALLIS: Are these percents or percents of --

MR. TILLS: That is a percent of hydrogen --

MEMBER WALLIS: -- by mole?

MR. TILLS: -- by mole.

The other thing that you can do, of course, with a sensitivity calculation like this is try to identify what is the dominating parameter.

The next slide is just showing you how that was done for these calculations. One has a hundred calculations; you like to draw as much data or as much information out of these calculations. One way of doing it is calculating rank coefficients that look at basically the importance of each of the parameters for a certain criteria that you select. In this case it was the uncertainty range that was being predicted in the previous slide.

I don't want to go through this in too much detail except to indicate that, obviously, things that you expected came up fairly strong. Now the rank coefficients mean that they vary between minus 1 and 1. As you get higher to 1, that means almost a perfect correlation. As you go lower, the correlation gets worse.

For a 95 percent confidence in this being an important parameter, for a hundred runs the rank coefficient would have to be .2. In other words, anything .2 or greater, you begin to see a correlation. Anything lower than .2, you probably don't have a correlation and the information is not of value.

So one of the things that is seen here is that there is an importance -- well, the other thing in terms of the sign of the correlation or the sign of the coefficient, if you are positive, that means that varying that parameter in a positive way has a positive increase in the negative. So you just get kind of a general idea what is dominating the calculation.

MEMBER WALLIS: Of course, the important

thing is this last slide you are getting to that we can take away as a message?

MR. TILLS: There were conclusions out of this. The first one, obviously, was from that slide that showed that, if you don't have any power, you're in trouble.

The other one was that, whether or not you have igniters powered or igniters and fans, you also have an effective control mechanism. So there was no "gotcha's," and that is what we were kind of looking for here.

MEMBER WALLIS: So there was no incentive to insist on having fans running?

MR. TILLS: Fans, that's right.

The only caveat on that is, obviously, those fans provide you with more uniform burning, as you would expect. So the burning occurs more where the igniters are.

There is a more rapid depletion of ice, and that is kind of indicated here. The hydrogen source term that we received from the RCS code did not propagate to give us large uncertainties in the containment calculations.

Circulation of the upper air through the refueling drains is a significant issue if it is considered that there is some uncertainty in that input. It is our belief that there probably is not any uncertainty in that input for a station blackout. The statistical uncertainty analysis indicated that there is a range of something like 5 percent over this calculation in the ice condenser, ice bed.

So that, basically, was I think what --

MEMBER WALLIS: That is a high number for hydrogen concentration.

MR. TILLS: It is getting to be a high number, right. I think it is approaching a high number.

MEMBER WALLIS: Isn't 14.7 percent already too high?

MR. TILLS: You know, the question of ice condenser loading as a result of either burn, rapid burning, or detonation is something we asked a number of people to provide input, and most of them declined, partially because it was a very difficult thing to try to analyze.

MEMBER WALLIS: You are trying to get detonation in a foggy, rainy atmosphere.

MR. TILLS: That's right. Allen will talk a little bit, I think he prepared a little bit, on what the consensus was when this was looked at in the early eighties. These results in terms of concentrations are not much different than what those people had to --

MEMBER WALLIS: Has anyone tried to burn hydrogen in this sort of an atmosphere that you get in the condenser?

MR. TILLS: I don't know. Charlie?

MR. ADLER: Not precisely this kind of atmosphere, but we tried to initiate combustion of mixtures in a condensing steam environment, where the steam was condensing and it formed nucleation sites, bulk condensation. It is quite difficult to get it started if there are one- and two-micron-sized droplets because they won't evaporate in a flame front, which raises the local steam concentration, which serves to quench.

So that is a dampening effect on the flammability of these mixtures, even at the relatively high concentration. That is a big heat sink that is also trying to decelerate any kind of combustion process.

MR. TILLS: I think most people don't realize what the conditions are when you try to melt out half of the ice within a few hours. I mean it is a tremendous amount of materials draining down.

MEMBER WALLIS: You also get a fog, don't you? It is not just rain? You get a fog?

MR. ADLER: You would have fog, in addition to the bigger droplets of drippings.

MR. NOTAFRANCESCO: Okay. What Jack presented was an updated evaluation to MELCOR. The thrust of my presentation is to go back possibly over the past 20 years and see how air return fans fit in this type of issue, whether it was required or is this a recent event.

This one we have seen already. It is the background.

What I wanted to bring up was some perspectives. We are dealing with low-event frequencies, and we are trying to look at a cost-effective configuration. So we are trying to look at performance and cost. Therefore, we are within the framework of a best estimate approach. We are using best engineering judgment and reasonable assurance as standards.

The ice condenser design attributes, the air return fans are part of the original design of the plant. The intent is to move upper compartment air to the lower compartment. There are containment sprays in the upper compartment, and the ice chest --

MEMBER WALLIS: So the purpose of these fans was to make the ice condensers more effective by circulating the environment through them or something?

