Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Advisory Committee on Reactor Safeguards 541st Meeting
Docket Number:	(not applicable)
Location:	Rockville, Maryland
Date:	Thursday, April 5, 2007
Work Order No.:	NRC-1514
	Pages 1-297

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

541st MEETING

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THURSDAY,

APRIL 5, 2007

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

MEMBERS PRESENT:

WILLIAM A. SHACK	Chairman
GRAHAM B. WALLIS	Vice Chairman
SAID ABDEL-KHALIK	ACRS Member
GEORGE E. APOSTOLAKIS	ACRS Member
J. SAM ARMIJO	ACRS Member
MARIO V. BONACA	ACRS Member
MICHAEL CORRADINI	ACRS Member
THOMAS S. KRESS	ACRS Member
OTTO L. MAYNARD	ACRS Member
DANA A. POWERS	ACRS Member

NRC STAFF PRESENT:
JOHN MONNINGER
ERASMIA LOIS
GARETH PERRY
ANTHONY MENDIOLA
PAUL CLIFFORD
RALPH LANDRY
SHI-LIANG WU
HAROLD SCOTT
BOB TJADER
ANDREW HOWE
MARK RUBIN
DONNIE HARRISON

ALSO PRESENT:
JOHN FORESTER
JEFF JULIUS
ROBERT MONTGOMERY
ODELLI OZER
BIFF BRADLEY
SCOTT HEAD
RICK GRANTOM

A G E N D A

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

(8:33 a.m.)

CHAIRMAN SHACK: The meeting will now come to order. This is the first day of the 541st Meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the committee will consider the following; Human Reliability Analysis Models, Proposed Revisions to the Standard Review Plan (SRP) Section 4.2 Reactor Fuels, Risk Management Technical Specification Initiative 4b Flexible Completion Times, Format, Content, and Assignments for ACRS report on the Safety Research Program, Subcommittee report on the Interim Review of the License Renewal Application for the Pilgrim Nuclear Plant, and preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Sam Duraiswamy is the Designed Federal Official for the initial portion of the meeting. We have received no written comments or requests for time to make oral statements from members of the public regarding today's session. A transcript of portions of the meeting is being kept, and it is requested that the speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so they can be readily heard.

Begin with some items in interest. Members are scheduled to interview two candidates during lunchtime today, and I hope you all have the packets and the schedules that give you that information, and where you'll be. It'll be in the subcommittee room, in the caucus room.

If you look under your items of interest, the pink package, you'll see a number of speeches there from the commissioners at the RIC. It's a good way to review some of the high-level presentation there. You may also be interested in looking further into the package. There's an Op-Ed about the ACRS interactions with Oyster Creek, and the interactions with the State of New Jersey on that that could be of interest.

Our first item today is on Human Reliability Analysis Models, and George will be leading that discussion.

DR. APOSTOLAKIS: Thank you, Bill.

We met with the Commission on October 20th of last year, and during the discussion the issue of -- several comments were made on Human Reliability; in particular, that there are several models that this agency has, plus there are models that the industry has developed. And following that, we received Staff Requirements Memorandum on November 28 of 2006, in which the Commission directed the ACRS to work with the staff and external stakeholders to evaluate the different Human Reliability models in an effort to propose either a single model for the agency to use, or guidance on which models should be used in specific circumstances.

Following that, we had a subcommittee meeting, the Subcommittee on Reliability and Probabilistic Risk Assessment. We met with staff and representatives of EPRI and the industry on March 22nd, 2007, and we discussed briefly the models, and some of the assumptions behind these models, and the differences. And the staff also presented to us their plans to organize a benchmark exercise in Halden, Norway. It was a very constructive meeting, in my opinion. We sensed that there is willingness on the part of both the staff and EPRI to work together, which is very good. There are some administrative issues that have to be resolved, and maybe the staff will address those today, so things are looking good.

There may be a plan soon to address the Commission's request, and without any further comments on my part, I will turn it over to Dr. Lois from the staff, or Mr. Monninger. Okay. I understand we have at least one person, and possibly three on the telephone. Right? John Forester, you're there?

MR. FORESTER: Yes, I am. Good morning.

DR. APOSTOLAKIS: Is Jeff Julius there?

MR. JULIUS: Yes, I am. Good morning.

DR. APOSTOLAKIS: Okay. Scientech representing EPRI. Did I say that correctly, Jeff?

MR. JULIUS: That's correct.

DR. APOSTOLAKIS: Okay. And Susan Cooper? She is not. Okay. John.

MR. MONNINGER: Thank you, Professor Apostolakis. My name is John Monninger. I'm the Deputy Director for Probabilistic Risk in Applications from the NRC's Office of Nuclear Regulatory Research. I want to thank you very much for allowing us this opportunity to address the ACRS once again on the NRC's Human Reliability Analysis program. With me, I have Dr. Gareth Perry of the Office of Nuclear Reactor Regulation.

One of the things I think is very important as we undertake this potential new project or effort is these interactions that we do have with the ACRS and external stakeholders. It's very important for us to understand the issues out there, the context behind the issues so that we can undertake any new projects with a full appreciation, and develop an approach forward to address those issues, as opposed to undertaking a project and briefing the ACRS when we're halfway through, whatever. I think these meetings are very beneficial and important to the staff.

Over the past year, we've been down here probably four, five, six different times discussing the NRC's HRA program with the ACRS. We've had discussions on our Good Practices, our beliefs on what some HRA Good Practices are out there, and we issued a NUREG last year or so. We've discussed the various HRA methods out there, and evaluation of those HRA methods against the Good Practices.

Also, we've had some discussions on our international benchmarking project, which you will also hear some more about this morning from Dr. Lois. And, also, we've been down to discuss our project on allowing some type of credit for manual fire actions, and we're also coming back to the ACRS in a month or two to discuss resolution of public comments.

That's pretty much all I wanted to say, but I just want to say, these meetings are extremely important for the staff as we undertake the beginning or the initiation of a new project to make sure that we have a full understanding and appreciation as to where the ACRS interests and concerns are. And we then take them into consideration in development of our project. So with that, I'll turn it over to Dr. Erasmia Lois.

DR. LOIS: Thank you. My name is Erasmia Lois, working for the Probabilistic Risk Assessment Directorate of the Office of Research.

I guess the context of the meeting has been defined by Dr. Apostolakis and John Monninger. And, also, what is the issue, also Dr. Apostolakis described it, and probably I shouldn't spend any time here. What I would like to note is that the NRC's action plan for stabilizing the PRA quality raises, in general, the issue of PRA quality and addressing the uncertainties with the PRA, and HRA is one aspect. And, therefore, the staff started working on the issue addressing uncertainties since six, seven years ago. We continue to -- we haven't addressed all of the issues, but we believe that we've done tremendous progress in addressing and minimizing the uncertainties that are produced as a result of --

DR. WALLIS: Not just the uncertainties.

I mean, HRA contributes to the mean, as well, contributes to the PRA itself.

DR. LOIS: Absolutely.

DR. WALLIS: It's not just the uncertainties. It's an important part of the PRA, and the mean values, or the best estimate values, or whatever you want to call them.

DR. LOIS: And it just depends on how you interpret the word "uncertainties", at least in my mind with regard to that.

DR. WALLIS: Without the uncertainties, it's an important contributor.

DR. APOSTOLAKIS: I think you're saying the same thing. But, Erasmia, I think the issue really is with models that deal with human actions during accidents. For routine actions, I don't think the issue is that great, test and maintenance, and all that. I mean, most people use the Swain and Guttman.

DR. LOIS: And they are happy with it.

DR. APOSTOLAKIS: And they are happy with it, so really, the focus here is there is a LOCA, there is a transient, and operators do things. That's where the models differ. Okay? And this is really a very difficult issue to handle.

DR. LOIS: So what I'm going to do quickly is to summarize some of the efforts that the staff has done so far to address the issue of HRA contribution to risk assessment and reliability of HRA results. I will very quickly provide a very high-level summary of the technical basis of our methods that are primarily used today for regulatory applications. I note that many more methods than those noted here, many of those used to be used in PRAs, but lately, probably the ones that I am noting are the ones that are showing up in regulatory applications.

I will summarize the observations regarding the HRA methods. I will provide the status of these international collaborative efforts to perform an empirical study on HRA methods, and then propose a plan for addressing the SRM. In the meantime, Jeff Julius from Scientech representing EPRI will also have a talk in two instances, one, to summarize the calculator, and another to present a plan that he proposed during the subcommittee meeting, and which we believe it's a good way to go forward.

Quickly, we briefed the committee, the PRA status, especially the ASME PRA status is an effort that addresses PRA quality, in general, and the HRA, in particular. After the ASME status, we developed more detailed guidance, the HRA Good Practices, evaluated the various methods against the practices. We have an effort here to develop data that will help to improve our assessment of human reliability using field data or simulator data in a more objective way. We are going to publish a user guide for the ATHEANA method, which is a method that was developed by the NRC lately, and it hasn't been used as much. But all of these efforts that I'm noting here gave us the opportunity to have significant interactions with the ACRS and other stakeholders.

In particular, we involved domestic and international expertise in human reliability and in human performance. We supported the Halden reactor project that has experience on how to perform simulator experiment to assess human performance. That experience was used primarily from human factors engineering purposes during the last three, four years with our strong interactions through a visit exchange and staff exchange, et cetera. Halden took off and started doing research focusing on human reliability analysis. We believe this is a very important effort, because it gives us the opportunity to interact collaboratively with international entities without actually paying additional money than what we do as part of our regular support of Halden reactor project.

Also, I'm noting that every time that we have international meetings, or even domestic meetings, we take the opportunity to have meetings on HRA and how we could move forward to address the issues that SRM asked us today to do.

DR. APOSTOLAKIS: All right. Let me ask something here. Is the policy an approach of the three phases that the Commission issued some time ago that by the end of December of 2008 or something, the agency is supposed to have standards, or consensus documents for the PRA applications. Does this include human reliability? Is that something we have forgotten? Should we try to develop a consensus document so that the applicants can use this? How is that working now?

MR. PERRY: Okay. This is Gareth Perry from NRR. What the Commission's phased approach for the plan to deal with the Commission's phased approach states is that by December 31st, 2008, the standards for PRAs for various contributors, internal events, external events, fires, low power and shutdown should have been published and endorsed by the staff. And, also, guidance for performing the various applications that are envisaged should also be endorsed.

It doesn't go as far as to say that there should be documents on the how-to aspects of the performance of the PRA, and it doesn't address whether we should have clear guidance on how to do HRA, for example. Although, clearly, there was an element of the phased approach that said that some work should be done in that regard, but it's not as crisp as it is in relation to the standards.

DR. APOSTOLAKIS: But I thought the whole idea was that we would have documents that would advise or guide both the industry and us as to what is expected, or the minimum expectations when it comes to uncertainty analysis, and so on. And that should include HRA. That would make -- in fact, I remember there was a sentence there that if the industry or an application didn't follow these consensus documents, the staff would give it very low priority. I think the ACRS objected. But, anyway, the argument was that you really have to have those, so I don't understand why HRA is not included.

MR. PERRY: No, HRA is not not included. There have to be methods -- the standards are going to allow for flexibility in the choice of methods.

DR. APOSTOLAKIS: Sure.

MR. PERRY: But what all the guidance documents do, is they state that you have to address the uncertainties associated with a choice of specific methods. So what I think you'll find is that in all the guidance documents there will be specific reference to addressing uncertainties. And, typically, HRA is included as one of the things where uncertainties really need to be singled out as a specific item in recognition of the fact that there are a number of different methods that give different --

DR. APOSTOLAKIS: That's not my understanding. I mean, yes, I understand that you have to state the uncertainties, but I thought these documents would go beyond that. Like the standards, for example, the ASME standard, it doesn't tell you exactly how to do it.

MR. PERRY: Right.

DR. APOSTOLAKIS: But it gives you some requirements, you have to --

MR. PERRY: Right. And those requirements --

DR. APOSTOLAKIS: Why shouldn't there be a document on HRA that does a similar thing? That's what I'm saying.

MR. PERRY: Well, the standard has a section on HRA that says what attributes the HRA has to meet to meet the standard. It doesn't say how to meet it.

DR. APOSTOLAKIS: I know, and it doesn't do that in any other area either.

MR. PERRY: Right. Exactly.

DR. APOSTOLAKIS: But isn't the idea of a phased approach that by the end of 2008, there will be a set of documents there that would facilitate the whole approach to risk-informing the regulations, in the sense that if you follow the guidance, the review is facilitated, the whole thing.

MR. PERRY: Right.

DR. APOSTOLAKIS: So there are no plans to develop such a document for HRA. That's really where we are.

MR. PERRY: Well, to the extent that I think the Good Practices document, and the evaluation of the methods against the Good Practices at least give guidance on what the capabilities of the various quantification methods are, and their limitations. I think the Office of Research has actually done a very useful task in that area, because I think that has to be incorporated into the decision making.

DR. APOSTOLAKIS: But as a result of this cooperation that we're talking about, shouldn't there be some NUREG somewhere at some time, answering the SRM and saying for this class of problems, this is a good model. And why shouldn't that be part of the phased approach?

DR. LOIS: So we believe that we are going to revise the methods evaluation document out of this exercise in terms that we're going to have a better understanding of the methods, and, therefore, the limitations and strengths, and, therefore, suitability for addressing --

MR. MONNINGER: I think it's -- we had always intended the Good Practices, the methods evaluation, the benchmarking project, all those to be supportive of the NRC's reviews and industry's efforts to proceed to risk-informed regulation. I think the notion is the explicit timing, what has been committed to in terms of December 2008.

We clearly view these projects as being supportive of that, but whether we explicitly committed to complete the benchmarking project or this project here by 2008, I think that's -- the notion was to get the standards out there, to have the standards endorsed by NRC through the Reg Guides, and then develop additional how-to methods. But those how-to methods, I don't believe are as tied to the December

2008. I mean, even after this, for years and years to come we will continue to pursue additional research and development in the PRA area, so I think --

MR. PERRY: And to be realistic, I think that -- you know how long we've been developing HRA methods. I don't think you're going to have consensus in the next year.

DR. APOSTOLAKIS: We have to reach closure soon. The thinking is that -- I really was under the impression that by the end of 2008, there would be a set of guidance documents out there that would facilitate this process.

MR. PERRY: And I think that's true, but the guidance will be what it will be, and I think it has to -- you have to -- I think what we'll have to do is take into account what we can glean from those documents, and make the decisions, as appropriate. And if it means that we're having to be a little more careful with certain areas, like HRA and perform more sensitivity studies, then that's what we will do to reach the appropriate decision. We need to understand where the weaknesses of the methods are, primarily, and then to come --

DR. APOSTOLAKIS: Well, I was hoping this collaboration would do that.

MR. PERRY: Yes, and I think to some extent the Good Practices document has already done that.

DR. APOSTOLAKIS: No, I disagree with that. Let's go on. The Good Practices does the usual thing. This method has good aspects, this method also has bad aspects.

MR. PERRY: It states what --

DR. APOSTOLAKIS: If I'm a reviewer, I have no idea what to do with that.

MR. PERRY: It states what they are.

DR. APOSTOLAKIS: It states what they are, yes. That's nothing --

DR. LOIS: This summary table of two pages, it's not very readable over here, but you do have a copy of the table. And the purpose of this table is to quickly show that methods were developed over the years for different purposes. I started out with what we call THERP method, which was developed after WASH-1400 and it was the first method, HRA method developed, recognizing the need for a detailed evaluation of human performance in a PRA. THERP proved to be resource intensive, and I guess for the purposes of NUREG-1150, we developed ASEP, which is a high-level, more conservative screening tool.

The industry and EPRI developed at the same time the HCR/ORE method, whose objective was to address some of the limitations that THERP had, provide a more objective way to calculate the human error probabilities on the basis of time availability curves, and at the same time, developed what we call the course-based decision tree method that would supplement the HCR/ORE for those human actions that would need -- would have many long times available to perform those.

SPAR-H was developed, started out from a need to have a high-level, quick HRA tool to perform precursor analysis. And then as the SPAR bundles were developed and becoming more and more detailed, I guess the human reliability aspect was becoming more detailed. And usually today it's been used in the ASEP program, as well as the SDP program. ATHEANA is the method that has been developed lastly, and it's the one that was developed out of the need to address real events, observations that we've seen, such as TMI, et cetera, the need to address our error of commissions, and become more realistic, and the capability to do more realistic analysis for the kinds of human actions that we're bundling in probabilistic risk assessments.

Therefore, these methods have different scope. And what I have here, under attributes doesn't mean that all of these are -- some attributes are good, some are not, as I'm going to go to the next page. But this is a way to demonstrate how different the methods are, do every method provides -- if you look at the very last row here, all methods are quantification tools. That's the bottom line, and that's the common characteristics.

Now, some methods provide guidance on how to identify, to incorporate the human error events in the PRA, helps you to -- provides guidance on how to really explore what's going on, and understanding why people are making mistakes.

DR. WALLIS: Erasmia, could you review for me what the output of all this is? I mean, the purpose of all this is presumably when you have a situation in the control room as they had at TMI at various times, operators do things. Do all of these methods predict what the operators are going to do?

DR. LOIS: Yes.

DR. WALLIS: They do?

DR. LOIS: Yes. That's the purpose.

DR. APOSTOLAKIS: To various degrees, though.

DR. WALLIS: To various degrees.

DR. APOSTOLAKIS: I think SHARP and ATHEANA do a better job searching.

DR. LOIS: It is to various degrees. The scope of these methods is different. Some of those are high-level, some of those are more detailed analysis. Also, they get there through different algorithms, but that's what they are. Mainly, quantification tools, some provide guidance on how to incorporate your HFE with a PRA, or how to search to understand why different -- why people may make --

DR. WALLIS: Well, guidance isn't a formula. I'm surprised. I think they have to be formulae for calculating.

DR. LOIS: Yes, they do. They have --

DR. WALLIS: So guidance is more than just guidance. It's actually a method, it's a methodology. It's not just guidance.

DR. APOSTOLAKIS: I think the SHARP, what Erasmia calls SHARP under the EPRI approach, and the ATHEANA, they do an excellent job looking at the sequences and trying to understand --

DR. WALLIS: They give you a methodology for doing it.

DR. APOSTOLAKIS: The deviation --

DR. WALLIS: It's very, very vague to me.

DR. LOIS: SHARP is like the Good Practices.

DR. APOSTOLAKIS: Well, it's a method for finding --

DR. LOIS: It's a Good Practices --

DR. APOSTOLAKIS: Yes, but these two methods, I think, spend considerable amount of time trying to understand the sequences, and what possible actions the operators might take, which is really the hard part. Then they differ on the quantification.

DR. LOIS: All of these methods have different algorithms, or they have guidance. Yes, it is guidance in a way, because if you look at THERP, THERP guides you to develop to do what it's called task analysis, to find out what it would take to accomplish that, and then gives you generic -- gives you tables where you can go and pick up numbers, and then modify the numbers on the basis of some performance --

DR. WALLIS: If I gave ten students a problem, they'd all come up with the same answer?