MR. NOTAFRANCESCO: Correct. Promote condensation and DBA issues related to the --

MEMBER WALLIS: Which is to reduce the pressure?

MR. NOTAFRANCESCO: Correct, and move some hydrogen due to DBA hydrogen control which is --

MEMBER WALLIS: It is really the steam control that they are for, isn't it? The original basis was --

MR. NOTAFRANCESCO: That's right.

Here's an ice chest, just to give some --

MEMBER WALLIS: Don't these ice arrays evolve with time?

MR. NOTAFRANCESCO: They do.

MR. TILLS: They change their geometry in that they're not just nice ice cubes for years?

MR. TILLS: They are biscuits with flakes of ice in it.

MEMBER WALLIS: And all kinds of stuff?

MR. TILLS: Yes, it is a very difficult thing to characterize. That is why Westinghouse ran experiments that were essentially full-scale experiments with dimensional, flowing through the ice, to get an idea of the heat transfer coefficients, and so forth.

MR. NOTAFRANCESCO: Okay, the cross-section of an ice condenser. Slide 6, again, post-TMI requirements in which the ice condensers were retrofitted with AC-powered igniters had to deal with 75 percent metal-water reaction for postulated degraded core accidents.

There are, as discussed, separate igniter units except in the ice chest and lower plenum, igniters to burn lean mixtures, maintain containment integrity, and TMI sequences that were analyzed assumed air return fans and containment sprays available.

In my review of the past history, I looked at some post-TMI assessments, staff SERs, treatment of the igniters and their return fans and IPE. I looked at relevant experiments, and we did this recent plant analysis with MELCOR.

MEMBER WALLIS: Now this SBO frequency is dependent on the reliability of your diesels, isn't it?

MR. NOTAFRANCESCO: Right.

MEMBER WALLIS: Wouldn't it be possible to spend another $100,000 on diesel reliability and reduce that number?

ACTING CHAIRMAN KRESS: Some of them are already at 99 percent.

MEMBER WALLIS: Some are at 99?

ACTING CHAIRMAN KRESS: From 95 to 99, depending on the plant.

MEMBER WALLIS: It will make a difference if you go from 95 to 99.

MR. ROSENTHAL: Pat Baranowsky did a five-year study of diesel reliability at real plants. He found that these were the reliabilities you have, .96. What he found was that those diesels that were promised to be .95 were about .96 and those diesels that were promised to be about .975 were also .96.

(Laughter.)

He was at AOD at the time. That study was subsequently redone about five years later because he had more data; he was facing updates. He found that the reliability was .96 again for the fleet of diesels.

It is really hard to make a .96 diesel into .99 diesel when it is the same --

MEMBER WALLIS: Well, it is hard to test it up to .99. In fact, it is hard to get a failure if it is .99.

MR. ROSENTHAL: Well, he had reasonably low data density because what he was trying to do was look for real on-demand failures where in the middle of the night some bus went dead for some reason and he had a legitimate, honest load. Then he added in the data from normal starts.

But my point is that you are not changing the essential design. So you essentially have a .96 diesel.

MEMBER WALLIS: But you're just working with that little bit of percent where it doesn't work; you're trying to alleviate. If you know why it doesn't work, maybe you could improve that more than doing this kind of stuff.

MR. NOTAFRANCESCO: Remember these are low frequencies when you add them all up, 10 to the minus 5.

Okay, slide 6, I just want to quickly go over the combustion behavior aspects, the different combustion modes. When I talk about slow speed combustion, I talk about deflagrations and diffusion flames; when I talk about fast speed, I talk about flame acceleration and DDT. I just give a comparison of the flame fronts of a couple of meters per second to a couple of thousand meters.

One of the post-TMI documents I drew upon was the McGuire hearings which took place in February-March of 1981 for about four weeks, in which the ice condenser was discussed in quite detail. There were notably experts that Duke provided on their team. These guys Bernard Lewis and Bela Karlovitz are quite famous within their field. So I try to pick some key insights from the transcript.

Their best guess or their best judgment is that the type of burning that would take place in the ice condenser is a continuous diffusion flame at the top of the ice condenser. We are talking about standing, stable flames.

MEMBER WALLIS: You've really got a flame inhibitor in the form of all this ice and fog and stuff in the chest.

MR. NOTAFRANCESCO: Well, but as the hydrogen exits the top of --

MEMBER WALLIS: Well, when it comes out --

MR. NOTAFRANCESCO: Some of the other points I am trying to bring here is obviously flame acceleration and DDT were one of the top of the issues. The experts claimed that the geometry and flow conditions inside the ice condenser are not conducive to producing a transition to detonation.

Somebody even asked, even without air return fans nor containment sprays, one of the experts said, then the hydrogen stream emerging from the ice condenser will mix slower with the air under the dome and will be ignited and will burn as a slow-burning diffusion flame.