DR. APOSTOLAKIS: No.

DR. LOIS: May not. We haven't tested.

DR. APOSTOLAKIS: Yes. That's one of the

things they're going to test.

DR. LOIS: We haven't done enough validation.

DR. APOSTOLAKIS: You remember that table from the ISPRA exercise of 25 years ago.

DR. WALLIS: It didn't work.

DR. APOSTOLAKIS: That was all over the place. Hopefully, this time it won't be like that.

CHAIRMAN SHACK: Well, but there's two sources of -- there's the question if you had a single method and people applied it, you get one set of answers. If you have multiple methods, you get --

DR. APOSTOLAKIS: The same people using different methods get uncertainties, and then the same method used by different people gives also -- it's really a very disturbing result, so hopefully these guys are going to do a better job.

DR. LOIS: I don't know. Shall I --

DR. APOSTOLAKIS: There's one issue here that I would like to raise, because I'm not sure you're addressing it explicitly. From reading the EPRI calculator methods and so on in the ATHEANA, it seems to me that an issue is the following. EPRI in its approach really emphasized the issue of how do we develop a method that can be used at least in routine applications by a lot of people who are not necessarily real experts in HRA? So in that spirit, they tried to develop more specific guidance with curves and so on.

ATHEANA pays more attention, I guess decided on the side of rigor, so everything is done rigorously with experts being guided at the end to evaluate the situation, and come up with the numbers; which, of course, makes it a very expensive exercise, and scares people that they will have to do that for every single human error in the PRA.

It's important to understand that, because there are two different philosophical approaches. ATHEANA is really rigorous, always, in every little -- every human action; whereas, EPRI says look, we are not going to gather experts every time, and most of the time you have engineers doing the PRA. They understand a little bit what it's all about, but they are not expert, and those guys should be able to do a lot of this.

DR. LOIS: Well, first of all, the NRC SPAR-H, for example, has elements of that aspect. ASEP was developed for that purpose, and it's more streamlined.

DR. APOSTOLAKIS: Okay. Fine.

DR. LOIS: However, to the -- EPRI right now is making tremendous amount of efforts to streamline the HRA to make it more consistent, adopted the -- we haven't reviewed the calculator yet, but it seems that they have adopted the Good Practices. They are addressing the limitations of HRA methods --

DR. APOSTOLAKIS: Yes, but a philosophical approach was not changed. They still want to give guidance to the average PRA analyst to do it, and that's what I'm saying.

Now, SPAR-H, by the way, is really an a posteriori approach. Given that something has happened, they go in and do their evaluation, so I wouldn't really put SPAR-H in the same group as ATHEANA and the HCR/ORE.

DR. LOIS: And the issue --

DR. BONACA: That's one point that was made during the meeting, was that by expert, however, I mean, within the plant, the operators are considered the experts that have been --

DR. APOSTOLAKIS: Yes, by and large.

DR. BONACA: That was an interesting point that was made there, because I think within the context of the PRA, the plant, and how it's being maintained, or the decisions that are made, then those experts are available.

DR. LOIS: ATHEANA has not been tested. We believe that may be very cumbersome, but we haven't tested that.

DR. APOSTOLAKIS: My point is --

DR. LOIS: The user's guide may give us the opportunity to test that.

DR. APOSTOLAKIS: Let's not talk about what may happen. The fundamental difference seems to be that EPRI goes out of its way to accommodate the average analyst; whereas, ATHEANA, so far, has not done that. I think that's a true statement. And this is the "weakness" of ATHEANA in the sense that a lot of people are scared when they look at what you have to do, and they just don't do it. That's a fact.

DR. CORRADINI: What do they do instead of that then?

DR. APOSTOLAKIS: They pick another method. Because when you do a PRA, it's a tremendous effort. It's a lot of work. I mean, to hear that you have -- like in NUREG-1150, when they had the severe accident expert elicitation, that's essentially what these guys are doing.

DR. CORRADINI: For every human action?

DR. APOSTOLAKIS: Well, yes. But they

don't fly experts from around the world, they use their operators, primarily. But still, it's quite a lot of work.

DR. BONACA: And they were talking about a limited number of critical actions, too.

DR. APOSTOLAKIS: See, that's the thing, can we eventually reach a point where certain human actions are handled in the EPRI kind of approach? But we have to wait for that, but I thought it was important for the members to appreciate --

DR. WALLIS: So you said ATHEANA was cumbersome and not being tested. Has it ever been used?

DR. LOIS: It has been used, limited use for the --

DR. WALLIS: Been used by licensees to try to -- in their PRA?

DR. LOIS: I don't believe so.

DR. WALLIS: Well, why is it on the list at all, if it's cumbersome, never been used, and never been tested?

DR. LOIS: The NSE used, developed ATHEANA as a method to address the errors of commission and other issues. It has been used for -- it was used for the PTS project. ATHEANA development experience has helped tremendously in identifying the Good Practices, and evaluating the method. So, although ATHEANA hasn't been used in the field tremendously, or as much, it has really tremendously influenced the thinking for HRA today.

DR. APOSTOLAKIS: Graham, I was just told that you can view ATHEANA as the HRA equivalent of TRACE for thermal hydraulics.

DR. WALLIS: That's not true at all. TRACE is tested, and --

(Simultaneous speech.)

DR. LOIS: So, with that, I don't think I should -- shall I explain here? Do you want me to?

DR. APOSTOLAKIS: I don't think it's worth going into the details.

DR. LOIS: No, okay.

DR. APOSTOLAKIS: I mean, the --

DR. WALLIS: I would have liked to have seen sort of a list of evaluation criteria for deciding which of these are any good, not describing what they do, but how do you tell which are any good? Are you going to tell us that?

DR. CORRADINI: I think you should go on, take your time for the people that -- I don't understand. I'm listening carefully, or trying to listen carefully, but I don't understand all this, so I'm going to ask the obvious question for a novice. So is there a standard problem that is done in the eight ways to see eight answers, or one answer, or something? I mean, usually in the world of what we do, there's a standard problem, and you watch the various tools torture themselves trying to get some result. Is there an equivalent here?

DR. LOIS: That's what I'm going to talk about.

DR. CORRADINI: Okay.

DR. APOSTOLAKIS: That's what this --

DR. CORRADINI: Okay.

DR. APOSTOLAKIS: So shall we have Jeff now say a few words?

DR. LOIS: Yes.

DR. APOSTOLAKIS: Jeff?

MR. JULIUS: Good morning.

DR. APOSTOLAKIS: Good morning.

MR. JULIUS: The short answer to that question is no, there's not a standard problem that was done eight ways to see a range of responses.

DR. APOSTOLAKIS: But there may be.

MR. JULIUS: But there have not been, at least recently. I mean, there's qualitative discussions in the development of NUREG-1842 that looked at the basis for the methods, and where does the data come from, but did not sit down and do a problem. The EPRI approach is to use the PRA analyst to the maximum extent possible, and you're right, that there is - the two aspects, as we see it, are the methods give formulas and an approach, but because there's such a wide variation when you make selection in the inputs used for those methods, that to produce human error probabilities that are consistent, so different analysts producing equivalent results, you need some guidelines.

For example, some methods use stress as an input, and you see this in SPAR-H, as well. There's a set of performance shaping factors, but the range of selections in there can vary orders of magnitudes, so when do you say that somebody is under a time pressure, or not under a time pressure? That's where the guidance supplements the methods. It's a hand-in-hand thing.

DR. APOSTOLAKIS: Now we have your Slide 2 on the screen.

MR. JULIUS: Okay.

DR. APOSTOLAKIS: Is that the one you're going to speak to?

MR. JULIUS: Yes.

DR. APOSTOLAKIS: Okay, Jeff, go ahead.

MR. JULIUS: Okay. What I wanted to point out in my slide was that EPRI followed the process developed first in SHARP, and then implemented by ASME, so it covers the various aspects of identification, the screening, the qualitative characterization, that's a definition of what we call performance shaping factors, what's the time available, what's do the procedures say, what are the cues and indications. Then in part of the qualitative there's a feasibility determination, is this action even feasible given the context of the accident scenario? And then the quantification is done using what we call the appropriate method. We have a variety of methods that are in the calculator. We have two main methods for doing the cognitive, does the operator even recognize the situation, do the correct diagnosis and decision making?

DR. APOSTOLAKIS: Excuse me, Jeff.

MR. JULIUS: Sure.

DR. APOSTOLAKIS: Not all members are so familiar with these issues.

MR. JULIUS: Okay.

DR. APOSTOLAKIS: Can you explain a little bit what the calculator is?

MR. JULIUS: Oh, the calculator is a software tool that EPRI has developed for its 70 utility members and six corporate vendor members to support the qualitative evaluation of human failure events, and the quantitative calculation of the human error probabilities for a PRA.

DR. APOSTOLAKIS: Great. Thanks.

MR. JULIUS: So the quantification decomposes the problem into the cognitive and execution, and then gives the possibility of one or two methods for each, and also has included the SPAR method. So, already we have --

DR. WALLIS: So you can pick different methods?

DR. APOSTOLAKIS: Just a moment, Jeff. There's a comment.

MR. JULIUS: Okay.

DR. WALLIS: So you can pick all different methods, and you can come up with a lot of different answers then, depending on which you pick.

MR. JULIUS: That's right. In the very small print on the screen on the upper right, you see the red is one basic event, and there's three or four options below it, so you can see the variation for doing different methods, because there are some cases where the methods are driven by different factors. One may be affected primarily by time, and that overrides some of the other things. Another method, there's plenty of time, and there's other aspects that are driving the quantification. So we allow for the selection of methods, and then we provide a process for doing the documentation and reporting. And then we provide guidelines to supplement this tool, because as has been pointed out, that there's -- the same utility guys, a group of two or three evaluating the same problem can produce a variation in results.

DR. CORRADINI: Can I just have you say that again, please? I'm looking at the fine print, and can I just say it back to you so I get it right?

MR. JULIUS: Sure.

DR. CORRADINI: So let's say, I don't know what any of this is, so let's say FEEDBLEED-1, there are three, I assume, probabilities calculated, 1.3 ten to the minus two, 1.3 ten to the minus three, 5 ten to the minus three under P(Cog) and P(Exec), three other numbers. And then I gather then these guys are added together. That gives you a total human reliability number for the event, so it's like a branch point probability?

MR. JULIUS: That's correct.

DR. CORRADINI: Okay. And then the person, somebody sees that it could be 3.4 ten to the minus two 1, or 1.6 ten to the minus one. They choose something, and then must justify it in a documentation format?

MR. JULIUS: That's correct.

DR. CORRADINI: And then move on to the next branch point, and so the calculator gives them various ways to estimate a branch point probability.

MR. JULIUS: That's right.

DR. CORRADINI: Okay.

MR. JULIUS: That's right, so that we can explore the very differences in the human error probability caused by the differences in methods. And then you see on that the FEED2 item right below the FEEDBLEED1, the blue indicates that that was the method that has been picked as the quantification method that is then exported to the PRA. So out of the different possibilities, that's the one that's actually in the model.

DR. WALLIS: Now if the operator were a computer, then presumably there would not be this great spread of probabilities. If the computer took in the information available to the operator and made the decision, presumably would not be such a great variability, so why have a person there at all?

DR. APOSTOLAKIS: The person has to pick the model. Right?

DR. WALLIS: No, why have an operator there?

I'm trying to think about why do we have people there? We have people there to respond to something which isn't routine. Isn't that why you have people there? And now you're just evaluating how they respond to routine stuff, which a computer could do better, or are you evaluating how they respond to something where you need a person?

MR. JULIUS: Well, that's partly why we have this disparity in the approaches, because some of the actions are modeling the routine response. For example, if an automatic actuation comes in on one channel and it doesn't on the other, the operator is supposed to manually start the train that didn't start automatically to the point where there's a local manual action out in the plant that's really recovery of a failed component where the guidance may be less, or he's going out and doing more of a troubleshooting, so really the range of the things we are quantifying range from something simple and pretty clear-cut, to something that's really challenging from a detection, and diagnosis, and decision making point of view.

DR. CORRADINI: So can I ask Graham's question a little bit differently, just so that -- because you're at least helping me understand. So in my mind, the two asymptotes are, if these becomes regularized based on procedures, the probability of failure approaches zero, and the more it becomes something unique to the operator having to diagnose, the probability approaches like flipping a coin.

DR. APOSTOLAKIS: Not exactly.

DR. CORRADINI: I mean, aren't those the two -- I mean, it would be probability one, necessarily, but it would approach probability one the more unusual it is for the individual to diagnose it. So, obviously, all of these calculators have those two asymptotes, or something like that?

MR. JULIUS: That's right.

DR. APOSTOLAKIS: In general terms, you're right.

DR. WALLIS: I mean asymptote and flipping a coin is a little difficult.

DR. CORRADINI: But I guess what I'm saying, though, as you said, it becomes more and more unusual that they have to diagnose this.

DR. WALLIS: That's when you need the person.

DR. CORRADINI: Right. But it becomes harder, though, to come up with a branch point probability which would essentially be like, it could be this or this.

DR. APOSTOLAKIS: And this is really the issue, what do you do in those situations? If you can say this is they're just following the procedures, I don't think the disagreement big, but when you go to these unique situations where you have identified now things that --

DR. WALLIS: What you can test, though, using simulators tends to be --

DR. APOSTOLAKIS: Well, they will talk about what they plan to do.

DR. WALLIS: -- the procedures one, where you think --

DR. APOSTOLAKIS: They have a plan.

DR. WALLIS: -- the probability should be one, but when you actually do the test with people, you find it's .7.

DR. APOSTOLAKIS: Yes. What will happen in the future, I think Dr. Lois has --

MR. PERRY: This is Gareth Perry, again.

I don't think you're quite right. I think most of these actions are actually procedure-driven actions, and there is a difference in interpretation of these different methods of what factors are that will drive the operators either to perform this on time, or not perform it on time. So I think that this is a real reflection of the differences that the methods give for procedure-driven actions. The diagnosis is really, I think in many ways, a misnomer given the type of procedure we have. It's really a decision making based on the instructions that he has in the procedures, given the perception he has of where the plant is, so it's not really strictly speaking a diagnosis.

DR. APOSTOLAKIS: Because the symptom-oriented procedures go far.

MR. PERRY: Right.

DR. APOSTOLAKIS: Far beyond --

mR. JULIUS: That is correct. I would endorse what Dr. Perry said. I mean, the diagnosis is really a broader term that talks about how the information is given to the operator, and what he's reading in the procedures. We do include the possibility, and this is endorsed by ASME, that some of these may have a weak or no procedural link. But, in general, it's -- and this is where ATHEANA gets into some, what are the different error-producing conditions? Is it the fact that the instrumentation is giving a different view of what's really going on? So some of those elements do overlap with what we have in the calculator, and I didn't put it on this slide, but we do foresee that there are ties between this generalized approach with the qualitative and the quantitative to support ATHEANA, as well.

DR. APOSTOLAKIS: Have you thought at all about putting ATHEANA in the calculator?

MR. JULIUS: Yes, we have.

DR. APOSTOLAKIS: And you decided something, or you're thinking about it?

MR. JULIUS: Well, we've decided that I think the calculator would provide a good tool to develop the baseline HEP, and to identify those types of factors that would be explored with this expert group in terms of the deviations from the space scenario. For example, if the instruments - what's the impact of the faulty or inconsistent instrumentation that may be causing a problem with the decision making? So we think that the calculator provides a good basis for starting an ATHEANA analysis, and doing a lot of the documentation aspects of it.

DR. APOSTOLAKIS: Okay. We are running a little behind, so shall we go back to Dr. Lois?

MR. JULIUS: Yes. Thank you for the opportunity.

DR. APOSTOLAKIS: Okay, Jeff. Thank you very much. You will stay on line?

MR. JULIUS: Yes, I will.

DR. APOSTOLAKIS: Okay. Good.

DR. LOIS: So if we would like to summarize what are the issues about the HRA methods, although they continue to be used, the underlying assumptions are different and haven't been updated, that data on which they were developed have not been updated. So we have a list of factors that we assume that are affecting human performance, and their definitions and interpretation of these factors to agreement on which factors should be -- there are methods we're using, as many as three or five other methods allow the analyst to determine what the factor is, and what is the inputs, to agree on the -- how do you determine and define the level of each factor. And, for example, what is it when we say high work load or high stress, and how to characterize the influence of the factor on the HEP. All of these issues haven't been addressed extensively yet.

And very little benchmarking or validation has been performed to test the methods against actual performance, if you wish, so that we need to understand how important are these differences. It may be at the end, if you have very good analysts, they come up with the same number, or the same conclusions, doesn't matter what the instrument is, the method is. So to understand the importance of the differences, it's also an important aspect for improving the reliability of HRA. And the question is what are we going to do about errors of commission?

For example, ATHEANA is preaching that error of commission may be the most important aspect when you're dealing with more difficult circumstances than circumstances that the operators have the right procedures, and they could just deal with the event in a very easy way. And, therefore, we haven't addressed the issue to what extent we should rate them as part of human reliability analysis.

DR. APOSTOLAKIS: I would add a fourth element. Maybe it's not an observation, but I'll come back to my earlier comment. I think there needs also to be a reconciliation between the two philosophical approaches with one which says let's make this as easy as we can for the average PRA analyst. It's like Einstein said, let's make it as simple as possible, but not simpler. And then identify the human errors where a more detailed rigorous analysis is required.

Another way of putting it, can we screen these, and some of them can be done using computer help, and others will require a more detailed -- I think that's a very important point.

DR. WALLIS: It seems to me if we're just following procedures, and every step if the pressure is bigger than 1000 psi, do A, if it's less, do B. The computer does that much better than a person. The computer can follow through the procedures and tell when you are violating or not violating procedures. That's the kind of decision you're asking for. But if you're asking for using judgment in unusual circumstances, then that's an awfully different one.

DR. APOSTOLAKIS: But that's one of the issues.

DR. WALLIS: That's where you need the people.

DR. APOSTOLAKIS: Right. Right.

DR. ABDEL-KHALIK: But really, I mean listening to this discussion, the question in my mind now is, are there any scenarios identified in the PRA that do not sort of fall within the emergency operating procedures?

DR. APOSTOLAKIS: Very few.

MR. PERRY: And, actually --

DR. APOSTOLAKIS: After TMI, I think --

MR. PERRY: And, actually, in the PRA standards, if the actions that are required are not addressed in the procedures, there's guidance not to take much credit.

DR. ABDEL-KHALIK: I beg your pardon?

MR. PERRY: The guidance in the PRA standard is not to take credit when there are no procedures for performing actions, typically.

DR. ABDEL-KHALIK: Everything we're discussing here pertains to operator actions as the operators follow the guidance provided by the procedures.

DR. BONACA: And, in fact, one issue is will you -- will the procedure be always correct. The more you go beyond your design-basis events --

DR. ABDEL-KHALIK: But the consequences of following the procedures is a separate issue, but whether you actually go, ultimately end up with success or failure. But if that is the case, why haven't we been collecting data from simulator experience to check against these specific operator actions within the procedure?

MR. PERRY: I think you have to be careful about collecting data from simulators, because a lot of that would be from routine training exercises, which would really not be valid. These would have to be unannounced casualties, if you like. You could do that, but still, I don't know that it's being done on a -- it hasn't been done in a comprehensive way. EPRI did it for a certain amount, and I think in most of those cases, you do run across most of the situations where, in fact, the operators do, in fact, succeed. I think in the EPRI experience, there were actually no real failures to perform the significant actions that you would model in the PRA.

DR. ABDEL-KHALIK: You know, a cynic would interpret your argument as saying, you know, all this training on emergency operating procedures is essentially worthless.

MR. PERRY: I hope not.

DR. ABDEL-KHALIK: But that's sort of the interpretation, by saying that I don't trust any data that I would collect from simulator training.

MR. PERRY: No, no, no, no. No. That's not what I was saying. What I was saying is that the data has to be relevant to the actual scenarios that you're modeling in the PRA, which would be that the operators didn't know what was coming.

DR. ABDEL-KHALIK: But, presumably, some training programs do that.

MR. PERRY: They do some of that, sure. Yes.

DR. ABDEL-KHALIK: So are you questioning, then, whether --

MR. PERRY: No, what I'm saying --

DR. ABDEL-KHALIK: -- or not the training programs are comprehensive enough to encompass the scenarios that we're trying to follow?

MR. PERRY: No, I'm not questioning any of that. I'm just pointing out that the data collection in those unannounced scenarios has not been performed in a comprehensive way. And that would be the database that you would need to generate human error probabilities of the type that we want in the PRA models.

DR. ABDEL-KHALIK: Well, if that's what we need, why aren't we starting to do that?

DR. LOIS: HRA has not been benefitted from systematic collection of data for so many years, although we're developing methods for -- I don't know whether they use --

DR. APOSTOLAKIS: I think --

DR. LOIS: For whatever reason, we haven't done that.

DR. APOSTOLAKIS: The issue of relevance of simulator-based data has been discussed forever.

CHAIRMAN SHACK: I mean, there are practical problems, too. I mean, these probabilities are fairly low, so you've got to run a lot of stuff.

DR. APOSTOLAKIS: Right. And with different themes and so on.

CHAIRMAN SHACK: Right.

MR. PERRY: And different procedures, too.

DR. APOSTOLAKIS: One of the challenges that these models have is to identify the factors, what they call performance-shaping factors that affect the performance of the operators in a real setting. So that's a perennial problem. I mean, there is a lot of good information in the simulator exercises, but is it like flipping coins, and then estimating the probability of heads? It's not quite the same thing, so that's where the issues are.

John, you want to say something?

MR. MONNINGER: I guess the only thing, you mentioned procedures, and if you look at, you know, capitalize emergency operating procedures. I mean, you have normal operating procedures, startup, annunciator response, all the way to emergency operating procedures, but then beyond the emergency operating procedures you have something called your severe accident management guidelines. So I just wanted to mention that when you said EOPs, there are beyond the EOPs, there's the severe accident management guidelines, which aren't as proceduralized, but they recognize that a tremendous amount of training, knowledge, and skills are at the site, resources are available, and you have teams of experts. And the severe accident management guidelines try to then, when you're sort of at the end of your EOPs, and if you're in a really bad accident, they try to drive you and lead you to perform some other actions.

DR. APOSTOLAKIS: I think Dr. Lois is planning to address some of these issues in the next slide, so maybe you have a chance --

DR. LOIS: Yes. In fact, now this discussion is a very good intro for what I'm going to talk about.

CHAIRMAN SHACK: It seems to me the first bullet is the only one that's really important. What are you actually going to do to benchmark these methods?

DR. APOSTOLAKIS: Well, let's --

DR. LOIS: Let's talk about it. What we would like to do is to do method-to-data, and method-to-data comparisons. And, as a result, to improve the guidance, as we were talking before, guidance documents, as well as the methods themselves.

DR. APOSTOLAKIS: You are on slide 11 or 12?

DR. LOIS: No, 12. So we have what we call empirical study before we were calling benchmarking study, and this is in conjunction with the Halden simulators, the Halden Reactor project. What we plan to do, and this is a collaborative effort, many countries actually participate in this exercise. It was initiated last August as a result of NRC's decision to go forward and perform an empirical study, and initiated this program, and other countries actually get along with this.

What we are going to do is, we're going to have -- Halden will have operator crews that are running simulator scenarios similar to those modeled in PRA, will collect crew performance data. And HRA analysts use their own method, will analyze the same human actions, so an information package has been sent to the different groups that participate in this exercise that includes all of the information; what is the scenario, what is the human action to be performed, what are the characteristics of the plan, what procedure is used, dah, dah, dah, everything that an HRA analyst would need to have in order to perform this analysis. And the results of these analysis will be reported back in terms of actual predictions. Failure probability, probably percent success.

DR. WALLIS: Now I have a question. I'm sorry, Erasmia, about same actions for the same scenarios. It seems to me that actions taken early in the scenario at different times change the later scenario, so someone who switches on or off a high-pressure injection at the beginning of some window he has, or the end of it, changes what happens later. In something like that the AP1000, whether or not those makeup tanks drain at certain times depends on what someone did earlier, and when he did it.

The whole thermal hydraulic scenario changes as the actions and the timing of them changes. So don't see how you can have the same actions for the same scenarios, because the actions themselves change the scenario.

MR. FORESTER: This is John Forester, Sandia Labs. I'd just like to note that the scenario is actually run on the simulator, and the operators are responding, so certainly what they do affects what happens later, obviously. But in terms of the analyst predicting what's going to happen, they will predict a failure probability, and they'll identify what kind of factors would affect a performance for a particular action. And then if they're looking at later actions in the scenario, then they're going to assume that that action was successful when they're making their predictions. And to the extent there's failures in earlier actions, then their predictions probably won't be relevant later, so it really relates to what actually happens in the scenario in the actual simulator.

DR. APOSTOLAKIS: But are the analysts going to identify various ways that a scenario may evolve? In other words, the SHARP approach or the ATHEANA approach to identify deviations, that is part of the exercise.

MR. FORESTER: No, that's not part of the exercise right now. This is a pilot study, and the scenarios themselves have been defined ahead of time so that the crews can be run through them, obviously.

And then the HRA teams will be predicting what they will be doing, but the ATHEANA team, for example, will not be identifying deviation scenarios at this point. I think we'll plan to do that later on, but at this point, we're basically assessing the quantification of the actions explicitly being addressed in the experiment.

DR. LOIS: But, John, we're talking about the pilot versus the actual study, so we just started the study, we're piloting it to test out the whole method how we would do, but eventually, we hope, if we have the resources and the time, we would test out all the various aspects of the methods.

DR. APOSTOLAKIS: Because if you start looking at the first action of the operators, and then everybody knows that, and analyze it, but then the operators do something that takes a scenario on a different path, then if you don't try to identify the different paths, then you're dead in the water. You can't do it.

DR. LOIS: So within the method, analysts will have the capability given the procedure, the operation, et cetera to say that operators will do okay, and, therefore, the next step will be to do that. Will that do okay? And then the next step may be this.

DR. APOSTOLAKIS: So they will identify deviations at some point.

DR. LOIS: Absolutely. Absolutely, within the constraints of the method.

DR. APOSTOLAKIS: Right.

DR. LOIS: And then, on the other hand, we're going to have the crews, the observations of what the crews did, and to what extent crews really took the scenario in an entirely different point.

DR. APOSTOLAKIS: Another interesting point here, because it has been discussed in the past. At the subcommittee meeting we were told that there will be at least one American crew participating, because in the past the issue was raised, Halden is in Norway. They tended to use Swedes, and Norwegians, and Finns. And now there will be, I believe, two crews from the United States?

DR. LOIS: Actually, it should be more than two. Halden is willing to even come in the United States and run some of these experiments, so there are negotiations. And EPRI is participating in the study; therefore, we hope that we'll have the opportunity to do it. Right now, we are piloting the study, so what happened is at Halden last December, 14 crews of a European plant, Westinghouse, three new plant run steam generator tube scenarios, two - one, which is the one that pretty much predictable through the emergency procedures, et cetera, one more complicated. And the HRA teams are given the scenarios and are analyzing those two scenarios with their methods. And Halden is collecting the observations and documenting those.

And what is going to happen is, we have an independent group of experts that will evaluate the results from the various teams with respect to Halden observations, Halden results. And then we plan to document --

DR. WALLIS: Can I ask you what you mean by "evaluate the results"? They're comparing what all these different people did with what all the models would predict they would have done? Is that what they're doing?

DR. LOIS: Well, for example, if a specific method, a group of analysts will determine that this specific human action has a high probability of failure. And the reason --

DR. WALLIS: So you will be comparing, you'll be saying this action had actually, in practice, an 80 percent probability of -- failed 80 percent of the time in the data.

DR. LOIS: Yes.

DR. WALLIS: And the prediction from various models were so and so, and so on.

DR. LOIS: Yes.

DR. WALLIS: Okay.

DR. APOSTOLAKIS: I suspect, though, that there will be a problem. I think what Gareth said earlier will happen. The crews will not fail.

DR. WALLIS: Never?

DR. APOSTOLAKIS: I doubt it.

DR. WALLIS: So nothing will be established.

DR. APOSTOLAKIS: I doubt it, so the probabilities that the various teams will evaluate will really be used to compare method-to-method.

DR. WALLIS: But if you know no one is going to fail, it's not an experiment.

DR. APOSTOLAKIS: I don't think we're going to get to the point that Said wants, where you have a set of data and calculate probabilities, because these guys are experienced.

DR. WALLIS: But if they never fail, there's no data.

DR. ABDEL-KHALIK: These are not fully

simulator exercises.

DR. LOIS: So the difficult scenario -- John Forester would like to say something here, but we have two scenarios, one which is probably what we call the vanilla scenario, the one that probably --

DR. APOSTOLAKIS: What scenario?

DR. LOIS: We call it vanilla scenario.

DR. APOSTOLAKIS: Vanilla.

DR. LOIS: The one that people may not fail, but Halden has surprised us. The study that I mentioned at the beginning when they set about doing the actual simulator runs for human reliability, although some of the scenarios were very easy, and the assumption is that following the procedures, they will not make a mistake. Some people did make a mistake.

DR. ABDEL-KHALIK: But, you see, that's where I have the most concern. Halden is a completely different animal than a power reactor, anyway. And, therefore, the operator's success or failure in following the procedures prescribed to respond to an event at Halden, it may have very little to do with how the operator would succeed or fail responding to an event in a power reactor on which they have been trained for many years.

DR. APOSTOLAKIS: Why do you say it's a

completely different animal?

DR. ABDEL-KHALIK: Oh, it's a completely different reactor.

DR. MAYNARD: In our subcommittee meeting, several of us raised that concern. The validity of this where you're going to a simulator that you're not familiar with, and it would depend on how it's laid out and structured here. I think it going to be extremely difficult, because you're introducing probably more factors than you can factor into your HRA analysis.

MR. FORESTER: This is John Forester. I'd like to comment on that. The simulator is -- they use the same procedures from the plant. There's a few minor differences, but their operating crews are doing the same basic job they would always do, and it follows very closely what would go on in their plant. Now the interface is different in the sense there is a digital control room in the simulator, but the operating crews are given training on how to use the interfaces, and the different ways to interact with the systems. And experience has been that they do very well with that, and really don't have any problems in terms of how they interact. Their job is still the same, they're still using the same basic procedures, and responding as they would in a real accident. So there are some minor differences, but the sense of it is, is that in terms of the cognitive processes involved, and the decision making processes, and what they end up doing, it's very close to what they would actually experience.

They may actually start a pump in a different way, but it's deciding to start the pump. And as long as they've had some practice in terms of how to do that on a simulator, then the assumption is that cognitively speaking it's a very, very close replication.

DR. APOSTOLAKIS: Mr. Monninger.

MR. MONNINGER: Yes. Erasmia, you can correct me if I'm wrong, but there's a difference between the Halden reactor over there and the actual simulator. It's my understanding that the simulator over there is for a Westinghouse 3-loop plant, which would be similar to a U.S. design. They use standard Westinghouse procedures, so it's not the Halden research reactor simulator, it's a simulator over there, but of a Westinghouse 3-loop design.

DR. MAYNARD: But you're still introducing environmental changes in there. It may be the same overall controls, but if it's digital versus the panels that they've got to work with, when you get into time pressure situations, and even though the decision may be the same, the way you physically do it is different. It introduces more variables there. I'm not sure if that keeps it all balanced.

DR. LOIS: I believe that the Halden experts have addressed these issues, the reliability and validity of the experiment. And my recommendation would be to, since Halden is an integral part of this study, to have Halden briefing the committee on their approach, and addressing these issues. We feel comfortable with the experiment because we know the details of the experiment, but definitely should be addressed.

DR. APOSTOLAKIS: Okay. The concern has been noted. I suggest, though --

DR. WALLIS: Is this the only test you're using?

DR. APOSTOLAKIS: Wait, wait, wait. I suggest that we spend a lot of time on this. You go to slide 16, which is really the proposed approach.

DR. WALLIS: I'd like to go --

DR. APOSTOLAKIS: And then we come back. Yes, sure.

DR. WALLIS: Try to respond to the SRM.

You're going to decide on the basis of this experiment that one method is totally superior and should be used?

DR. LOIS: No.

DR. APOSTOLAKIS: She will address the response to the SRM now in slide 16, and then your question.

DR. WALLIS: I'm just wondering what --

DR. LOIS: So what we're going to do from this experiment is learn about the methods. We're going to have the opportunity to understand how people are using their methods, why they decide certain things, how their underlying assumptions of the methods are influencing the results, so we have this method-to-method comparison opportunity, as well as method-to-data opportunity.

DR. APOSTOLAKIS: Let's talk about -- right. And then we can place everything in this context, because this is really, on 16, this is the heart of the matter.

DR. WALLIS: Are you really going to come up with an unequivocal recommendation for one method?

DR. APOSTOLAKIS: Well, let's see what they plan to do here.

DR. WALLIS: Okay.

DR. APOSTOLAKIS: This is a proposal.

DR. LOIS: Jeff Julius, this is the EPRI proposal during the subcommittee, we will have Jeff Julius talking to it.

DR. APOSTOLAKIS: Okay, Jeff, tell us what you guys are proposing. We are on slide 16. I assume you have the presentation in front of you.

MR. JULIUS: Okay.

DR. APOSTOLAKIS: So this is what the committee will have to address in the letter to the Commission at this meeting.

MR. JULIUS: All right. In the ACRS PRA Subcommittee meeting on March 22nd, I proposed a series of activities that may be included as elements of a plan to address the staff response memo. And these activities were, at that time, not necessarily meant to be all-inclusive, but the gist of these activities was to look at this problem from a different perspective. The past NUREGs and approaches have looked from the bottom up, if you will, to look at what are the methods, what's the basis for the method, what's some of the assumptions or limitations behind the method. And the approach I've outlined is to say now let's go around to the other end and look at the applications where these methods are used, and to see does the selection of the methods of the selection of shaping factors within the method, would that have changed the decision making? And so the plan starts in at the top of the slide with establishing a joint team between the industry and the NRC, so this goes to the point of this should be an activity that's got involvement of the staff, as well as the external stakeholders. Then from that team, we establish common terms and an integrated overall approach.

One of the lessons learned from NUREG-1842, for example, this was the evaluation of methods, was the methods -- different methods were meant to do different things. If one method was meant to lay out the whole process, which I've called the framework, but the whole big picture for doing the HRA, but not specifically prescribe what method. Another one meant to go in, I'm going in to quantify a cognitive error, or a time-limited situation. So once we have a common set of terms and an overall big picture of what the whole process is, then we can understand how the context where these methods are used.

Then the third bullet there is to review the applications, and the role of the HRA in the decision making. Some of these applications I expect there would be, perhaps, insensitive to the HRA, maybe something like an integrated leak rate test extension for the containment, that may be more of a function of where the plant is in the Level 3 PRA, and not necessarily the Level 1 human errors. Some may be dominated by the human reliability, and we've seen that in cases for the significance determination process as part of the reactor oversight, as well as the implementation of Management Directive 8.3.

8.3 is the Management Directive that says when an event happens, or a potential event happens at a plant, that the conditional core damage probability would be evaluated to determine to what extent the staff will respond. Will it be a single guy that goes out to talk about what happened, or will it be an augmented inspection team?

Some of these applications, you might expect, might have had more influence from the HRA, but to really look at the applications and document the insights of the review, and decide to what extent the HRA methods, or the selections within the methods influence the decision. Because if we have these differences, and it isn't going to change the decision, then this -- maybe there's better uses for the money elsewhere.

DR. APOSTOLAKIS: But, Jeff, is the main objective of doing a good job in the PRA without necessarily facing a particular decision, is that buried somewhere here? In other words, I'm doing a PRA, and as was said earlier, I want to make sure that the numbers I produce and the scenarios I produce are meaningful. Wouldn't that be part of this evaluation? I mean, we don't always have to make a decision like a power uprate or something. I mean, we just want to have a good model of the plant.

MR. JULIUS: Yes, you're right. That is an important aspect of it. And I guess that would be buried in here in terms of the -- I mean, any of these applications you do the baseline, and then you do the delta, so the decision would be the delta, but maybe the first step is an evaluation of the baseline.

DR. APOSTOLAKIS: I would add a bullet there saying that the baseline PRA has to be a solid piece of work, and then look at the various decisions that might be --

DR. LOIS: Mr. Perry wants to add something here?

MR. JULIUS: Yes. I think -- I mean, it's all very well to say just having the PRA is an aim in itself, but that's like saying having a saw is an aim in itself. But without a piece of wood to cut, it's really not very useful. So I think you have to -- when you say you want a PRA, you have to say how are you going to use that PRA. And maybe you're using it to get insights on the safety aspects of the plant, and it's those aspects that I think that should be addressed in these applications, not just a PRA for the sake of it. You need it for a purpose, you need it for an assessment of CDF, you need it for an identification of vulnerabilities, you need it for an assessment of the insights. So I think in the context of applications, those are the aspects that I think you need to address.

DR. APOSTOLAKIS: These are too specific. And what I'm saying is yes, I want to understand the CDF. And I don't see that anywhere.

MR. JULIUS: Gareth is right, you develop the saw, is it a band saw, or a crosscutting saw? I mean, the typical application that maybe we've used as the baseline is maybe configuration risk management, because the plants are using that as day-to-day application of the PRA to control maintenance.

DR. APOSTOLAKIS: When they come here and they ask for a license extension, usually there's a question, what is a CDF? Well, I would like to know that this CDF is based on some method. I don't necessarily base my decision on that. That's all I'm saying.

DR. WALLIS: But when a BWR comes up, you've got a little box and it says the probability of the operator making this decision right is .325. Well, where does that come from?

DR. APOSTOLAKIS: Anyway, it was just -- I mean, this is --

DR. WALLIS: But, seriously, it does. I mean, you get all kinds of numbers. You get some numbers which are surprisingly big for false decisions.