Again, in another place having to do with flame acceleration, some have a strong sideways confinement in which one needs to get a DDT, and any expansion that takes place during a deflagration phase of the propagation will hold back the transition to detonation.

So these key insights were articulated at the time, and I think it is quite germane on how we are carrying it today.

Another aspect is the IPE treatment. Back in the CPI Program, which was the Containment Performance Improvement Program, a generic letter went out, and it was evaluation of interruption of power to igniters. Again, no air return fans were mentioned. I surveyed some of the licensees' evaluation in response to the generic letter or supplement; the licensee comes back and said there's a small cost benefit. Again, there's no identification by the licensees that air return fans are necessary. Moreover, some discussion on some of the licensing says, well, we will consider powering some igniters as part of the accident management program.

I have looked at some IPE event trees. Again, continuous operation of igniters seemed to be sufficient. It wasn't a necessary linkage between the two systems.

The purpose of this slide was to give an overview of the data that has taken place over 20 years, since 1981, in which the experts gave their insights. None of the experiments have exposed any disagreement with those judgments.

As you know, RES has been an active participant in hydrogen behavior programs. During the eighties the focus has been on looking and pretty much evaluating the efficacy of igniters and pretty much it focused on slow speed combustion, which that is the intent of igniters.

During the nineties the NRC participated in a number of flame acceleration experiments. I have given you a reference for that also.

One of the tests we discussed earlier has to do with ignition in a condensing mixture in which there's like 20 percent hydrogen, but it is steam inert. The sprays are on. There's no violent detonation or anything. It is a deflagration type of burning.

So I am just saying a preponderance of the evidence -- well, I've got the summary here. A preponderance of the evidence demonstrates that igniters reliably initiate combustion at lean mixtures, exhibit low flame speeds, and the testing does confirm some of the tests were done as continuous injection, and diffusion flames did exist and were observed.

There's no opportunity for flame acceleration in the covered regions in the ice condenser. There is a smooth transition in the steam-condensing environment, and besides burning locally and efficiently, igniters induce bulk circulation currents which promotes mixing.

This just summarized the MELCOR.

MEMBER WALLIS: Now this bulk circulation is modeled successfully in MELCOR, you think?

MR. NOTAFRANCESCO: I think we said bulk circulation patterns were --

MR. TILLS: Yes, bulk circulation patterns are modeled well.

MEMBER WALLIS: Not mixing with any

given --

MR. TILLS: But not within a given volume, where you would expect, either by using your own judgment or because of the slow injection sources, that there would be pockets of those secondary circulation areas.

MR. NOTAFRANCESCO: Again, the post-TMI requirements had a 75 percent metal-water reaction as the upper limit. The latest MELCOR sequences pretty much range between 50 and 60 percent metal-water reaction.

The overall conclusion: Core ice condenses during populated SBO sequence. Back-up power to igniter system alone is sufficient. Collectively, past findings on relevant combustion testing provide an adequate basis. Again, we provide the downside of accelerating the -- utilizing the air return fans accelerates ice meltout which, delaying ice bed, could extend fission product scrubbing and containment integrity.

So the bottom line is, looking over an overview and the preponderance of the evidence, we believe it is sufficient just to back up power to igniters in an ice condenser plant, not promote the inclusion of air return fans.

MEMBER WALLIS: So your conclusion is you don't need to power the fans?

MR. NOTAFRANCESCO: Yes.

MEMBER WALLIS: You don't need to. There's no payoff.

MR. NOTAFRANCESCO: Yes, that's right.

MEMBER WALLIS: But you still want to insist on diesels, mixture diesels, to power the igniters in the ice condenser plants?

MR. ROSENTHAL: Now we are into the final part of the discussion, which to summarize and get some advice from you.

MEMBER WALLIS: It didn't seem to me that you made a very good case for that.

MR. ROSENTHAL: Excuse me?

MEMBER WALLIS: It didn't seem to me you made a very convincing case for insisting on these diesels just for the igniters. You could look at the cost/benefit numbers. You have to be very risk-averse or something in order to say you must do it.

MR. NOTAFRANCESCO: Do you want to go back to this one?

MEMBER WALLIS: Yes.

MR. ROSENTHAL: Sure. Okay. What you see hashed in are those situations in which you can make a cost/benefit argument. When the cost/benefit ratio is less than -- and remember the costs are about $200,000 to $300,000 to $400,000. That is your measure. When the cost/benefit ratio is less than .1 or greater than 10, it is a pretty easy decision.

MEMBER WALLIS: Well, I think you would have trouble making a case for the 320 and 310s there. So you would probably wipe out those ones.

MR. ROSENTHAL: What I'm saying is when there's 320 on a mean value and 320 on the cost, so you have a cost/benefit ratio of 1, that's the very time that you ought to making your risk-informed rather than a risk-based decision.

The cost/benefit analysis itself is absolutely risk-based. So, yes, one of the questions is, how risk-averse are you? How much do you believe your understanding of the phenomenology? Do you believe that it is adequate to suppress the initiating frequency by making plant mods or do you have to have some balance on mitigation?