DR. APOSTOLAKIS: Okay. Let's go on.

MR. JULIUS: That was the third step then, to review the applications. But then keep in mind, this is -- typically, these evaluations and comparisons have been done, or have been the Level 1 internal events, which was the primary basis for the model up until now. But with the scope and quality initiative, the SECY-04 pushing towards full scope models, then we need to also look ahead to spatial PRAs that are fires and floods, and external events, and shutdown initiators, and perhaps severe accident management types of actions that are part of the Level

2 analysis, or using the PRAs for advanced reactors with digital controls. So I think the other aspect of this discussion is that maybe some of these differences are hard to tell, because it was meant for the internal events and power, and now as we turn to these other uses, we might find that the limitations are even more glaring, or important to the development of the PRA for these other situations. So the plan was then to establish a team, establish a common set of terms and an approach, and then to look at applications, or look at the PRA to be used for configuration risk management even in the application, maybe as a baseline, but then to determine from the application end of it what are the influences of the HRA.

DR. APOSTOLAKIS: Okay.

DR. LOIS: So that was the EPRI proposal, and from our perspective, we believe that this is a good proposal, addresses the SRM needs. If we establish collaborative efforts, we'll be able to achieve better handling of HRA for internal event analysis. Note that all the discussion we've had before on HRA methods is focused more on internal event analysis, and expand and modify the methods for what I call here emerging applications, the need that now we have to address HRA applications for external events, for actions that are performed outside the control room, et cetera. And it will allow us to optimize resources and timeliness. So we're going to evaluate, develop a draft MOU, and find out whether or not we can do it collaboratively, and yet retain the independence as regulatory agencies.

DR. APOSTOLAKIS: But there is a precedent for that, the fire collaboration.

DR. LOIS: Yes.

DR. APOSTOLAKIS: So it can be done. I mean, it's not --

DR. LOIS: We believe it can be done, but we're not in the position to say it will be done right now, because --

DR. APOSTOLAKIS: Who is the ultimate decider?

DR. LOIS: OGC will have a big role.

DR. APOSTOLAKIS: Yes, but if there is precedent, I hope things will move smoothly.

DR. LOIS: Assuming that the MOU will be established, we believe that the review of regulatory applications for importance of HRA is important, and should be done first, establishing common terms, and a framework should also be done. And we believe that it will be achieved through the empirical study, or the empirical study will start and will help a lot towards the achievement of this integrated approach. And collaboration on new needs will help facilitate a timely resolution, which is another important aspect for human reliability.

DR. APOSTOLAKIS: Is the empirical study limited to the Halden analysis, or are you going to include actual operating experience of what people did?

DR. LOIS: That's what the project does. We are also collecting data, LERs, and we hope that we'll use those, as well. You have to realize, or we have to realize that these are not one-year efforts. In order to be able to establish the procedures or the methods for using field data, to understand how these models should be changed and improved, it will take some time.

DR. WALLIS: Could I ask you something here? I mean, you were -- suppose you were trying to propose a single model for the agency. Has the Halden study been designed in order to be able to distinguish the characteristics of these seven models in such a way that you are going to end up with a conclusion that one is superior to all the others?

DR. LOIS: Right now we don't know.

DR. WALLIS: Perhaps, you need a different experiment.

DR. LOIS: We haven't done a pilot. We believe that the Halden data will help us understand the methods, understand how people are using those, and how we can --

DR. WALLIS: But there may be some methods which are not properly tested by these tests.

DR. ARMIJO: Is that your objective, or shouldn't that be your objective, to come up with one, maybe two methods, depending on the situation that the Commission will use?

MR. MONNINGER: I don't believe - this is John Monninger, a priori, that our objective is to say that it should be explicitly one model. I think --

DR. ARMIJO: Well, one, maybe two others, but certainly not seven.

MR. MONNINGER: Well, the objective is to clearly go in and evaluate the models, and say these models are good for these purposes. And if that ends up that a couple of models aren't good for any purposes, so be it, but it may end up that two models are potentially equally acceptable for a given purpose, but good enough.

DR. ABDEL-KHALIK: Whatever program you're going to do at Halden, have you found a volunteer utility that would allow the NRC/the rest of the industry to do exactly the same thing on their simulator, and find out whether you actually get the same results? I mean, allow a totally independent team to just observe. I mean, you have five crews that go through simulator training once every six weeks, you have three or four hot license trainees, you have shift technical - you have a lot of people going through the simulator. And I'm sure you'll find a volunteer utility that would allow an independent observation team to go through and watch what's going on, and essentially collect similar data to whatever you are going to collect at Halden, and see whether -- it just would be a sanity check as to whether or not what you're collecting is really meaningful.

DR. LOIS: This is within our objectives. We would like to have repeated experiments, preferably in U.S. plants, and we hope that the utilities will volunteer to have the experiment. So the actual study we're piloting, we hope it will include experiments where you use different scenarios and different plants, we hope.

DR. APOSTOLAKIS: Jeff, do you think that

EPRI can help with that?

MR. JULIUS: Yes. My knowledge on this one was that the Halden folks have come out and participated for the last two years in our annual EPRI HRA User's Group meeting, and that at least one utility has gone over and volunteered to participate in the experiment there. What I don't know is to what extent they have discussed this idea of taking them back and re-running the experiments on the utility simulator in the United States. That sounds like a good idea, but I don't know if that's been discussed yet or not.

DR. WALLIS: Let me ask you something very specific. How will Halden help you evaluate ATHEANA? ATHEANA assumes that highly trained staff using good guidance just do not make random or inadvertent errors. Now how can you test --

DR. LOIS: So the experiments, we have --

DR. WALLIS: And they also use expert --

DR. LOIS: Including more complicated scenarios, and simpler scenarios, so that's one way to evaluate that.

DR. WALLIS: I think you ought to give us some sort of a matrix which says how the Halden tests will evaluate these various seven methods.

DR. LOIS: Absolutely. We haven't -- we're not briefing you today on the pilot, on the empirical study. It will take a few hours to brief you on how we set up the experiment, what are the measures, how we would interpret the results. And we're here to tell you that we have that study. We'll be more than happy to brief you on another day.

DR. WALLIS: But it seems to me the key test, isn't it, the only test?

DR. LOIS: We hope we are doing - we are designing the study appropriately, and we will be more than happy to brief you on it.

DR. APOSTOLAKIS: I think you should give more emphasis to the actual operating experience. I have found the augmented inspection team reports to be extremely useful when it comes to operator actions and so on. The LERs are not that useful, but any time there is something serious at the plant, they send a special team, and these AIT reports are really great. They go into a lot of detail, and I would give them equal weight.

I get the impression from this, maybe it was not intended, that you are relying on the Halden experiment a lot, or 90 percent. But I would say --

DR. LOIS: This is the first actual

testing of the methods with the same data.

DR. APOSTOLAKIS: I understand that, and I think it's a very important task, but I would also emphasize everywhere I could that the AIT reports, for example, will be a very important input here, because they tell you what happened in real settings. And there may be another interesting result would be to look at what happened, and maybe compare with what you get, if you could, from Halden, and say something, because this issue of the relevance of simulator results is always there. I would give it a little more --

DR. LOIS: Thank you very much for that. Ten years starting from now I'll be --

DR. APOSTOLAKIS: Why do you guys keep bringing up that. I mean, we're talking about the technical content of the results.

DR. LOIS: Definitely, we --

DR. APOSTOLAKIS: We don't get involved in --

dR. ABDEL-KHALIK: I would carry this idea a little further in a sense, if you have a detailed report prepared following a specific incident at a specific facility, why don't you go back and apply these reliability models to that specific incident, and see what would they predict, what they would have predicted?

MR. PERRY: Well, the majority of the methods are really methods for quantification of human error probabilities. One event does not make a human error probability, particularly because you don't know what the denominator is. All you've got is one data point, so you can't really do that. But what you could do with that information is to try and understand the influences that made the errors, and that's where I think you'll get the qualitative information that will support the models.

DR. APOSTOLAKIS: Also, not only the inferences, but also, what they actually did, because both SHARP and ATHEANA worry about these things. And that qualitative information is extremely valuable.

DR. ABDEL-KHALIK: But observing what happens in a simulator to all the crews over a one-year period would give you enough events in the denominator to allow you to estimate reasonable probabilities.

MR. PERRY: Yes, and that's -- well, I don't if it will ever get you the probabilities, but it would certainly give you a lot of information. But you've got to also understand that that's a very expensive undertaking.

CHAIRMAN SHACK: I mean, that data is collected, isn't it? I mean, that would seem, to me, a fairly -- a relatively inexpensive exercise, to essentially record those results, and just put them in a database somewhere.

DR. APOSTOLAKIS: Which results are these?

CHAIRMAN SHACK: The simulator results from all the tests, just build a database of that.

MR. PERRY: It depends whether you -- well, you also need a lot of qualitative information, and that may be the --

CHAIRMAN SHACK: That may be the difficult part.

MR. PERRY: That may be the difficult part.

DR. LOIS: But, indeed, we have what we call the HERA project, which has developed a structure to collect data. And if we collaborate with the industry, it will be much easier to collect that information, and create a database which will allow to test the methods on the basis of this empirical data. So it may be possible, and we will take those recommendations in our planning.

DR. APOSTOLAKIS: I guess the comments you are getting are going to the direction that there is a lot of information out there that should be integrated into this, and not just the Halden exercise.

DR. LOIS: And probably, I have over-emphasized the empirical study since we're having data collection efforts --

DR. APOSTOLAKIS: You're excited.

DR. LOIS: -- for the same purpose.

DR. APOSTOLAKIS: Right. Eighteen, let's make sure we go through this.

DR. LOIS: So we believe that we should - I don't know - prioritization of items, if we go ahead with the collaborative effort. We should -- some activity should be in parallel. EPRI is participating in the empirical study, and review of the regulatory applications with respect to the influence, or the importance of HRA results should be a priority. This will clarify, at least, where we should pay attention up front.

Assuming that the MOU is approved, the review of the applications will be rather short-term activity, establishing common terms and integrated approach. Probably, we may be able to establish a preliminary framework, one that we agree up front earlier, but it seems to be at least about two years effort. And in addressing emerging needs, should we determine from the regulatory and agency needs, for example, there is work, some work planned on HRA work for advanced reactors. At this time it's NRC dependent work. I don't know if it would be possible to do this as a collaborative effort. It all depends on what the MOU will allow us to do. With that, I would like to thank you very much.

DR. APOSTOLAKIS: But you don't have anything about the timing, or the time in which you will actually respond to the SRM. When are we going to have one, or two, or three models appropriate for the application? That's what they are asking. Is that three years, four years? I mean, this is the scheduling of the EPRI proposed tasks.

DR. LOIS: Yes.

DR. APOSTOLAKIS: Now if the Commission asks, we asked you to propose either a single model, or guidance --

DR. LOIS: So then this is the certain - establishing common terms and integrated approach will be in about 10 years.

DR. APOSTOLAKIS: So in about two years, we'll have the answer. Okay.

DR. LOIS: We believe that we'll have the answer.

DR. APOSTOLAKIS: Okay. And you have a slide that's called conclusions. Do you want to address that?

DR. LOIS: Sure.

DR. APOSTOLAKIS: Nineteen, or you have already covered it?

DR. LOIS: I think I have.

DR. APOSTOLAKIS: Okay. So are there any comments or issues that members will want to - or maybe the staff wants to say a few words. John?

MR. MONNINGER: No. I guess just from the start, I think it is very important for us to understand the ACRS' issues and concerns, and we definitely appreciate the guidance and advice that you're providing.

In terms of schedules and resources, we tried to give a rough estimate. Now one of the things, you know, this hasn't always been within our planning horizon. This is essentially a new task, so currently it is not in our budget, so what we have to do is, we have to look at this in terms of, is it high priority, medium, low? What other projects do we have ongoing? What can potentially be shed, slowed down, et cetera, so to a certain extent, we're trying to work the budget, we're working the schedule, we're trying to work the MOU, the approach, et cetera.

I'm not sure what the ACRS will propose back to the Commission, but I wouldn't see that within a four, five, six month time frame the ACRS - well, I don't want to put words in your mouth. It would seem to be extremely difficult to say that going forward there should be one model, or these are the three within the six, seven months that the ACRS was given. I think it would be fair to say that - something along the lines as an approach has been developed, the notion of working collectively with stakeholders, if possible, something along those lines would be appropriate.

I mean, I think the question is whether the conceptual framework laid out will ultimately lead us into a decision to coalesce around a few models or not. I think that's very important as to what --

DR. APOSTOLAKIS: At this stage, I think the most we can say - we'll discuss this this afternoon - we, essentially, comment on the plan. Right? That's the only thing we can comment on. And I realize and appreciate that you have your own problems regarding budget and all that.

Okay. Any other comments, or any suggestions? I think the common terms that Jeff proposes, doing that would be a very important thing to do. Just stating, it seems to me, assumptions without evaluating them, and whether they're reasonable or not, is not really very useful, so I hope that this is what you guys are going to do, this joint team.

And, also, I will repeat - when I reviewed the EPRI documents, and also, we were told here, both by Jeff and Mr. Elawar, who is the utility representative with EPRI, they really tried very hard to develop a method and put in their computer that would help an average PRA guy include human reliability in the PRA. And the price you pay for that is that you are not as rigorous as maybe another method. You proceduralize the process too much.

I think in a lot of cases, this is a good thing to do, because otherwise, you scare people away, if you tell them they have to do expert opinion elicitation all the time. So this is something that I think should really be discussed among the group. And, in other words, it's not just a theoretical needs to be rigorous and so on, you have to address the practical issues, too. Okay?

DR. WALLIS: Practical issues are paramount, George.

DR. APOSTOLAKIS: What?

DR. WALLIS: The practical issues are paramount.

DR. APOSTOLAKIS: Of course, yes. So it really should be something that you should have as part of the deliberations.

DR. ABDEL-KHALIK: Can I just summarize my --

DR. APOSTOLAKIS: Absolutely, Said. I was expecting you to do it.

DR. ABDEL-KHALIK: -- observations. Number one, I think sort of following up on something that Mike brought up, I think it would be a good idea to establish a set of standard problems against which various models could be compared.

Number two, I think it would be a good idea to establish a goal, that by the end of `08, that the agency will publish a NUREG on the application of various human reliability models consistent with the goal of the December `08.

And the third thing, just to make the Halden experiment worthwhile, recommend that one or more volunteer utilities should be sought to essentially duplicate the program at their own simulator facilities, so that the validity of that data can be further checked. Those are my observations.

DR. ARMIJO: Basically, run that same set of problems.

DR. ABDEL-KHALIK: Correct.

DR. MAYNARD: I'd like to add just a couple of comments along Said's. First, I would like to see some stronger goals set for completion. I'm concerned that two, three, four years from now we may be sitting here, especially when you get into collaborative efforts, and a lot of different people involved, and if we keep taking a long time, that you have to question do we really need it, because they've already made a lot of decisions between now and then. So I'd like to see some stronger commitment, stronger goals scheduled. And I would like to see a little bit stronger desire to reduce the number. I don't really get the feeling that everybody is willing to reduce it. And I think that seven models and what we're doing is not manageable. And I think we may be trying to make too scientific a non-scientific action of human performance.

I would really go along -- I think we'd be better off if we establish some criteria that utilities started gathering on their simulators, because they're running simulator scenarios all the time. And I think you'd actually end up with a better database to use numbers to plug in. You actually end up with site-specific PRAs, numbers, human reliability numbers to plug in. So I think from a practical sense, that that would actually give you better data to use in your PRAs.

DR. BONACA: Well, many utilities have already done that in a way. I mean, their PRAs, they've really based a lot of decisions on operator action probabilities coming from PRA observations.

DR. MAYNARD: If they're running simulator scenarios every week, sometimes the crews knows what's coming, most of the time they don't, especially in the distractors and stuff, but there could be a set of criteria put out in what you measure. And maybe there's one scenario a week or something. Over time, with the time that we've invested in these HRA models, if we would have started gathering data, we would have a database right now that would be very large, and probably much more reliable for what number do we use in a PRA.

Those may not help you, particularly from a human reliability, from a design standpoint of how do you reduce human error, but as far as for a number to plug into a PRA, I think it would give you better data.

DR. KRESS: Do you see this as a voluntary program from all the utilities? You can't say go do this, you know.

DR. APOSTOLAKIS: Gareth.

MR. PERRY: Yes. I've got a couple of comments. First of all, on the standard problem, I'm not really sure what you mean by that, because, in fact, in terms of the quantification of human error probabilities, I don't think we have a database to compare with set of standard problems. For example, we don't have a database that will tell us that the probability that operators fail to evidence, operators fail to initiate SLIC during an ATWIS in a boiler, for example. So that's one difficulty; otherwise, what you're doing is you're just getting comparisons of methods for a standard definition of a human failure event.

DR. ABDEL-KHALIK: What is the basis, then, for selecting the research program at Halden? What elements of the program?

MR. PERRY: I'm not sure about that. I'm

not involved with that program, so I'm not going to respond to that. But let me, also, add a couple of other thoughts, which I think might have been missed in here; and that is, that there are two aspects to human reliability analysis. One of them is to identify the right human failure events to put in the model. That aspect of it is not addressed by the quantification models, which is the -- I think, principally, what we've been focused on.

The identification of human failure events is a function of SHARP-1, and it's a function of ATHEANA. It's a very important function. It's also addressed in the ASME standards. These are the things that you need to do to make sure that your logic model correctly reflects the use of the procedures by the operating crews. That aspect has to be done correctly.

The quantification aspect of it, the important thing there, given that you've identified the events, is that the probabilities of the various human failure events is ranked appropriately according to the factors that determine the probabilities.

And in terms of applicability of PRA and the results to decision making, I think what we need to do is to establish whether a method is good enough to provide that ranking, given that the structure of the logic model is correct. Then we can deal with uncertainties and the absolute values of those probabilities by performing sensitivity studies, things like that. So I think you have to put this thing in the context of PRAs, how they're being used, and how they're being developed.

The important task of understanding how the operators interact with the plant as the accidents are developing, I think is probably well-addressed by ATHEANA and SHARP-1. George mentioned that. And what we're really dealing with is differences in the methods of the quantification.

DR. APOSTOLAKIS: But the question then -- I like that description, and I think Said's question - having said all this, this is the objective. How is Halden going to help me address both, or one of them, or parts of one, parts of the other? This is really the idea of designing experiments.

MR. PERRY: Right. And that's a good question.

DR. APOSTOLAKIS: I would go beyond that, come back to my earlier comment. And how are the AIT reports going to help me in the first or second, as you said, most likely the first one, the qualitative part, because you actually see what they did in particular situations. I think that would be -- it would be a nice slide to have a matrix of some sort that identifies the basic elements of the HRA, and how each one of these sources of information will help us. That would be a very nice thing to do in a future presentation.

MR. JULIUS: Yes. This is Jeff Julius. I believe, and Erasmia can correct me if I'm wrong, I mean, that's why the Halden is set into these phases. And the first phase is to look at some data that's already been collected, and decide the usefulness of it. And we do that in the context of making some predictions, so we make some predictions. Then we see how useful it is, and that will influence how we continue on in the subsequent phases.