These are weak containments. You know that you have a reasonably high failure probability due to hydrogen if you get into this SBO sequence. So our judgment was -- and, yes, we are risk-averse -- but our judgment was that there were more considerations that said it was better to err on the side of requiring the igniters to be powered than not. Admittedly, that is a judgment call, based on these other considerations.

MEMBER WALLIS: Look at Duke, for instance. Duke is going to install a flood wall, right? So the numbers you are looking at, and it is the second one up from the bottom --

MR. ROSENTHAL: Thirty-two.

MEMBER WALLIS: -- or even the bottom one, it seems to me hard to justify that because your numbers which are shaded there are taking some extreme cases.

MR. ROSENTHAL: Yes.

MEMBER WALLIS: So it is very hard to say, "Duke, you must do this."

MR. ROSENTHAL: If you accept that you can drive, that you are willing to take all the risk reduction in terms of prevention, and I don't have the philosophic answer. In fact, we would like your views on that very question. If you want some balance with mitigation, then you will go forward on it.

Shall we do the ice condensers in the Mark III separately or together?

ACTING CHAIRMAN KRESS: Yes, I think we

ought to view them separately.

MR. ROSENTHAL: Okay.

ACTING CHAIRMAN KRESS: I haven't run the numbers exactly, but if I take the Duke cases with the best estimates down at the bottom, I think if you ran 1.174, assuming that those required items were already in place, that they could probably justify taking the amount on the 1.174 basis based on those numbers. So if that were the case, it would be silly to put them in.

MEMBER WALLIS: This is a kind of reverse 1.174.

ACTING CHAIRMAN KRESS: Yes, a reverse 1.174.

MEMBER WALLIS: I mean, you're asking for a very --

ACTING CHAIRMAN KRESS: I don't think you could make the same case for Sequoyah based on the numbers I see, but, you know, just looking at the delta LERF curve that you get, probably in 1.174 space they could come in and say, "Look, on a risk-informed basis, we could take these things out if we had them in there." If that were the case, and it looks to me like it would be for those, it would be silly to require them to put them in.

MEMBER WALLIS: It would be kind of a Gilbert and Sullivan opera. You would be putting them in and taking them out by using different parts of the regulations.

MR. ADLER: I want to say that, if you go back and look at the original motivation for putting these in, there was a defense-in-depth element to that argument. I mean people made the case that these are low-probability events back then. Utilities did not fail to note that they had made improvements since TMI and they thought all these events were low probability.

But the Commission judged that, because these were small-volume containments that led to high concentrations, steel containments, many of them, not reinforced concrete but relatively thin, steel-shell containments, that the failure modes could be much larger than what you might expect for reinforced concrete, too.

I want to point out, too, that we haven't, at least I haven't, heard -- maybe it was mentioned earlier -- that the use of a mean value for NUREG-1150, my personal view on that is that those mean values are fairly strongly influenced by the random ignition assumptions in NUREG-1150, which were biased, frankly, to produce DDT in the ice bed. Because they had to assume random ignition in order to get to the problem of transition to detonation.

ACTING CHAIRMAN KRESS: Which means you need to use some lower --

MR. ADLER: Well, but in a station blackout, in the absence of active power in the plant, you might look more closely at the DCH study numbers and higher percentiles from NUREG-1150, to look at how important that particular assumption is. So that it starts to push you up from the 300 number up to the neighborhood of 1,000 for Sequoyah pretty quickly.

ACTING CHAIRMAN KRESS: Well, you know, this might come down to a question of defense-in-depth. Let's examine that just a minute.

You already have defense-in-depth because these meet adequate protection and are already at acceptable risk level, which is where you normally expect defense-in-depth to be playing a role. Now we are dealing with enhancements, and the question is, do you want the same kind of defense-in-depth considerations for enhancements, cost/benefit-type things, when you have already had your defense-in-depth philosophy put into achieving acceptable risks in the first place?

My own personal opinion is that is not a good place to invoke defense-in-depth when you are talking about enhancements and that you ought to be more concerned about being sure you have the right benefit/cost ratio and err on the side of not being -- err on the wrong side that a regulator normally doesn't err on, because here you are talking adding burden at an already acceptable risk plant. So you need to err on the side of, well, I'd better be darn sure of my cost/benefits, which tells me, instead of using the 95 percentile, I ought to be using the 5 percentile.

It is a strange look at it, but it is because I am in a different regime in the regulatory sense. If I did use that philosophy, then none of these, including the ice condenser, passes my test for a backfit requirement.

MR. ADLER: Well, I will take one last go at it, and that is that defense-in-depth was meant to apply to the containment function and not invoke reliance on initiating events, initiating event frequencies.

It is also true that in some of these risk studies some of the early failure mechanisms still are associated with relatively low release fractions to the environment. Some rather favorable assumptions are made with respect to scrubbing, even for the early failures.