DR. LOIS: Exactly. I guess, given the breadth of the issues that we have with HRA, we have a very small scope experiment here. Let's see how we quantify human failure events for very well described human failure scenarios. So that will give us the understanding of how well, if different methods can predict failures within this analysis, and also, how the methods are applied. We haven't done that. This will give us the opportunity to understand how different analysts use their methods to come up with human error probabilities, to identify potential performance, certain factors that influence, believe that they influence the performance, et cetera. So this is -- assuming that we'll have some insights on that aspect, which actually that aspect will be the, what I call the pilot ending the real experiment, then we may -- we'll have to expand. And assuming that that's a success, we will have to expand to these other issues, how the ATHEANA concept, or the SHARP concept, identifying potential human failure events given this scenario, what are the potential deviations from the expected scenario, et cetera.

It will be a big experiment, and we'll take very small steps to go forward. That, I agree, should be -- these efforts should be complemented or supplemented by the use of operational experience data, and we are collecting those; and, therefore, we have to in the collaborative efforts include that aspect of it, so that we build it from both --

DR. APOSTOLAKIS: But if you look at the experience with PRA over the last 30 years, the beginning, we really worried a lot about failure rates, and propagating the uncertainty and all that. Slowly, the importance of that decreased, because people realized that the major source of uncertainty is actually predicting the scenarios. If you miss one scenario, you are in deep trouble. And whether the failure rate has a 95th percentile here or there, is more or less irrelevant.

Then, of course, the issue of common cause failures became very important, and so on, and so on. And I suspect here, too, eventually what will dominate is our ability or inability to identify what they will do, rather than quantifying something that we have already identified they will do. So you are approaching it first from the quantification part, where I think that eventually identifying the scenarios will really be the big driver, because they may do something that is completely unexpected, and is not there in the PRA, and so on. But that's where operating experience can give us some advice, the qualitative part. And is there any reason, maybe it's budgetary reason, why we have to focus on quantification first, and then do the other?

DR. LOIS: Actually, we have ongoing --

DR. APOSTOLAKIS: Can do both.

DR. LOIS: Because we have the HERA.

DR. APOSTOLAKIS: The HERA, yes.

DR. LOIS: We're collecting information.

We have this empirical study going on.

DR. APOSTOLAKIS: Yes.

DR. LOIS: We haven't been collaborating with EPRI on these issues. If we do --

DR. APOSTOLAKIS: You could.

DR. LOIS: -- it will help us to expedite --

DR. APOSTOLAKIS: One last comment, because we're running out of time. I really think what Dr. Abdel-Khalik said is important, and others, I sense, feel the same way. Can we have some guidance by the end of `08, even if it's not perfect?

MR. MONNINGER: I guess --

DR. APOSTOLAKIS: You have to think about it.

MR. MONNINGER: Yes. Thank you.

DR. APOSTOLAKIS: Any other comments from the members? Okay. Thank you. Back to you, Mr. Chairman.

CHAIRMAN SHACK: With 30 seconds to go, George. What timing.

DR. APOSTOLAKIS: Don't forget, you started late.

(Laughter.)

CHAIRMAN SHACK: I think it's time for a

break until 10:45.

DR. APOSTOLAKIS: Very good.

(Whereupon, the proceedings went off the record at 10:29:53 a.m., and went back on the record at 10:47:38 a.m.)

CHAIRMAN SHACK: It's time to come back into session. Our next topic is Proposed Revision to Standard Review Plan Section 4.2 on Reactor Fuels, and Sam Armijo is going to be leading us through that.

DR. ARMIJO: Okay. Thank you, Mr. Chairman. Earlier this week, the Materials, Metallurgy and Reactor Fuel Subcommittee met with the staff, and also representatives of the industry to review the plan. This is a major update and revision of the standard review plan, and it has many changes, all developed from experience, and from research. And, in general, my personal opinion, a very good update.

There are parts of it that are some criteria, particularly in the RIA criteria that are interim criteria, and so parts of this Standard Review Plan are for application exclusively to new plants. However, there are nuances, and I've asked the staff to make it clear what parts of the SRP would be applied to existing plants, what parts would be applied to fuel only in new plants. And, also, if they can, what they believe will be the time scale for the application of the RIA criteria to existing power plants. So with that, we're going to have roughly about an hour of presentation by the staff, about half an hour presentation from industry representatives. With that, I'll turn it over to Tony.

MR. MENDIOLA: Good morning, everyone, and please excuse my voice and my breathing pattern. I'll try to make myself clear as much as possible. Anyone who doesn't know me, my name is Anthony Mendiola. I'm the Chief of the Nuclear Performance and Code Review Branch, a position I've only held for about a month. Some of this information is new to me, as well as new to me, of course, as making presentations in front of the ACRS Full Committee, as well as my staff making the first presentation in front of the Full Committee themselves.

The purpose of today's briefing is to provide information to the full committee about revisions to Standard Review Plan Section 4.2, Fuel System Design. This presentation will be two parts. The first part is fundamentally just the actual revisions to the SRP Section 4.2 that have been made, and capturing a variety of data that has been collected over time. And providing staff guidance on the review of new fuel system designs based on information that we receive from industry operating experience over the past several years, fuel research programs, both foreign and domestic, as well as information associated with advanced fuel designs and advanced cladding materials.

That presentation will be conducted by Dr. Shih-Liang Wu, and we'll go through each of the changes that have been effected into SRP Section 4.2.

The second part of the presentation, and the bulk of the presentation will be led by Mr. Paul Clifford, who is going to discuss the reactivity-initiated accident interim criteria. These criteria is what we are going to apply to current ECD applications and COL applications. Specifically, the ones we expect to get in about a six month time period. And it was associated with having those criteria set forth prior to the applications, which we expect to receive later this year.

DR. WALLIS: These apply to new reactors?

MR. MENDIOLA: The interim criteria.

DR. WALLIS: Don't apply to old reactors.

MR. MENDIOLA: Not at this time. No, sir. We do not anticipate applying --

DR. WALLIS: You're developing something that applies to something that doesn't exist, and you're not doing anything about what does exist?

MR. MENDIOLA: The interim criteria are made to apply to the applications we expect. The final criteria, which we're still in development of with fundamentally getting more test data.

DR. WALLIS: So if they're more restrictive than you have on existing plants, one might ask why they're not applied to existing plants.

MR. MENDIOLA: That's the determination the staff has yet to make, is how to apply the final criteria to the operating fleet. And we expect that that will be a majority of the work that we have in front of us with this information with this reactivity-initiated accident criteria.

As I mentioned, our action with the criteria has to do with developing the criteria to support new reactor licensing. We've interfaced with the industry, thus far, with two public workshops, both conducted late last year, and received a variety of comments in preparation for the interim criteria, which we established as part of Appendix B of the SRP, Section 4.2. This provides fuel cladding failure criteria, core coolability criteria, and radiological source term information to apply to the DCD applications and COL applications.

We are currently, as I mentioned, finalizing this criterion guidance, and will make, of course, the revisions to the impacted Reg Guides, and have all this information readily available, as well as an implementation schedule to provide and apply these criteria to the operating fleet, as well.

DR. WALLIS: I'm still puzzled by this new fuel reactor licensing. I mean, the criteria are presumably based on fuels which are used today, or they're anticipating different kinds of fuels?

MR. MENDIOLA: They're anticipating different kinds of fuel, different reference fuels.

DR. WALLIS: That's the real motivation for it, is it?

MR. MENDIOLA: To apply the information we've learned over the years to the new fuels that we expect to get application.

DR. WALLIS: And not to apply to what we've got today.

MR. MENDIOLA: Not at this time, not until we acquire more data.

DR. WALLIS: I'm still trying to figure this out.

DR. ARMIJO: The way I understand it, Graham, is the -- particularly in the RIA issue, the criteria are still interim, but the new plant applications need something to guide them. It's recognized, I think, that there's a lot of conservatism, or maybe more conservatism than the staff ultimately will believe is necessary, so they want to start with a conservative set of criteria so the new plant designers can get to work.

DR. WALLIS: What do you mean by "new plant" then? Is AP1000 a new plant?

MR. MENDIOLA: Yes.

DR. WALLIS: And ESBWR is a new plant.

MR. MENDIOLA: Yes.

DR. WALLIS: Okay.

DR. MAYNARD: It would be anybody who hasn't made an application yet.

MR. MENDIOLA: Correct.

DR. ARMIJO: On the other side, as far as the existing plants, it wouldn't make a lot of sense to apply interim criteria to existing fuel and existing plants that are more conservative than they need to be, so better settle apply the final criteria to the existing plants on a time scale that makes sense. That was the logic --

DR. MAYNARD: You also have different regulatory requirements to impose a new requirement on the existing plants, the existing licensees, a process they have to go through to --

DR. ARMIJO: It's a little more complicated. But, technically, the logic makes --

DR. WALLIS: In a way, it's a roundabout way of signaling to the existing plants that you're going to have new criteria.

DR. ARMIJO: Yes.

MR. MENDIOLA: Absolutely. Yes, sir.

DR. WALLIS: Okay. Thank you.

CHAIRMAN SHACK: Is Watt's Bar, if it's completed a new plant?

(Laughter.)

DR. ARMIJO: I asked the staff to kind of -- you know, there are going to be a lot of nuances to the new SRP, when does the new SRP apply? And that these kind of questions are going to come up, and I asked them to the extent they can, just to clarify that.

DR. KRESS: Well, speaking of reactivity insertion accidents, would you include among those void induced reactivity excursion in a liquid metal-cooled reactor?

MR. CLIFFORD: Well, it is kind of a general term, reactivity-initiated. The BWR has reactivity-initiated from a turbine trip, but it's the pulse width characteristics that separates these type of events.

DR. KRESS: Yes. You would have an entirely different situation with the liquid metal-cooled reactor. It could not meet these criteria, I'm sure.

MR. CLIFFORD: I don't believe that the staff believes that these criteria applies to anything by light water reactors.

DR. KRESS: I appreciate that clarification.

MR. LANDRY: Mr. Chairman, if I may, it's Ralph Landry from the staff. The timing on this is according to the requirements of 10 CFR Part 52. Part 52 requires that a COL application be reviewed under the guidance of the SRP section in effect six months before the COL application is made. Therefore, all the new plants which will be coming under COLs in the fall have to have the SRP sections in place today.

A new old plant, or an old new plant, however you want to term it, like Watt's Bar, would still be a Part 50 plant. It is not coming under a

COL application, and under Part 52. If that comes in, it will be coming in under a Part 50 review, so that is not bound by the requirements of Part 52 and COL.

DR. ARMIJO: Thank you, Ralph.

MR. MENDIOLA: Fundamentally, that concludes my comments. I'd like to turn over the presentation to Dr. Wu to go through the changes to the SRP Section 4.2.

DR. WU: My name is Shih-Liang Wu. I will present the majority of the Section 4.2, except Appendix B, which is going to be presented by Paul Clifford.

Let me just comment that besides in a new reactor and an old reactor, that's when we're going to apply those. I mean, one of our concern is whether the Section 4.2, the new version of it March, year 2007, is going to apply to where they're going to apply a new field design. I think the impression is we are going to apply to new fuel designs, but not existing fuel designs. For example, if you have like the G has -- I think right now currently the Gs, 14 or 15. They have Gs 17, then we apply this new criteria of Section 4.2 to their field design, except Appendix B, which they make a different schedule.

DR. WALLIS: It's interesting, I haven't

seen this yet, but the data on which you base this is presumably based on the existing fuels.

DR. WU: Yes.

DR. WALLIS: You're going to apply it to something else.

DR. WU: Yes. According to our experience, I mean, the lessons learned, the industry and those in the international theater, so research.

CHAIRMAN SHACK: We have a lot of material to get through. Maybe we could get through this part, and then move fast.

DR. WU: Okay.

DR. WALLIS: Get to the technical stuff.

CHAIRMAN SHACK: Right.

DR. WU: I'll go to the next slide. Well, the structure we have run as a design basis, we have fuel systems damage, and a fuel rod failure, and a fuel coolability, three categories. And then start on fuel system damage. Now those are light blue color, that means we made a significant change, and those - dark colors means that we didn't make any -- either we did not make any change, or a change was very insignificant. So let me go to the next one.

The first one is the oxidation hydriding, and crud. In the past, we specify only that all these effect in the thermal behavior should be considered, so the new criteria is you need to specify the limits in terms of oxidation and hydriding. And then all these limits has to be based on mechanical testing to show adequate strength and ductility. And in most cases, the industry did not distinguish between oxidation and crud, so in essence, we just –- if it was along with oxidation with crud, that is also acceptable for us.

The next slide. The dimensional change is the old rod bow and the old irradiation growth, that was the old story. The new phenomena is recently, I think, we discovered was in the BWR channel box. Now the phenomena is the BWR channel box in the past, they can cause BWR due to differential irradiation growth, and stress relaxation. The new phenomena we found out is a shadow corrosion in the channel box. And shadow corrosion we're causing the channel box to bow forward from control blade, which it causes the control blade insertion, I mean, friction.

DR. BANERJEE: Well, what is shadow corrosion?

DR. WU: In this case, is the -- because in the BWR they got the control blade deeply inserted through the cycle, so when they pull out, it comes up like -- they find that the channel box has a shadow, which is a cruciform of the shadow. And then those are corrosion product, and then got extensive hydride.

MR. CLIFFORD: The BWRs, if they have deep insertions of their cruciforms, which are stainless steel clad, and they reside next to the Zirconium channel box for an extended period of time, there is some belief a galvanic reaction causes corrosion --

DR. CORRADINI: Like a small electrochemical set, big electrochemical set, small potential, big area, sorry. I apologize.

DR. ARMIJO: But the net effect, Said, is that there's more oxidation on one side of the channel than on the other side, and you also have more hydrogen pickup that causes more actual elongation on one side than the other, and you wind up bowing towards -- getting interference with the control blade. We're working on different --

DR. WU: The side with the shadow corrosion where the bolt hold the control blade. So this is what we call in industry lesson learned, and then we incorporate into the recent change to SRP. And that's based on this, so we put this new requirement, and then, also, the fourth item we measure for BWRs we may require testing and surveillance to ensure the control blade has insertibility. But in actuality, the industry already make recommendation here. Next slide.

The next one is the rod internal gas pressure. And then in the past, we always -- don't show no exceed system pressure, the first item. But in the cultural history, actually, we already allow the rod pressure to exceed system pressure, but based on three different criteria. The first one is a no cladding liftoff. That means no cladding moved away from the field. The second one --

DR. WALLIS: I'm sorry. By "system pressure", you mean operating pressure on the --

DR. WU: Yes, the -- right, the reactor coolant system pressure.

DR. WALLIS: What happens when you reduce the pressure? You don't care about that?

DR. WU: No, no. We are talking about this junior operation.

DR. WALLIS: Well, presumably, if there's pressure inside and you relieve the outside pressure, you might get cladding liftoff.

MR. CLIFFORD: That's specifically analyzed as part of the design analysis. It would evaluate both long-term steady state.

DR. WALLIS: Okay, but it doesn't seem to be addressed by the slide.

DR. WU: Yes. I mean, this analysis is not that simple, because all the vendors submitted their methodology report, and then analyze all the different scenarios to make sure that no cladding liftoff. And then the second is no hydride reorientation in a radial direction. And the third is no hydride reorientation in a radial direction, so they have demonstrated that in order to allow them to exceed system pressure.

DR. WALLIS: So there's no cladding liftoff, even when you've depressurized, and you're moving the fuel around for reloading and all that?

MR. CLIFFORD: When you shut down, the temperature drops, and the internal pressure drops significantly.

DR. WALLIS: Okay. So that's what saves you then.

MR. CLIFFORD: Yes. They do analyze a transient where they would have a depressurization over a period of time, and you would depressurize the RCS towards the trip set point.

DR. WALLIS: So there's no cladding liftoff under any circumstances.

MR. CLIFFORD: Correct.

DR. WALLIS: Thank you.

DR. WU: And then my understanding, all the industry has already adopt the second criterion. And the last item in the fuel damage is that control rod reactivity and insertibility. The first one is saying is a B4C material. You don't allow it to have depleted B4C.

The second one is the change in control rod configuration. If you change the shape of the control rod. And then the third one, if you are including new materials, any kind of new absorber.

DR. WALLIS: Third one, fourth one, what are all these things? Are these things you analyzed, or what?

DR. WU: Well, if you change these, it would need to be reviewed by us.

DR. WALLIS: Need to be reviewed.

DR. WU: Yes. For example, the fourth one is industry may allow to existing in a control rod, go to a longer lifetime. But because they may change the neutronic design, or may change the mechanical lifetime for existing control rod. In that case, we need to review that.

DR. MAYNARD: How much is included

mechanical design? I can see a whole range of -- something very simple. Just saying the NRC would have to review any mechanical --

DR. WU: Well, depend on -- I guess -- well, of course, depend on the situation, but let me just mention that, for example, in the case of BWR, they used to have control rod shield sheet, the control blade. And then when the G introduced, they call it maritime control blade, which is, in this case, all stainless steel tube welded, using laser weld. That's not sheet, so this is entirely different mechanical design, because you guarantee, make sure that all those welds the control - the timing rod has to be in tact, so in that case, we would review that.

DR. MAYNARD: Okay. And I can understand the big one. My concern is, I can envision some pretty minor ones that I'm not sure would have to be brought to the NRC.

DR. WU: Oh, yes. Well, in that case, like changing roller blade, you know, the roller blade, the roller -- yes, in that case we don't review that.

DR. MAYNARD: Okay.

DR. WU: That's very minor.

DR. MAYNARD: Or it might be a very quick review. You mean, it's a matter of --

DR. WU: Well, just a general agreement that they give us the information, and within 30 days respond. If they don't respond it just expires automatically.

DR. MAYNARD: I just want to make sure we're not unnecessarily burdening them with reviews for minor things.

DR. WU: No, no. Okay. So the next item, we go to the fuel rod. So in this case, the blue color has only three items. Now the first one, excessive fuel enthalpy is referring to Appendix B, which is going to be presented by Paul later on. And then let me just go to the seventh item, first thing, I would delay until we talk about the next one, coolability, because in there, the fuel rod is bursting, so in this case, I only discuss the items number six, which is pellet-cladding interaction.

So the pellet-cladding interaction, in the past we only talk about the PCI, which is pellet-clad interaction, and causing by stress corrosion cracking. And in the new version, we add on the PCMI, the pellet-cladding mechanical interaction. And this is a strength treatment, the fuel is pushing the cladding, and then causing the --

DR. WALLIS: How about chemical reactions between the pellet and the cladding?

DR. WU: Yes. Chemical is actually is referring to -- as a general term, PCI is referring to the --

DR. WALLIS: Oxidation of the cladding from the pellet. This is a very big area, this pellet-cladding interaction. I don't quite understand the -- you're going to talk about the rod insertion. Isn't that the issue we're talking about?