So that is one of the reasons why fifth percentile numbers are as low as they are. But I guess immediately after TMI the focus was on defense-in-depth but with the perspective of containment function more specifically.

ACTING CHAIRMAN KRESS: Well, that's why the igniter is in there.

MR. GRIMES: Dr. Kress, this is Chris Grimes.

I would also like to put a little perspective on this: that this is a cost/benefit study that concludes a decade or so of research into this question, but we still have an obligation in implementing a recommendation to go out to seek public involvement and comment on the values, the uncertainties, the desirability of establishing a new requirement.

I share your view primarily because my experience in containment analysis tended to show that most of the experimenters had a real hard time getting hydrogen to burn when they want it to. But there is also the aspect that we see in the present public comments on the risk-informed changes to 50.44 in terms of a measure of public confidence in having the added capability to protect the containment.

I will point out Jack characterized these as small, fragile -- I don't think he called them "fragile" -- weakest, but the owners of pressure suppression containments are fairly proud of them and don't like to consider them weak. But there was a reason why they were smaller. It was you put in these pressure suppression capabilities in order to reduce construction costs, but they are weaker containments and they are the last boundary to radiological release.

So there is a defense-in-depth aspect to establishing the regulatory standard of performance, and it will be incumbent upon us, as the implementers of this research study, to go out and seek the broadest public views about those values. If the prevailing view is that the analysis was too conservative for the purpose of trying to make a cost/benefit argument, then this requirement might be rejected by the Commission. On the other hand, if there's a prevailing public confidence issue associated with protecting the containment, then we could see value being added to this close call.

ACTING CHAIRMAN KRESS: My experience being on this Committee with the public comment version of things like this is that you will get significant comments from utilities, plus significant comments from NEI, possibly some from EPRI, and two of the intervenor organizations will comment and maybe one private citizen. I don't know how you incorporate all that because all the utilities are going to say this is not worth it; at least I think they will. NEI will say it's not worth it.

MR. GRIMES: Of course, NEI will say that.

ACTING CHAIRMAN KRESS: But the two intervenors will say, "For heaven's sakes, put these things in." That's what they will say. So you pretty well know what is going to come out of the public.

MEMBER WALLIS: You need a real public comment by a real public.

ACTING CHAIRMAN KRESS: Yes, but I don't know you get that really. I don't know how you get that.

MR. GRIMES: Well, we are working on trying to come up with more performance measures for the regulatory analysis. I will tell you right now I face that challenge in terms of trying to determine what are good ways to provide measures of common defense and security issues for all of the work that NSIR is doing for security requirements.

But we did get substantial public comment on 50.44 changes relative to the reliance on commercial-grade equipment. So we normally only get one or two members of the public to comment, but if we continue to try to offer a broader view, perhaps we can get some more feedback on the public confidence aspect.

But I am not going to presume a priori that in this case of a close call that we would naturally construct the circumstance as you describe, where we are going to propose that we want to go out and impose a requirement to add a feature that a Reg. Guide 1.174 application would turn around and remove.

We would want to construct a regulatory analysis in such a way that we would prevent that kind of bureaucratic --

ACTING CHAIRMAN KRESS: Nightmare.

MR. GRIMES: Yes, circle. I'm sure there's a much better term for it, but the only ones that come to mind are not publicly expressible.

MEMBER WALLIS: Well, you could call it an "absurdity." You could call it an "absurdity."

MR. GRIMES: Yes.

ACTING CHAIRMAN KRESS: Well, once again, though, we always beat our head on the wall when it comes to how much defense-in-depth is sufficient and how do we decide. It comes down almost to always being a judgment call.

MR. GRIMES: In this circumstance I share some of Charlie's sentiments, having been a containment analyst. I can tell you that I have a simple view that the defense-in-depth feature is that we err on the side of protecting containment. I am more concerned about, if the cost/benefit analysis is the predominant decision factor in this, we could end up in some cases with some plants having this auxiliary power capability and others not, and having to explain to Congress why you ended up in that circumstance.

I find that as the defense-in-depth feature, as protecting ourselves from getting into a circumstance where it --

ACTING CHAIRMAN KRESS: Under that kind of thinking, though, you would require it for both ice condensers and Mark IIIs.

MR. GRIMES: That's correct, and you would do so by saying that you're going to provide more weight to the defense-in-depth interests of protecting the containment than you are even a risk-informed cost/benefit analysis about the relative value of auxiliary power.

ACTING CHAIRMAN KRESS: But you've already got two diesels and sometimes three and four in plants, which is defense-in-depth.

MR. ROSENTHAL: Beyond three, you get into common-cause failure things. You really don't buy more with four or five.

ACTING CHAIRMAN KRESS: But that's already the level of defense-in-depth for this thing. So, you know, the question is, how much defense-in-depth do I need?

MR. ROSENTHAL: Or, alternately, am I averse to early failure, conditional containment failure probabilities of .15, no less than .65 --

ACTING CHAIRMAN KRESS: When I have an assured leak containment failure.

MR. ROSENTHAL: Excuse me?

ACTING CHAIRMAN KRESS: When you have a for-sure leak containment failure anyway.

MR. ROSENTHAL: Due to the core concrete --

ACTING CHAIRMAN KRESS: It's going to fail. These things are going to fail late anyway.

MR. ROSENTHAL: Yes, due to MCCI.

ACTING CHAIRMAN KRESS: It's a tough call. I don't know how the -- the question is -- there's two questions: How should we use these uncertainties, and then how should we invoke defense-in-depth? It's two separate questions altogether, to my mind.

MEMBER WALLIS: I think that's what you need to bring to the full Committee. You need to forget about all these technical arguments and summarize them very quickly. Then say, "These are the decisions we face. Which way should we make our decision? Here are the various bases that we could base our decision upon."

ACTING CHAIRMAN KRESS: You might show this thing here and explain how you got it, and also show the bottom line of the cost estimates because I think those are pretty reliable and pretty straightforward. Then just say, "We're faced with the question of how do we use these uncertainties, and do they pass the cost/benefit test? And how do we invoke defense-in-depth?" I think that's the questions.

MR. ROSENTHAL: Well, I would solicit your views.

ACTING CHAIRMAN KRESS: I think my views don't matter a lot because it's the Committee views that prevail, and I don't know, you may have 10 different views.

MEMBER WALLIS: But when I look at the decisions made by the agency in the last five years and then this 1.174-type, I don't think this would fly. I think this would have flown very well in the eighties.

ACTING CHAIRMAN KRESS: Yes, I think if you take a risk-informed view of this, it would probably make it not fly.

MEMBER WALLIS: Yes, make it not fly, right.

ACTING CHAIRMAN KRESS: That's my current view.

MEMBER WALLIS: Then, because we have said that risk-informed decisions will always come up again, someone will say, "But you must have more defense-in-depth; therefore, you can't do it." We've said that before. We have raised that flag many times. If this turns out to be that way with this decision, people will wonder if any risk-informed decision will fly because someone will bring in defense-in-depth.

I am not sure the present climate is conducive to accepting your arguments.

MR. GRIMES: Well, this is Chris Grimes.

What I want to make sure is clear is you have two opportunities to comment on this. The first opportunity is relative to the robustness of the analysis supporting the research conclusions and recommendations. But then you will have another opportunity to discuss it in a broader regulatory coherence way as we come back to the ACRS with a recommendation in terms of the implementation, and whether or not we would proceed with rulemaking or whether or not we would try to do this within the context of the existing regulations.

ACTING CHAIRMAN KRESS: Let's comment on the robustness.

MR. GRIMES: Right.

ACTING CHAIRMAN KRESS: We can do that. I think the cost side of the thing was extremely robust and very believable and a good analysis. The benefits are driving the uncertainties. I mean, if you take the benefits minus the cost, it's the benefits that's driving all the uncertainty for most of it.

It is about as robust as it can be, relying on existing information. To go out and do a full, integrated uncertainty analysis on the benefits, it is just, I think, asking way too much for this issue. I don't think it is worth that at all. It is a huge undertaking, I think.

So I think in terms of doing what you could to assess the uncertainties, I think you have done about all you can. I can't think of anything else I would ask you to do.

So, as far as whether it is robust or not, it's not very robust, but it is the best you can do. The question is now how to make use of that information. Then that comes down to the second question: How to use the uncertainties and how to use defense-in-depth?

MR. GRIMES: In such a way that we don't damage the credibility of the regulatory process.

MEMBER WALLIS: I think we might say that the technical analysis in terms of the physics, and so on, sounds believable.

ACTING CHAIRMAN KRESS: Yes.

MEMBER WALLIS: It is a pretty thorough investigation.

ACTING CHAIRMAN KRESS: For example, I think I would buy off completely on the MELCOR stuff that says you don't need the air return fan. I think that is pretty robust.

I think we just take the PARs out of this altogether. They just don't pass the test at all. So we are just dealing with the igniters.

I think you've got about as much information as you are going to be able to get. I can't see where you can get more. So you have to make your decision based on this information you have.

MEMBER WALLIS: Well, I'm not sure I agree with my colleague that it is only the benefits that are subject to uncertainty. These costs, as if $5,000 or $175,000 -- let's take $50,000; that sounds to me to be full of a lot of uncertainty.

MR. GRIMES: But that is one area where we can definitely get a substantial amount of public comment with more precise --

MEMBER WALLIS: What is the elasticity here? If you force the utilities to do it, they might find a way to do it cheaper. I'm not at all sure we have to make it so expensive.

MR. GRIMES: And if we are able to articulate it in a way that it becomes a performance-based rule as a feature of 50.44, they might find even further ways to reduce the cost. But I can tell you through some of our experience that $50,000 for training is not unusual for some of the most simple procedural changes.