DR. ARMIJO: That's the biggest issue.

DR. WALLIS: So why are we talking about all these other things?

DR. ARMIJO: Which could be very expensive.

DR. WALLIS: We keep going into these, we could --

DR. ARMIJO: Okay. We should probably quickly on these.

DR. WALLIS: Because they all raise questions.

DR. ARMIJO: These are ones where I think there's no industry --

DR. WALLIS: So we should be quiet about these?

DR. ARMIJO: Probably a good idea.

(Laughter.)

DR. ARMIJO: Just for time, but not because the questions aren't great questions.

DR. WU: That's right.

DR. CORRADINI: Masterfully done.

DR. WU: Okay. And then the PCI, the general in PCI criteria is that we have 1 percent strain limit and a no fuel melting, which is the old story. But then in this case, the 1 percent strain limit when you add on the mechanical testing will show that irradiated cladding remained ductile to sustain 1 percent strain.

Now this is new in terms of that, because in the past, we don't need to treat them with irradiated cladding. Now in this case, referring to irradiated cladding, which is because the high burn-up effects.

DR. CORRADINI: So I'm going to turn to Sam. So there's no industry issue here.

DR. ARMIJO: Well, if you can't make cladding that'll strain 1 percent, then you shouldn't be making fuel. They know how to do that. It just makes it very clear what the --

DR. WU: This was not a the high burn-up

issue, because, you know, high burn-up, and the cladding may not be able to survive the --

DR. CORRADINI: No, I understand that. So just one FYI for me, so this is not new from the standpoint that industry does do sort of -- does mechanical testing of irradiated cladding anyway, now.

MR. CLIFFORD: I can provide -- I have two fuel designs under review right now, and this issue has come up, and they've provided the information to support their strain limit. So this is something we've been doing for years.

DR. CORRADINI: Okay. Thank you.

DR. WALLIS: It's not just irradiated cladding, it's everything that's happened to the fuel, which has affected the cladding. Let's not open that.

DR. CORRADINI: Yes. Right.

MR. WU: Okay. So the last item is the fuel coolability, and then there's three items. The second item, explosion of fuel is referring to Appendix B.

DR. WALLIS: Well, I'm not going to -- do you know what fuel coolability means?

DR. WU: Cool geometry.

DR. WALLIS: I don't know what that means.

DR. WU: Well, in this case, I mean

whatever accident occurs, the fuel rod, the structure cannot be changed.

DR. WALLIS: Aha, so you cool without changing the structure.

DR. WU: That's what we call cool geometry. The spacing cannot be changed, the fuel cannot encounter each other. That's what we mean. This cladding embrittlement, the criterion we didn't change. Here we just mention that we could go to rule making to implement a performance-based acceptance criteria later on.

So the last item is fuel rod ballooning, which is the same as the bursting in previously. And NUREG-0630 is still there, and then they talk about burst strain and flow blockage. We need to consider during LOCA event.

Now the third bullet is referring to non-LOCA event that is when we allow rod pressure to exceed system pressure, there will be a tendency under some other condition, it could have burst, causing the similar effect in a LOCA condition, so whatever we need to consider in a non-LOCA accident condition. If there's no question, that completes my report.

DR. ARMIJO: Okay. Let's get into the RIA issue.

MR. CLIFFORD: I guess I'm the headline.

DR. ARMIJO: Yes.

DR. WALLIS: Are we writing a letter on the RIA thing?

DR. ARMIJO: We're writing a letter on SRP 4.2, which includes --

DR. WALLIS: Are we writing a letter on all those things we just went through so quickly, we couldn't ask any questions?

DR. ARMIJO: But the focus is on this one, since this the only part --

CHAIRMAN SHACK: You could have come to the subcommittee meeting.

DR. ARMIJO: That's true, but that's what we're doing.

DR. WALLIS: Thank you.

MR. CLIFFORD: Okay. My name is Paul Clifford, and I'll be presenting the interim criteria for the reactivity-initiated accidents. First, I'll be addressing why I'm here, why we've issued interim criteria, and then we'll get to the when, when it will be implemented.

First off, the reactivity-initiated accidents is a family of accidents, that's the control rod ejection for PWRs with a control rod, or control blade drop access for the BWRs. The interim criteria are being issued because the staff is aware that the current guidance, the current criteria are flawed. They're non-conservative, and this is based upon research's evaluation of all of the empirical database that's been conducted in the 70s, 80s, and 90s. And that was presented to the staff, or to the committee when RIL0401 was issued, and that was back in March of 2004.

The interim criteria serve two important purposes, and it's important to get this out right away. First, they provide the staff with conservative criteria for which to go forward and license the next generation of reactors. And, secondly, they provide the industry with a target. We understand that due to the restricted nature of the new criteria, it's going to take some time for the industry to develop the methods and the tools necessary of implementing it. And in order to develop a new method, and new models, we need to know what the criteria might look like, so we're providing this as a target for them.

We have this two-staged approach. First off, we have this SRP update, which includes the interim criteria in Appendix 4B, and we will be issuing a RIS, a Regulatory Information Summary in the next month or two where we will try to provide guidance, provide -- we'll communicate what expectations are with respect to implementing the new criteria, the interim criteria, and where we're going with the final criteria. And that's the second half of this approach, and that is to perform a rigorous evaluation of the empirical data that's out there. And, also, to gather forthcoming testing at NSRR, which we're hoping will provide us with some valuable insight, and allow us to fine tune the interim criteria before we publish final. And when we go -- what I mean by "publish" is, there are three Reg Guides that are affected by this, Reg Guide 177, Reg Guide 1.195, and Reg Guide 1.183.

DR. MAYNARD: I'm a little confused. You say there's no safety concern due to conservative methods, yet we're going to come out with more restrictive requirements? Can you help me with that? Why do we need it if the current methods are conservative?

MR. CLIFFORD: We rely right now on an operability assessment that was performed by research, where they essentially said let's draw a line in the sand based upon a more rigorous evaluation of all the data we have to-date. What's the point at which cladding will fail? And they came up with an oxidation dependent curve, and then using more realistic three-dimensional physics codes, I believe they used PARKS, they determined, based upon an evaluation of several operating reactors that you would never achieve the reactivity insertion or the pump jump necessary to even fail the cladding.

In other words, the current methods of 1D, 2D methods are so conservative that they may calculate 280 calories per gram, but if you took that exact same loading pattern and used a three-dimensional tool, you'd be calculating about 50 to 60 calories per gram. So even though they're calculating something that's high, realistically, it's just not there.

DR. CORRADINI: So can you go that one more step, maybe not now, but when you do all this together. You're still -- about what the -- how the criteria is affected by the methodology? Because, I guess, that bothered me, too, but your explanation still leaves me kind of cold.

MR. CLIFFORD: Okay. We have criteria that's very high, that's non-conservatively high, but the methods that are used to judge whether or not you meet those non-conservative criteria are so overly conservative that in the end it washes away. What we want to do is say well, the empirical data doesn't support 280 calories per gram, or whatever the value is. It supports something a lot lower, so we're going to lower the criteria, make it realistic. And in order to meet the realistic criteria, we're going to have to use realistic methods.

DR. WALLIS: What you're saying really is there's no calories per gram until it's calculated by some method.

DR. BONACA: I mean, the reason why the methods have been so conservative through the years was because the limit was high, so nobody spent the money to do three-dimensional neutronic calculation to get the values down. I mean, that was the reason why they just kept operating with the point kinetic and static calculation, no feedback, no nothing, practically. And you got the value which was still below 280 calories per gram for PWRs. And so the industry has been living with that. Now this change will force them to go to more expensive methods, if you bring down the limit.

DR. WALLIS: What you're really saying, the criterion, it cannot be independent of the methodology used to make the calculation. It cannot be.

DR. ARMIJO: Sure it can.

DR. KRESS: It can.

DR. ARMIJO: You can set the criteria based on the actual performance in a test.

DR. WALLIS: That's clearly not so if you -- well, yes, you can do that.

DR. CORRADINI: That's what I think they said they're doing.

DR. WALLIS: What you're allowed to use as a calculation procedure is important, though.

DR. BONACA: Well, as long as you can demonstrate that you have a hyper-conservative calculation procedure, they let you use it.

MR. CLIFFORD: The problem we have in the staff is, an operability assessment is a snapshot in time, someone looks at past operation, past fuel designs, past loading patterns, and says okay, we're okay. But every day that transpires after the operability assessment, somebody could be off making a different fuel design, make a new loading pattern, just treating the fuel differently, such that it may be invalidated. It may invalidate the conclusions of the operability assessment. That's why we feel we need to issue conservative criteria for the next generation of reactors, because we don't know what the next generation reactor cycles are going to look like, or what the fuel designs may be look like, so we don't have an operability assessment for the SBWR.

DR. ARMIJO: Okay, Paul, we better move along.

MR. CLIFFORD: Okay. There's two parts of this presentation which need to be separated, and I'll do my best. The first part is the radiological consequences, and this is the evaluation that's done to meet 10 CFR Part 100 dose criteria. And in order to do a proper dose calculation you need to know two things, how many rods fail, and what's the source term within each of the rods that needs to be considered. The second half of the agenda is the core coolability limit.

Fuel cladding failure - the current failure criteria specified in Section 4.2, or the previous Section 4.2, had 170 calories per gram as the DNBR high cladding temperature failure for BWRs, and it also had a DNB, statement about DNB for PWRs. What's wrong with the current criteria in the SRP is that all the empirical database -- the empirical database was based on low burn-up or no burn-up fuel tests.

Also, it was determined that the 170

calories per gram was not always adequate to protect the rod integrity, and that's because the criteria was based on non-PCMI failure modes. Now we realize as you get corrosion and burn-up, PCMI becomes a dominant failure, so we need to develop criteria to address PCMI.

And lastly is that there's always been a presumption that fuel failure occurs if you exceed your critical correlations, which may be overly conservative for such a fast transient.

DR. CORRADINI: But that's the opposite effect that you're just mentioning.

MR. CLIFFORD: Yes.

DR. CORRADINI: Okay.

MR. CLIFFORD: The failure mechanisms experienced during the reactivity-initiated accidents are a high cladding temperature failure, which you could characterize as post DNB cladding, oxidation, and embrittlement, and fuel rod ballooning. Next is pellet cladding mechanical interaction, PCMI. And lastly, if you achieve extremely high fuel enthalpies, you could get multi-fuel expansion, and classic deformation of the cladding, and we will address each of these.

The staff has taken a more rigorous look at the data, worked with research, with RIL0401 and developed separate criteria to address each of the previous mechanisms. The first bullet here is to address the high cladding temperature failure mode, which is 170 calories per gram for any rod with an internal pressure at or below system pressure. That addresses the hot zero power cases where you have post DNB sort of failures. And if you have a rod internal pressure that's higher than system pressure, that criteria has been reduced to 150 calories per gram, and that's to account for the potential for ballooning.

For intermediate and full power conditions, fuel cladding failures is presumed if local heat flux exceeds design limits, so we've maintained this overly conservative approach to the presumption of fuel failure if you exceed DNB.

The next criteria, which is the PCMI failure criteria, we'll get into in the next slide.

DR. WALLIS: Maintaining this first paragraph here? You're maintaining this now?

MR. CLIFFORD: Right.

DR. WALLIS: Well, I thought the next figure shows values less than 170.

MR. CLIFFORD: Yes, I'll get to that. The first bullet is addressing only the high cladding temperature failure mechanism, and the next two slides we will be describing what the failure criteria is for the PCMI.

DR. CORRADINI: Can I say it back to you another way? This dominates at zero burn-up.

MR. CLIFFORD: High cladding temperature failures, which is DNB, rod ballooning, dominating on fresh fuel, because fresh fuel has the ductility because it doesn't have a lot of corrosion.

DR. CORRADINI: So zero burn-up, fresh.

MR. CLIFFORD: Correct.

DR. CORRADINI: Okay.

MR. CLIFFORD: And PCMI becomes dominant once you start to lose ductility due to corrosion.

DR. CORRADINI: And the change from 170 to 150 - I'm sorry. Yes, the differentiation was in the current criteria.

MR. CLIFFORD: Right. The current criteria mentioned 170, and the tests that were done at BIGR showed that the 170 was still valid. However, there were some tests done at BIGR and NSRR that showed that there was failure below 170 if there was rod internal pressure --

DR. CORRADINI: But the 150, I guess

that's what I was wanting to get at. I thought that was new. That is new, then.

MR. CLIFFORD: That is new.

DR. CORRADINI: Okay. Thank you.

MR. CLIFFORD: The PCMI criteria, now this is for PWRs, the staff determined that we were going to develop two separate curves, one for PWRs and one for BWRs. What's presented here is the PWR failure criteria. The blue dotted line is what was presented early in RIL0401, and that was prepared by research. The red line is the proposed interim criteria being developed by NRR. The difference between the two lines fundamentally is that the cold BWR tests on Zirc-2 were removed from the population when we drew the line. There were several cold BWR Zirc-2 data points down at the knee of that --

DR. WALLIS: I guess when you presented to the subcommittee you had some data on this?

MR. CLIFFORD: Oh, absolutely.

DR. WALLIS: And you somehow decided not to present any data today?

DR. CORRADINI: It's in the stuff we were sent, in the Appendices. I know it's there. I saw all the little dots.

MR. CLIFFORD: Right.

CHAIRMAN SHACK: But until you analyze that data, you don't know it disappears.

DR. ARMIJO: There's a lot of data, and I think the EPRI report shows the data that are the basis for this.

CHAIRMAN SHACK: You had another argument, though, at the subcommittee meeting that that's almost like your solubility limit for the hydrogen out to where you put that first break.

MR. CLIFFORD: Correct.

CHAIRMAN SHACK: And that seemed to me a good argument.

MR. CLIFFORD: Right. Right. For the PWRs, hot zero power up through operating temperatures. The knee in this corresponds to about 23 microns of oxide, which is approximately 100 ppm of hydrogen, and that's roughly the solubility limit of hydrogen at operating temperatures. And what you see is we haven't experienced any PCMI failures below this point here. There were PCMI failures here. Those were the BWR tests conducted at room temperature, and I'll address those in the next criteria.

The green dotted line here is a -- well, these two lines here, the RIL0401, and the interim criteria are both truly empirically based. There is some minor scaling of the empirical data, but it is really just an evaluation, a line drawn in the sand based upon the test results. The green line is something that was provided by EPRI based upon their FALCON mechanistic evaluation, which they use the models in FALCON, and which are tuned to separate effects of database. And all I'm trying to show here is, here are two entirely different methods coming up with the failure criteria that are not that different.

DR. CORRADINI: And the procession from oxide wall thickness of essentially zero to .2 of the wall thickness is just simply a function of burn-up.

MR. CLIFFORD: Well, more specifically a cladding type. Cladding type would -- the alloy, whether it's a modern alloy like optimized ZIRLO and M5 versus --

DR. CORRADINI: Okay. So that also appears in the database that drew the line.

MR. CLIFFORD: Right.

DR. CORRADINI: Okay. I have another slide.

DR. WALLIS: When you drew these lines, you drew them to envelope the data with failures, and so they're below all the failures.

MR. CLIFFORD: Not below all the failures.

DR. WALLIS: Okay. Then you didn't add some conservatism.

DR. ARMIJO: Show it quickly, Paul.

MR. CLIFFORD: I could pull it up real quick.

DR. ARMIJO: Just show it quickly, Paul, because I think we're going to --

DR. WALLIS: You didn't add some conservatism saying that to be sure we'll make it 10 percent lower or anything like that?

MR. CLIFFORD: This is what you're looking for right now.

DR. WALLIS: It's very sparse data, and you've got two French data you threw out and stuff like that. But it seems to me very bold to draw a line through this like that.

MR. CLIFFORD: Well, that's always a problem you have with empirically based --

DR. WALLIS: Well, you could be very conservative and say because we're uncertain, we're going to draw a line at 50 right across the whole thing.

MR. CLIFFORD: You could.

DR. WALLIS: But why not?

DR. ARMIJO: Well, because you have a lot of success points --

mR. CLIFFORD: We do have two different mechanisms in play here. Over on this side, there's no PCMI, and on this side there is PCMI. Here you have really DNB related failures, and there is both a lot of data to support that 150, and there's still the requirement that the licensees are using DNB to calculate that.

DR. WALLIS: If you want to be really sure you have no fuel failures, you would want to draw a line somewhat lower than that, it seems to me. Wouldn't you, if you want to be really sure?

DR. ARMIJO: Remember those data are test reactor data with no adjustments for a lot of things.

DR. WU: Simple test data in a core condition it's not in a typical reactor condition.

DR. BONACA: I'm just confused about one thing. I thought that the requirements for rod ejection accident for PWRs allow you to have some degree of fuel damage.

MR. CLIFFORD: Absolutely.

DR. BONACA: So you're not really drawing a line here to separate fuel damage from no fuel damage.

MR. CLIFFORD: No, this would be one line that would be used to determine how many pins failed. That would go into dose calculation. You can exceed this line, but then you have to assume that the rod failed.

DR. BONACA: Which is what you have to do today, too. Simply the line is not conservative.

MR. CLIFFORD: Well, today many of the PWRs don't have a line.

DR. BONACA: I think there is a misunderstanding that says that you expect to have below the line there will be no fuel failures. I don't think that's the case.

MR. CLIFFORD: You can be below this line and still have a calculated fuel failure based upon DNB.

DR. BONACA: That's right.

DR. WALLIS: Well, I just think as a member of the public, it's very difficult to understand your rationale. And maybe there is a very good one, but it's very difficult to understand why you draw a red line like that through this point and the other points.

DR. BONACA: I'm trying to understand, in fact, what separates -- what does the red line separate? There are some points below that where you would be DNB failures.

MR. CLIFFORD: Right. They would -- okay. A licensee would use this when they develop a fuel loading pattern. They would run several cases where they move, where they eject several rods. Say it's a PWR, they eject several rods with a given fuel management pattern, and they would have to determine how many rods exceed this line, and that would be included in their dose calculation. They would also have to do a DNBR calculation using the core codes to calculate how many pins were going into DNB, and you have to add those to the population above this line to give the total number of --

DR. BONACA: There's a line there, what --

CHAIRMAN SHACK: It's the PCMI failure line.

MR. CLIFFORD: It's the PCMI failure line.=, which doesn't exist now.

DR. BONACA: Thank you for telling me. I mean, I just missed it totally.

CHAIRMAN SHACK: It's to address this mechanism. He's got other mechanisms.

DR. BONACA: All right. Now, is all the data there to do a PCMI failure data?

MR. CLIFFORD: Correct. All of the points, all of the solid points were failures due to PCMI.

DR. BONACA: Okay.

DR. ARMIJO: Okay. So let's go back to --

DR. WALLIS: What's the probability of failure if I have .06 and I have 100. I've got one point in there which failed. Now what's the probability of failure?

MR. CLIFFORD: The reason we didn't bound these points here is because we expect further testing at NSR. These were conducted at cold conditions, 20 degree Celsius.

DR. WALLIS: After the testing, you might move the line.

MR. CLIFFORD: We expect to move the line.