ACTING CHAIRMAN KRESS: Yes, that wouldn't surprise me at all.

MR. ROSENTHAL: When you're all said and done, I truly don't believe that polishing the numbers is going to resolve the issue.

ACTING CHAIRMAN KRESS: I think you're right. That is basically what I was saying. You've got the numbers that you need, and polishing them is not going to help. You have to make a decision based on them, and it is a matter of philosophy and how you feel about it almost.

I might ask if any of the members of the public or the utilities want to make any comments.

MR. BARRETT: Yes, this is Mike Barrett from Duke. I guess I would offer just a couple of thoughts.

As one of the, I guess, holdouts, I have always been rather skeptical that powering just the igniters alone was adequate. Now it is clear the staff has done a lot of work here, and they have done some now seasoned, done some research into what has been said. I think they have made some progress into allaying my concerns somewhat on that.

But I still am a little bit concerned

about using the lump parameter codes for this type of analysis. I am also a little concerned, while the analyses address several different amounts of hydrogen released, it appeared to be a single accident sequence, a reactor coolant pump seal LOCA, core uncovery somewhere around two hours or so. So it appeared to be a fairly large reactor coolant pump seal LOCA.

The sequence that was analyzed may not be probablistically the most significant sequence for which we ought to be trying to deal with these issues. At least for the Duke plants, use of generator run failures dominate the station blackout frequency. You would be looking at being five, six, seven, eight hours on your decay heat curve by the time you were looking to having core uncovery, or longer.

Maybe that doesn't change the behavior of what we saw here; maybe it does. I really don't know. But it seems to me there are other issues that are of various levels of importance that may or may not impact the overall conclusions of the analysis.

But I guess just one thing, just a point for some thought: If the recommendation is to go ahead and power igniters, if a utility chose to want to do fans and igniters, would you be dissuading them from doing so? I mean, you have this negative consequence in your slides about the ice melting faster. That is certainly true, but at the same time, for those of us maybe that are a little not yet convinced, I don't want to have my fans there; that may not be enough of a negative for us to want to change the way we would implement it.

ACTING CHAIRMAN KRESS: That's a good point.

MR. BARRETT: A point for thought there.

MR. ROSENTHAL: We agree, but, Dr. Kress, I am compelled to make some comments about Mark III.

ACTING CHAIRMAN KRESS: Okay, please do.

MR. ROSENTHAL: Can we? I'll be fast.

From a strictly cost/benefit standpoint, we are even an order of magnitude farther away from making a decision that you should go forward. But there are other considerations.

One is regulatory coherence. If you strip out everything that you think you know and you say, "Well, I've got these steel containments and they're roughly the same volumes, and one's got ice wrapped around it and another one's got water in the bottom, but you can morph one into the other; they really aren't that different," of all the containment types, you rely on pressure suppressions that are this big chunk of concrete. They are the weaker of the containments.

You have a high conditional containment failure probability for this sequence for Mark III. For some, but not all, Mark IIIs, station blackout is 95 percent of the core damage frequency. So you are not providing containment protection for the sequences that you want the most.

You have a lot of hydrogen in the Mark III because you've got a lot of zirc. So you've got to really believe that you understand the phenomenology.

So for those reasons, we would go forward on the Mark III. Now one could argue it just plain isn't cost/beneficial. You have a process called the backfit process and it doesn't make it.

Prevention is preferred over mitigation for a dollar spent. The CDFs of these plants are quite low. You have pool scrubbing, which we know works, but there's a question of, under what circumstances will you bypass the pool?

ACTING CHAIRMAN KRESS: See, the backfit rule guidance, does it say anything about defense-in-depth in there? I've forgotten what exactly it does say. I know it has a safety --

MR. ROSENTHAL: My savior.

MR. GRIMES: Not with specificity. It says defense-in-depth is a consideration.

ACTING CHAIRMAN KRESS: Oh, it's a decision.

MR. GRIMES: And I would hope that we're now going to extend the regulatory analysis guidelines to include an explanation about how public confidence should be considered. We don't have measures for that yet, either.

But defense-in-depth --

ACTING CHAIRMAN KRESS: But as a good regulator, you need to think about those things.

MR. GRIMES: Right.

MR. ROSENTHAL: Okay. So if you could provide us some guidance on Thursday?

ACTING CHAIRMAN KRESS: Well, that will be my charge to the Committee, if that's what you want, is guidance. I think, one, we have about an hour-and-a-half on Thursday. I would abbreviate a lot of these discussions and get to the bottom lines. I think I would tend to leave out most of the MELCOR stuff and just give the bottom line on that, unless you get asked for more.

I would concentrate on this kind of curve for the averted costs on the cost side of the equation and give those two and show how they compare, and then just say, "Our issues are this," and they are pretty much what you spelled out, and say, "We're seeking guidance from you guys."

This is more, I think, a question of philosophy and regulatory coherence than it is the bottom line of the numbers. So I think that is what I would do.

MEMBER WALLIS: Could I bring in another thought here?

ACTING CHAIRMAN KRESS: Yes.

MEMBER WALLIS: I'm thinking about all of these things in some sort of context. We mentioned 1.174. If you go ahead with this, which looks like kind of a marginal decision, but if you come down on the side of being more conservative and that containment is something you want to protect and it is good for public confidence perhaps, and so on, and you recommend this, then how about the efforts which are underway to legislate that we don't have to worry about large-break LOCA?

I mean that seems to me a much bigger decision going the other direction, saying, instead of being conservative, we are going to use risk to do away with something which the public has regarded, I think for a long time, as a sort of keystone of defense-in-depth. It seems very strange if we go so incrementally this way and then come back with something which is a huge step in the other direction in terms of large-break LOCA.

MR. GRIMES: That is why I mentioned before that, from the standpoint of trying to develop a framework for risk-informed regulation, we need decision criteria that are going to inform us not only about risks and benefits, but also ways to put defense-in-depth into measures and to provide more guidance about what truly contributes to public confidence.

Containments contribute to public confidence. The details of the interworkings of an ECCS calculation do not necessarily contribute to public confidence.

(Laughter.)

MEMBER WALLIS: No, you don't need to know the interworkings to realize that you've been told for 40 years that we are considering the biggest break and now we are going to step back from it. You don't need to know anything about the details.

MR. GRIMES: We stepped back from large

delatine breaks 20 years ago, and we have been backing away from it ever since. But we have recommendations on trying to risk-inform 50.46 and Appendix K that move them in the direction of being more performance-based.

We don't necessarily need to frighten the public by telling them that we're taking out all kinds of protections in the vessel and the fuel, but I do agree that there's got to be an explanation about how all of these initiatives are coherent, are consistent, are achieving some demonstrably simple explanation, that is, an explanation that can be articulated to a Congressman in seven minutes or less. That is sort of the performance standard in terms of how we would be able to develop simple explanations about regulatory analysis for changes that go either way.

I noticed with some chagrin that in the feedback from the Nuclear Safety Research Conference that Mr. Lochbaum has developed a new sound bite that just chilled me, and that is that the one edge of this sword is razor-sharp and the other edge of this sword is Nerf-like. If that is the image of the risk-informed cuts both ways, then we've got a lot to do to work on public confidence.

MEMBER WALLIS: Well, it seems to me, to

go back to what we said a little while ago, that you want to get in the representative public, because eventually that is really where the decision should be made, not made by Mr. Lochbaum and not made by some self-interested utilities.

ACTING CHAIRMAN KRESS: Yes, but I don't know how you do that.

MR. GRIMES: It's been a real challenge to try to get a representative cross-section of the public involved in rulemaking activities. Despite his creative use of the English language, Dave Lochbaum is still one of the best bellwethers that we have in terms of public reaction to regulatory initiatives.

ACTING CHAIRMAN KRESS: He is worth listening to from that standpoint.

MR. GRIMES: Yes, and I take that comment about the two-edged sword as a measure of how the public views risk-informed initiatives.

MR. ROSENTHAL: Okay, we will have the benefit analysis. We will have the cost analysis. We will introduce the policy decisions and ask for your guidance. We will say that we don't intend to go into the details of the MELCOR or the hydrogen DDT. We will have staff there prepared to answer questions.

ACTING CHAIRMAN KRESS: Yes, that's right.

I thought your little discussion on just looking at the face value of Mark IIIs with respect to ice condensers was a good perspective to give here.

MR. ROSENTHAL: I'll beef that up.

ACTING CHAIRMAN KRESS: Yes.

MEMBER WALLIS: I think you should have the bottom line for the MELCOR study, the final page.

ACTING CHAIRMAN KRESS: Yes, I think get to the bottom page.

MEMBER WALLIS: But you don't need to look into the noding and all the curves and all the wiggles and squiggles and graphs and all that. Keep that in reserve.

MR. ROSENTHAL: There is one graph in there that says, if you don't have it, you blow it apart, while if you have the igniters with or without the fans --

MEMBER WALLIS: That's a useful one. That's a good one.

ACTING CHAIRMAN KRESS: That would be a good one to have.

So I guess it will be an interesting discussion. We will have Dana and Bill Shack, and George will be here. That will be interesting. George is not going to be here? Oh, darn. It will be interesting, I think.

MR. ROSENTHAL: Thank you.

ACTING CHAIRMAN KRESS: We appreciate this very nice discussion, very nice presentations.

So I will now adjourn this meeting.

(Whereupon, the foregoing matter was concluded at 5:19 p.m.)

## CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards Thermal-Hydraulic Phenomena & Reliability and Probabilistic Risk Assessment Joint Subcommittees Meeting

Docket Number: N/A

Location: Rockville, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

/s/ Rebecca Davis

Rebecca Davis
Official Reporter
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