DR. WALLIS: Oh, okay. Thank you.

DR. ARMIJO: Analytically, EPRI has done that. They'll show you what they expect that the tests would show. So these are untreated data, pretty much raw data.

MR. CLIFFORD: There is a small amount of

DR. ARMIJO: Small amount.

MR. CLIFFORD: It doesn't take into

account a lot of things.

The line drawn here is conservative. We anticipate that when we issue final criteria, we have to take into account the new data that's going to become available, and a more rigorous evaluation of that data, which means we could back and then scale some of these other points. We expect the line to be a little higher, but with interim criteria you don't want to -- if you use something that's going to be overly conservative, or at the same time non-conservative relative to what your final is going to be, you want it to be close but maybe a little too conservative.

MR. SCOTT: Paul, can I make one other -- this is Harold Scott from the research staff who helped draw the line. Think about this, and this is one of our considerations; if you drop that line precipitously at .04, then it would look like there was a cliff or a sudden change. We knew that wasn't true, so we couldn't justify having that line drop precipitously, so to the left of .04 we knew about where it was. To the right of .08, we knew about where it was, so the only thing we could do is draw a straight line between them. We didn't have any basis for making that curved down or curved up, but we couldn't have it be --- Paul, go up there and point to that top black, right there, draw the line precipitously down to the bottom one to go through the points. There would be no explanation for that.

DR. WALLIS: But it's empirical, whether there's explanation or not, it happened.

MR. SCOTT: Well, there's uncertainty, then.

CHAIRMAN SHACK: Yes, but there's also uncertainty about what are the relevance of those tests that we're missing.

DR. ARMIJO: Yes. And there's technical

CHAIRMAN SHACK: All tests are not equal here on this graph.

DR. ARMIJO: Right. Exactly. And you have to make adjustments for pulse width, temperature.

DR. WALLIS: Okay.

DR. BANERJEE: You know, your data on the -- if you show it as oxide to cladding ratio, then it scatters in a different way completely.

MR. CLIFFORD: The reason we chose the ratio was because there was --

DR. BANERJEE: This isn't the ratio. This is just --

DR. WALLIS: This is the ratio.

MR. CLIFFORD: This is a ratio.

DR. BANERJEE: Okay. If you chose burn-up, say.

MR. CLIFFORD: The PCMI phenomena is driven by the ductility of the cladding more than it is the burn-up on the pellet. The reason we tried to normalize this with wall thickness was because there was a large spread in the thickness of the specimens. I believe it went from -- I have it right here. The wall thickness went from 495 microns to 915 microns. So we had to take that into account because a wall thickness is directly proportional to stress.

DR. CORRADINI: So this is kind of in the weeds, and so the Chairman over there is going to tell me I should have been at the meeting, so is the gray circle, the three grays circles we've been messing about with, is that the oxide thickness at the point of failure? Is that the average oxide thickness? You know what I'm asking? What you're really telling me is, it's not a dot, it's like this because the rod actually had a range of thicknesses. That's what I think you just told me.

MR. CLIFFORD: No, that's not what I was saying.

DR. CORRADINI: Oh, I thought you said the oxide thickness on the rod had a range.

CHAIRMAN SHACK: The wall thickness of the cladding is different, different clads.

DR. CORRADINI: Oh.

DR. BANERJEE: So if you just take the oxide thickness --

DR. CORRADINI: So this is the oxide thickness at the point of failure.

MR. CLIFFORD: Point of failure, this was the reported oxide thickness. It doesn't change during the transient.

DR. CORRADINI: No, that I understand.

MR. CLIFFORD: It's the reported oxide thickness --

dR. ABDEL-KHALIK: So all the open circles on this graph have been ruled to be non-PCMI failure.

MR. CLIFFORD: No, they didn't fail.

DR. ABDEL-KHALIK: They did not fail.

DR. ARMIJO: They were subjected to the same stresses, but they didn't fail.

DR. WALLIS: Well, one thing it indicates is that the X axis is not the right way to predict -- to plot the data.

DR. ARMIJO: Let's not change this now.

DR. WALLIS: That's one conclusion you

could reach by this kind of scale or plot.

MR. CLIFFORD: If you look at burn-up, it actually is a lot less behavior. The RIL0401 looked at it from a burn-up perspective, from a lot of different perspectives, and they concluded that corrosion was the best way to present the data, because it is a loss of ductility driven mechanism, which increases with corrosion and hydrogen uptake.

DR. ARMIJO: What the staff would really like to have is the hydrogen concentration, because that's really the embrittling material, but they don't have that data. But in PWR fuel, the oxide thickness is a surrogate for the hydrogen, and that's why they chose that. In the BWR case, they do it directly against hydrogen.

DR. BANERJEE: Looking at your data, though, it's not obvious that oxide to wall thickness ratio is much better than just oxide thickness. I'm just looking at the data right now.

DR. ARMIJO: If all the specimens had the same wall thickness, that would be true.

DR. BANERJEE: No, I'm just looking at the data - this data plotted just against oxide thickness alone. And if you look at Figure 3.0, yes, but there are four figures.

MR. CLIFFORD: Right.

DR. BANERJEE: This one is 3.04, the one that you're showing, basically, the data there. And --

mR. CLIFFORD: Figure 3.0 dash?

DR. BANERJEE: Dash four, and if you look at 3.0-6, it more or less looks the same to me. I mean, it's not any worse or better.

DR. WALLIS: It looks the same, but you draw different line, wouldn't you?

DR. BANERJEE: You'd draw a different line.

DR. WALLIS: You reach a different criterion.

DR. BANERJEE: I mean, the scatter doesn't look any worse or better from what I can see. How did you actually decide? Did you use some regression tools or something to see whether the scatter was less?

DR. ARMIJO: You know, I'm going to have to step in because look, we're at quarter of 12. We've got to finish Paul's presentation, and there's also a presentation by EPRI.

DR. WALLIS: But is he going to make a convincing case or not?

DR. ARMIJO: I think he will.

DR. WALLIS: Well, I just don't see where it is. That's all. And maybe it was at the subcommittee presentation.

DR. ARMIJO: Yes, it was.

DR. WALLIS: Okay.

DR. BANERJEE: Missed the subcommittee meeting.

DR. ARMIJO: This subject if you would have been there been helpful, but I think if you look at this presentation along with the EPRI presentation together, you'll get a better picture.

DR. ABDEL-KHALIK: Now the CABRI data point, the one anomalous data point way low there, that's been just thrown out, judged to be --

mR. CLIFFORD: Right. There were several international conferences on this.

DR. ABDEL-KHALIK: Okay.

(Off the record comments.)

DR. ARMIJO: Let's move on, Paul, or else we'll never --

mR. CLIFFORD: Okay. The next one is the BWR, and I might as well show this slide which has the data points on it. Well, this is important. This is important right now. Here we're issuing the criteria as a function of oxide or oxide to wall ratio, and all that's then interpreted by the industry, would be that they would convert that to a burn-up dependent line, which is more useful when you're doing fuel management. And when you do that, you need to take into account the kinetics of a particular alloy, and maybe even the temperature of your reactor. It could be offering different fuel duties, and what you would end up with, here's two examples of converting that line for an advanced alloy with very low corrosion to an older Zirc-4 corrosion properties. As you can see, the dip in the line changes, so there's certainly an advantage to using a low corrosion advance alloy here because this is not taken to scale.

DR. CORRADINI: So just to say it differently, the PCMI mechanism disappears with an advanced alloy because your corrosion and your oxide thickness build-up puts you back in the region where the damage mechanism is the first mechanism.

MR. CLIFFORD: Absolutely.

DR. CORRADINI: Okay.

MR. CLIFFORD: It just takes longer to get to the point where you clad loses sufficient ductility.

DR. WALLIS: What does this mean in terms of operation? Does it mean that you have to take the fuel out at 30, 35, or something?

DR. ARMIJO: You might have to berate it.

MR. CLIFFORD: If you have Zirc-4, if you had like a high 10 Zirc-4, then you would find yourself with a very low acceptance criteria, which means you wouldn't be expected to fail more rods due to PCMI.

DR. WALLIS: And, therefore, you'd have to not operate.

MR. CLIFFORD: If your dose calculation is unacceptable --

dR. ABDEL-KHALIK: Now this conversion process would be valid if your database included these advanced alloys. Is that true?

MR. CLIFFORD: Each of the vendors would present oxidation models and hydrogen pick-up models which would then be used to convert the corrosion dependent line --

dR. ABDEL-KHALIK: But the line that you drew before, the red line based on the data on which this translation is being made, would be valid if, and only if, it was developed included data that includes advanced alloys.

MR. CLIFFORD: That's a good point. The

database that we're using to draw was made up of -- well, for the PWRs I'll take out the Zirc-2. It had Zirc-4, it had low 10 Zirc-4, MDA, E110, Zirlo-M5. It did include a large spectrum, and the upcoming tests would also be done with advanced clad. I'm pretty sure there's a test with M5 or MDA, so the advanced cladding alloys are represented by that population.

DR. ABDEL-KHALIK: So what would a fuel vendor with a brand new alloy do with this new criterion?

MR. CLIFFORD: That's a very good point. It's something we will need to struggle with. I would expect that if you came with a new alloy, and you have to demonstrate that the oxidation kinetics, you have to know your oxidation kinetics so you can know where to map it, but there's probably still a hurdle to overcome that would probably need to be some demonstration that your PCMI characteristics be a separate effects testing, to show that the strain rates would fail at a similar strain rate as what we've seen in the population. I don't think we would blindly apply this curve to any future alloy.

DR. CORRADINI: So you're -- can I just -- Said is asking the question that I think is crucial, which is, so you get a new fuel, a new alloy, never saw it before. Step one is they'd have to know how its hydrogen pickup and oxidation is behaving. Secondly, that you would probably expect to see out-of-pile tests, and I heard you kind of -- there was a kind of vagueness there. I almost sensed that you might have to look at some in-pile testing.

DR. ABDEL-KHALIK: You definitely have to do that.

DR. ARMIJO: Not necessarily in-pile, but irradiated tests just to make sure you didn't have some other embrittling mechanism, other than hydrogen.

DR. CORRADINI: I understand.

DR. ARMIJO: So that you would maintain ductility, and so that you could use that curve. But that's what fuel manufacturers would do, anyway. They don't want that fuel to fall apart.

MR. CLIFFORD: And that really is a limitation to an empirically based limit. It's valid over the database, and the range of the database extrapolation gets dangerous.

DR. CORRADINI: I think that was his whole point.

DR. ABDEL-KHALIK: Absolutely.

DR. BANERJEE: So what you're really saying is that the oxide thickness for an advanced alloy grows less with burn-up.

MR. CLIFFORD: That's the reason they're introducing --

(Simultaneous speech.)

DR. ARMIJO: That's their driving force.

DR. BANERJEE: All right. So that makes sense. But you would have to know that.

MR. CLIFFORD: We have to know that, and we really have to know the hydrogen pickup factors too. Okay. So this graph shows you how it would be applied to different types of alloys.

The next block, I'll stay with this slide package for now, is BWR. BWR PCMI failure - here's our database. It's consistent with NSR tests. These were all conducted between 20 and 85 degrees Celsius on two conducted above 20, the rest were at 20. The barbell represents the reported range in hydrogen. And as was mentioned earlier, hydrogen is the principal embrittlement mechanism. If we had hydrogen data for all the PCMI, for all the PWR test specimens, we would prefer to go that route also, and report it as a function of hydrogen. We just don't have that data right now, and we'll be looking into trying to get some of that data over the next 18 months before we go final.

Here we had the reported hydrogen content and the failure points in the dark circles, and we drew the line. Once again below this point here. We've seen that we don't experience a lot of failure. And PCMI becomes dominant.

DR. WALLIS: There's no evidence in that ramp there at all. There's no evidence there. You just draw a line.

DR. BANERJEE: You have failures on the left-hand side.

DR. ARMIJO: You've got to connect the points. That's basically --

DR. WALLIS: But there's infinite number of ways to connect two points.

MR. CLIFFORD: Well, we drew the 150 here because it corresponds for a hot zero power PWR. It corresponds to the 170 calories per gram that is the limiting failure for the high clad temperature failure point. In other words, even if you didn't see failures due to PCMI, and there are - we have thick VVER cladding that's very similar to this, where we didn't have any failures, and it was up here. And we didn't want to draw this up, because it makes no sense, because you're always going to be limited here by high clad temperature, so we didn't want to bring this up, even though you may have been able to make that case.

DR. CORRADINI: And the reason it's 150 instead of 170 is?

MR. CLIFFORD: For hot zero power you'd be starting at about 20 calories per gram.

DR. CORRADINI: Okay.

MR. CLIFFORD: I'm sorry. This is a chain. Everything here is a delta, whereas the 170 is an absolute.

DR. CORRADINI: Got it. Thank you.

MR. CLIFFORD: So we drew these lines around these dumbbells, or whatever you want to call them here.

DR. WALLIS: Why did you have a kink in the red line at the dumbbell?

MR. CLIFFORD: Here?

DR. ARMIJO: You've got a couple of successes there. See those.

DR. WALLIS: Yes, why did you have a kink? Why did you change the slope? Why didn't you just keep it going? There's an infinite number of questions here.

CHAIRMAN SHACK: He wants to keep it going down.

DR. WALLIS: Keep going down to zero. You're on the slippery slope, just keep going.

MR. CLIFFORD: We hadn't seen a failure which was dispositioned below 50 calories per gram.

DR. WALLIS: There's no data.

MR. CLIFFORD: Not on this slide, but on the other slides, for the PWR, yes. For the BWRs.

DR. WALLIS: Well, I'm glad this is an interim criteria.

MR. CLIFFORD: That's one of the reasons it's interim.

DR. BANERJEE: Is there going to be more data?

MR. CLIFFORD: There is going to be a handful of more tests that will hopefully allow us to not only add a few data points, but also do a better scaling analysis.

DR. WALLIS: How many data points are you going to add, enough to make a better decision?

MR. CLIFFORD: Well, once again, if you're living with an empirically based limit, as opposed to a mechanistic based limit where you can try to fill in the blanks, but here the strategy was to just draw the empirical base limit, which all you can do is connect the dots the best you can with what you have.

DR. BANERJEE: Are you doing stuff at higher hydrogen content, because really, it's an issue related to that line. Right? Which goes on 150 up. Let's assume you have data which supports that kinked line you've got now, but you haven't got any data above 150 hydrogen content, from what I can see.

MR. CLIFFORD: Off the top of my head, I'm not sure if any of the plant tests, what the hydrogen concentration on the plant tests are.

DR. WALLIS: How high do the plants go today in hydrogen content?

MR. CLIFFORD: Most BWRs only end up with 40 or 50 microns of oxide.

DR. WALLIS: This is PPM, it says.

(Simultaneous speech.)

MR. CLIFFORD: These correspond to a lower hydrogen, but there is variability in measurements.

DR. WALLIS: Are there plants that operate at 200 ppm?

MR. CLIFFORD: We don't believe so.

DR. WALLIS: You don't believe that? I mean, what's true? I don't know what you believe.

MR. CLIFFORD: Industry hasn't come out and said that they can't live with this curve. I'm sure if they had fuel rods out --

DR. WALLIS: You don't know where the existing plants are relative to this curve?

CHAIRMAN SHACK: No. Can they live with Graham's curve, the one that comes straight down?

DR. WALLIS: Well, I want to know where they are today. Do they operate now at 200 on the X-axis, and 50 at the Y-axis?

DR. CORRADINI: That's all he's asking you, where do they operate now?

DR. WALLIS: Operate today.

MR. CLIFFORD: I don't believe they reach 200.

DR. WALLIS: But do they? I don't want to know what you believe, that doesn't --

mR. CLIFFORD: Well, it's important --

DR. WALLIS: Do you know?

MR. CLIFFORD: It's important to realize, too, that by the time a rod reaches this sort of corrosion, its reactivity is so low that it's incapable of producing the power --

DR. WALLIS: That's an important piece of information.

DR. ARMIJO: That's one of the reasons why that line is around the 50, but there's a lot of, unfortunately, proprietary data, maybe it's been shared, on hydrogen content in fuel. And there is a lot of scatter, and I've seen stuff as high as 200.

DR. WALLIS: That's what you should do. You've got to put the -- as the stuff gets older, it gets more hydrogen, but it can't heat up so much.

DR. ARMIJO: Right.

DR. WALLIS: You've got to show that on this figure, it seems to me, so we know where we are relative to what's being done today.

MR. CLIFFORD: Well, this figure will only be used as a point. There would have to be analytical evaluation done for all sorts of fuel at different burn-ups.

DR. WALLIS: No use presenting what's going to be used unless you show what's being done today is related to it. If there are plants now that are way up to the right there, then something has to be done.

MR. CLIFFORD: Right now they have 170 going straight across. That's their failure mode, and they do not have PCMI failure mechanism. They're not analyzing that.

DR. ARMIJO: This is going to require that the analysis be done. That's going to require that the hydrogen data be taken out of their vaults and put on the table.

MR. CLIFFORD: Absolutely.

DR. ARMIJO: And justify that they meet the requirements.

DR. ABDEL-KHALIK: Where would a twice-burned 60,000 megawatt days per ton GE14 fuel bundle fall on this graph in terms of hydrogen?

MR. CLIFFORD: Well, we have a GE representative here.

(Off the record comments.)

MR. MONTGOMERY: Mr. Chairman, may I interject a comment here?

CHAIRMAN SHACK: Yes, Robert. Robert, just give your name.

MR. MONTGOMERY: My name is Robert Montgomery, I with Anatech Corporation, and I'm representing EPRI today.

The industry has taken this curve and applied it to BWR fuel that's in operation today, given, I would say, using better estimate, not the licensed neutronics methods, but better estimate neutronics methods. And there are some data points above the red line here on the plot that Paul is showing, but not very many. And, again, we're talking about a failure line, so these would just be fuel rods that have to be counted in a dose consequence calculation. So it's not a limitation, at this point. It doesn't appear to be a limitation at this point to industry with regards to this line. It will depend somewhat on the methods that are approved to be used, of course.

CHAIRMAN SHACK: That's not addressing the question of what is the hydrogen content, though.

MR. MONTGOMERY: Oh, is that the question we want to ask?

DR. ARMIJO: Yes. Is there a whole lot of data out there at 250, 300 with hydrogen?

DR. ABDEL-KHALIK: If I have a high burn-up, twice-burned assembly in a BWR core, where does it fall here?

CHAIRMAN SHACK: In terms of hydrogen.

DR. ABDEL-KHALIK: Hydrogen content.

MR. MONTGOMERY: My comment applies to beyond 150 ppm, so there are fuels out there beyond 150 ppm, but they're high burn-up, so they would only be in the 50 to 70, maybe 100 calorie per gram zone. I thought that was the question. We're talking about the cloud that's out there.

DR. WALLIS: Is the ppm up to 200 if it's above 150?

MR. MONTGOMERY: Yes. You can see a few rods up at 200, maybe even 250.

DR. WALLIS: 150 or 200.

MR. MONTGOMERY: Or even 250.

DR. WALLIS: 250. So if you're at 250, so it seems to me, you ought to know where to draw the red line when you're up at 250. We don't know where to draw the line when we're up at 250, do we?

MR. MONTGOMERY: Well, we have data, as Paul has shown here, we have data that goes between 150 and about 225.

DR. BANERJEE: What does that mean, that little dumbbell thing? Because in your next figure, which is in the report, the dumbbells disappear.

DR. CORRADINI: They got smarter.

DR. BANERJEE: Yes, this is Figure 3.1-9, if you go to 3.1-10, the dumbbells have vanished now.

DR. WALLIS: Well, have they -- which way have the points gone, to the left or the right?

DR. CORRADINI: To the left. They've gone close to the line, as you'd expect. It's the left-hand --

DR. BANERJEE: What is the difference --

mR. CLIFFORD: We just removed these points from the line when we were comparing it to the

--

DR. BANERJEE: Oh, so you just removed those points?

MR. CLIFFORD: The VVER data.

DR. BANERJEE: You just removed them.

MR. CLIFFORD: We put the points here. We just removed these points here.

DR. BANERJEE: Okay.

MR. CLIFFORD: It would be conservative to use the --

DR. CORRADINI: And you've added the VVR data which you showed, which you mentioned before. Right?

MR. CLIFFORD: Right.

DR. CORRADINI: Okay.

DR. BANERJEE: But there is no evidence of what happens to the right to say what fails and what doesn't fail. Right? There is no unfailed data below that.

MR. CLIFFORD: No, there's not.

MR. MONTGOMERY: There are -- I'm sorry to interrupt, but there are - if I may make another comment. There are technical reasons for why there would be a plateau there, in a way, and that has to do with the mechanical properties of the cladding, the elastic behavior of the cladding.

DR. ARMIJO: Why don't we just table at that point, because we're bogged down on this thing, and you've got to finish your presentation, which was discussed on the committee, but we're running out of time.

DR. WALLIS: We're going to have to decide how to vote, or whatever.

DR. ARMIJO: Yes, I understand, but we still have to finish the presentation.

DR. BANERJEE: We haven't even got to the coolable core geometry.

DR. ARMIJO: I know. Why do we always get these?

MR. CLIFFORD: Once again, this plot here just shows what the current criteria is. This shows more restrictive.

Radiological guidance. The current criterion in guidance with respect to meeting the part -- is 10 CFR Part 100, and the guidance states that you need to be well within the guidance, which corresponds to 25 percent.

Appendix B of Reg Guide 177 and Reg Guides 1.183 and 1.195 stipulate what we call the gap inventory, the amount of fission product that has made to the gap, and is able to be released upon clad failure. And it states 10 percent of the iodines, and 10 percent of the noble gases.

DR. CORRADINI: That's the assumed source term.

MR. CLIFFORD: That is the assumed source term in the Reg Guides. The problem is that there has been fission gas measurements following RAI tests on unfailed specimens, and these measured fission gas concentrations exceed the 10 percent which is stipulated, which means there's another mechanism in play.

DR. WALLIS: But 10 percent is not the right criterion.

MR. CLIFFORD: Ten percent represents only what would diffuse during normal steady state operation out to the gap, to the plenum region. It doesn't take into account any gas that would be released during the transient. So we've identified there's two separate mechanisms. The first one, as I mentioned, was the thermal-driven diffusion of the fission products inventory during time and temperature during normal operation. And, secondly, during the transient, the pellet fragments and there's grain boundary separation which results in an additional mechanism to release fission gas. And the amount of fission gas, I'll go back, is correlatable to the increase in enthalpy of the fuel during the transient.

DR. KRESS: Is there a hidden parameter here that's the burn-up?

MR. CLIFFORD: We looked into the burn-up, and we would have expected to see more burn-up behavior, because you've got to imagine --

DR. KRESS: You would have thought during burn-up it increases --

mR. CLIFFORD: Right.

DR. WALLIS: If there's no burn-up, there's no fission gas release. So you've got one point.

DR. ARMIJO: No, I think Tom's question was in a high burn-up rod we have even more --

DR. WALLIS: Yes, that's what I mean. I mean, it's obviously --

CHAIRMAN SHACK: He's just giving you the limit of no burn-up, no gas.

DR. ARMIJO: Okay.

MR. CLIFFORD: This is a percent of fission gases available. This isn't an absolute percentage, so low burn-up pellet is going to have less fission gas available for release than a high burn-up pellet. It's just the percentage.

DR. WALLIS: So you're proposing a new --

CHAIRMAN SHACK: We've got to move on guys, so let's --

DR. KRESS: Well, let me ask one more question. Is this strictly fission gas, or are yo including some solids in there?

MR. CLIFFORD: This is strictly fission gas.

DR. KRESS: Okay.

MR. CLIFFORD: It's Krypton, Xenons, and Iodines.

DR. KRESS: Yes, but you're not including any solids that might come out.

MR. CLIFFORD: That is correct. So what we're recommending is that the licensees consider both contributions, the steady state fission gas which would be roughly the 10 percent that would be there during normal operation. And then this additional mechanism which is the transient fission gas release.

DR. WALLIS: And that's a percentage.

MR. CLIFFORD: That is percentage.

DR. ARMIJO: We're going to have to zip through this.

MR. CLIFFORD: Okay. The next part is

entirely different. We've been talking about doses, fuel failure, source terms, now we're getting into GDC-28, which is coolability and maintaining reactor vessel integrity.

(Off the record comments.)

MR. CLIFFORD: We're all familiar with the phenomena at play as far as the potential for expelling fuel particles, either molten or non-molten, and the interaction with reactor coolant which result in a steam generation and pressure pulse. And there's also potential for flow blockage and fuel rod ballooning.

The regulations right now are based on GDC-28. The current criteria in Reg Guide 177 provide details on how to meet the overarching requirements of GDC0-28. And right now they state that as long as you maintain a radial average enthalpy less than 280 calories per gram in any node, you'll be okay. And your reactor vessel pressure needs to be less than Service Level C. Service Level C is not in question. We're maintaining that.

The problem with the current criteria is that we've known since 1980 that the 280 calories per gram is non-conservative, and fuel rods at PBF that experience 280 calories per gram, which is acceptance criteria, exhibited a loss of rod type geometry, and did not meet the requirements.

Further, there was a conclusion that had you reported the acceptance criteria in different units, that 230 would have been the more appropriate limit. In other words, there was a misinterpretation of the results from the tests. And, also, the current criteria does not address fuel fragmentation and dispersal, and the current criteria does not address fuel rod ballooning.

DR. BANERJEE: But it was -- MacDonald's experiments didn't show an effective burn-up. Right?

MR. CLIFFORD: MacDonald, yes. Start tree and PBF had mostly low burn-up. I believe there was two or three rods that were up in the mid to high 20s in burn-up. There were a couple of data points.

DR. CORRADINI: I was going to say PBF – I thought the fifth test.

DR. BONACA: All the vendors self-impose themselves some limit, like 250 calories per gram, 230.

MR. CLIFFORD: Not all vendors and all licensees have imposed stricter limits.

DR. ARMIJO: But this will do that.

DR. BANERJEE: So at the moment, I mean,

if you use this, it would be flat 230?

MR. CLIFFORD: Right now it would be 230 going straight across for all burn-up. Correct. Well, I'm sorry, today we have 280, which is --

DR. BANERJEE: Today it would be 280.

MR. CLIFFORD: It's 280. That's what's in the regulations, the Reg Guides. The empirical data as shown, as I mentioned, there has been experimental evidence of loss of rod geometry and molten fuel coolant interaction reported at SPERT PBF, There's also been fuel fragmentation dispersal reported in various RAI test programs. It has also been reported pressure pulses at various RAI test programs.

DR. BANERJEE: Are you going to show us any data, or is that only the subcommittee meeting?

DR. CORRADINI: It's proprietary at the subcommittee only. I think that's what the Chairman is saying.

DR. BANERJEE: But isn't that -- I mean, the data seems to show that some fuel dispersal occurs at fairly low fuel enthalpies.

MR. CLIFFORD: Yes.

DR. BANERJEE: And, furthermore, it depends also a little bit on pulse width, or not?

MR. CLIFFORD: Yes. Absolutely depend on

pulse width. We're not going to define a numerical limit to address fuel dispersal. That is something that the -- we're just going to provide a criteria that the industry will then need to demonstrate that they can meet.

In other words, the first two criteria up here are going to be hard and fast calculated limits, which is something that's quantified. The next two limits, which I'll get to in the next few slides, are more qualitative, where the industry is going to need to present data.

DR. WALLIS: Could you explain what you mean by no loss of coolable geometry due to fuel pellet and cladding fragmentation?

DR. CORRADINI: Graham, I don't think he's going to get there yet.

DR. WALLIS: We're never going to get there?

(Simultaneous speech.)

DR. ARMIJO: Just a matter for the Chairman, I'd like to add. We've got -- if we're going to close at 12:15 --

CHAIRMAN SHACK: We're not going to close it. We're going to run until 12:30, and everybody is going to grab a very fast thing so we can get back to the interviews.

DR. ARMIJO: It wouldn't be fair to --

DR. WALLIS: If you want the committee to make a decision, the committee has to understand what it's deciding about.

DR. ARMIJO: But I think we obviously made an error in not scheduling enough time for this subject. And I'm just asking that maybe take that into account, or we'll go as long as we can. We're in a bind, so we'll just --

DR. BANERJEE: We have a lot of time to prepare our letters this time.

DR. ARMIJO: Maybe we should put more time into these Full Committee reviews on such a big topic, and we just didn't schedule enough time for this thing. That's a problem, and I just apologize for that.

DR. ABDEL-KHALIK: Mr. Chairman, is there any problem with continuing the discussion following the lunch break?

CHAIRMAN SHACK: We're just discussing that. Let's just see how far we can get before we bump the rest of the schedule.

DR. ABDEL-KHALIK: Thank you.

MR. CLIFFORD: Okay. This slide here

shows, to address the first two criteria, which is right now we currently have 280 calories per gram in the Reg Guide. MacDonald determined looking at SPERT, Tree, and PBF that 230 was a more appropriate limit. We concur with MacDonald's conclusion, so we're going to maintain the 230, so at no time can you exceed 230 calories per gram. And that protects the rod geometry.

IN addition, there is a requirement that you can't achieve fuel melt temperatures, and the reason for that is that once you achieve fuel melt, then you have potential of expanding, and breaking, and having molten fuel to coolant interaction. So to avoid molten fuel coolant interaction, we avoid melting temperatures. And here is just two calculations. The calculation of fuel temperatures is very design-specific. The thickness of the pellet, the thickness of the cladding or the moderator, so we're not dictating a specific limit. We're just saying that use approved methods and demonstrate that your fuel temperatures remain below melt. So here's just two examples of a particular fuel design. This is provided by EPRI.

DR. WALLIS: So after 27 years, you're deciding eventually to accept MacDonald's recommendation?

DR. CORRADINI: He's a difficult man to work with. You have to --

(Laughter.)

DR. WALLIS: It's taken a whole new generation of people.

DR. CORRADINI: (Laughing.) I'm sorry. I apologize.

DR. BANERJEE: Is he still around?

DR. CORRADINI: Yes.

DR. ARMIJO: Gentlemen, let's keep going here. The point is here is a no --

DR. CORRADINI: Let's not dump on fuel. Right.

DR. WALLIS: Well, this is very strange. Why now?

MR. CLIFFORD: Well --

CHAIRMAN SHACK: We can do it without a backfit. Okay. Let's move on.

DR. WALLIS: You can do that without a backfit. That's why. Right?

DR. BANERJEE: When you said approved methods for T melt calculations, what did you mean? I mean, there was a huge discussion on what is an accepted method, and an approved method in one of the subcommittee meetings a few months ago. Do you really mean approved method, because that means that everything has to be validated, and all that sort of stuff.

MR. CLIFFORD: Correct.

DR. BANERJEE: Not just an accepted method.

MR. CLIFFORD: It would be approved. It would be submitted, reviewed, and approved.

DR. BANERJEE: And are there codes which actually do that?

MR. CLIFFORD: I believe there are approved suite of codes that do that right now. Of course, some of them are 2D or 1D, so they're very conservative.

DR. BANERJEE: So they could be very conservative.

MR. CLIFFORD: Correct. But when they revise their methodology so that they don't get -- so they could limit their clad failure during PCMI, they're going to be introducing 3D kinetics and when you introduce 3D kinetics, that's also going to help you out here in the fuel temperatures, also affect reactivity.

DR. ARMIJO: Okay.

MR. CLIFFORD: Okay. So the acceptance criteria for one and two essentially would be the lower of these lines. It would be the lower of your fuel temperature calculation, which is strongly dependent on burn-up, and it would be the MacDonald limit up here.

DR. WALLIS: Why would you ever do this when all the other criteria ask for lower fuel enthalpies? Why would you ever worry about this one at all?

MR. CLIFFORD: You can exceed the previous limits, because that defines when clad fails. These are the upper limit that can't be exceeded.

DR. WALLIS: Oh, I see. For any of the fuel.

MR. CLIFFORD: Any fuel, not one fuel.

DR. ARMIJO: See, as long as the doses are okay.

DR. ABDEL-KHALIK: Am I missing something here? Why set it at the blue line, rather than a line depending on the pulse width, which may be 10 or 20 milliseconds?

DR. CORRADINI: But I think, Said, that's the second criteria. It's the lower of the two.

MR. CLIFFORD: The second criteria would

specifically account for the pulse width --

DR. CORRADINI: Pulse width.

MR. CLIFFORD: Because reactor-specific fuel rod design specific, where you would take that into account and calculate --

DR. CORRADINI: The way I read this is the blue line is operative at low burn-up, and depending upon what the ejection is, the green line is operative at high burn-up.

DR. BANERJEE: Maybe, depending on the fuel.

DR. CORRADINI: Yes.

MR. CLIFFORD: Well, fuel temperatures do decrease -- I mean, fuel conductivity decreases with burn-up, you get pellet edge peaking due to Plutonium build-up in a rim formation. And, also, you get extremely high localized burn-up in the rim region, all of which result in out here melting in the rim region or melting in the periphery, and this would occur at a pretty low enthalpy.

Okay. The first two, as I mentioned, were very quantitative. The next two are very qualitative, in the sense that we understand that there's no criteria now to address this phenomenon, and there needs to be an established line in the sand, say, for determining whether or not you get a significant pressure pulse from the interaction of non-molten fuel, small fuel particles which are ejected into the coolant. And it's effect on the integrity of the evaluation of the reactor vessel pressure integrity.

DR. WALLIS: You're telling us this is something you don't understand how to evaluate?

MR. CLIFFORD: All we're doing is telling -- we're providing guidance to the reviewers that say the licensee coming in needs to include an evaluation of the interaction of the fuel and the coolant in determining the pressure pulse, and determining whether or not the reactor vessel --

DR. WALLIS: Is there a technology for doing that?

MR. CLIFFORD: There is a limited database of mechanical interaction, mostly from severe accident space that has been done.

DR. WALLIS: How will you evaluate something if you don't know what the basis for it is?

MR. CLIFFORD: Well, there needs to be a conversion of the energy to fuel to steam, and there is data available, and there's data presented in the EPRI topical report.

DR. KRESS: You first have to know how

much non-molten fuel gets ejected. That you're going to have to measure. There's no other way to do that. Then you can bound it, the energetics of that, if you know how much is ejected, because you don't know how much energy it has, convert it all.

MR. CLIFFORD: Right. And the amount of energy is not just the amount of fuel, it's the size of the particle, and the shape of the particle.

DR. KRESS: That would be a refinement. But then you'd have to know a lot more about the ejected fuel.

MR. CLIFFORD: I'm not dispositioning this. All I'm saying for the staff is, this is something that the applicant needs to address, as opposed to now they just have a blind eye to it.

DR. KRESS: Well, that's tough. You would have to take a piece of fuel at different burn-up levels, eject it to these pulses, and measure how much stuff gets ejected. That's not an easy test to do. And I guess they're saying we have to leave that up to the applicant.

DR. ARMIJO: Figure out a way to avoid that situation, in the design of your plant, the operation of your plant, design of your fuel.

DR. KRESS: Of course, even this goes away if you use 3D kinetics.

DR. ARMIJO: Right. That's the other way.

DR. KRESS: That's the solution to all of this.

MR. CLIFFORD: Also, as was mentioned, there is a very strong burn-up dependence on the amount of fuel that could be dispersed, whether there's a rim region or not, so maybe you could -- if you could show for instance, as an example, that you don't fail any cladding above a burn-up that corresponds to having no rim formation yet, then there would be very low --

DR. WALLIS: Well, this sort of reminds me of the sumps. I mean, you have some guidance which says that sump screens should not clog. But until you know what makes them clog and how to evaluate it, that's sort of a useless statement. Is this one of those things that they've got to evaluate something, but no one knows how to do it?

DR. BANERJEE: Or they can try to design around it, I guess.

MR. CLIFFORD: They can prevent fuel coolant interaction by design, or by analytical tools, or a combination thereof.

DR. CORRADINI: So this is -- I'm still

trying to read into this. This is above, this is if you lie above 1 and 2, or this is even below 1 and 2?

DR. BANERJEE: No, below, below.

DR. WALLIS: Below 1 and 2.

MR. CLIFFORD: This is below. You can't --

DR. BANERJEE: One and two you can't exceed.

DR. WALLIS: Even then, you've got to do something more.

DR. ABDEL-KHALIK: I guess I'm concerned about conceptually, we're moving from one uncomfortable current position to another uncomfortable future position. The current position is uncomfortable because we're saying the methods used are conservative, even though the limits currently imposed are non-conservative, and that's why we feel comfortable, albeit, deep down we are uncomfortable because we're doing all this work. And now you're essentially forcing people to go to detailed 3D methods, and yet you're not giving them adequate limits that are commensurate with the level of detail in which these methods will be used. So I'm not sure what we're gaining by doing this.

DR. CORRADINI: Well, first of all --

DR. BANERJEE: Well, one and two are clear, I think we've gained something there.

DR. MAYNARD: If we do nothing, we're stuck with the old criteria, which may be just as bad for the future, not ready to go to the ultimate answer, so this is an interim step that is more conservative than what's on the books right now.

DR. CORRADINI: I don't understand if I was an applicant what I'd do -- I mean, I think sites -- I'm just like --

DR. ARMIJO: I would do everything I could to avoid getting into that situation.

DR. CORRADINI: Right. But that's what I guess I'm getting at quantitatively. I understand how I would avoid getting into one and two. I don't understand three and four. You're saying that any reactivity insertion at all, you must show three and four.

MR. CLIFFORD: Correct. If you have clad failure, you have to show three and four.

DR. CORRADINI: If you have clad failure, you must show three and four.

MR. CLIFFORD: Yes.

DR. BANERJEE: I understand your conduct. We're making --

mR. CLIFFORD: If you don't have clad failure, then three and four go away.

R.C.: How do you show non-clad failure? How do you show that the clad doesn't fail?

DR. CORRADINI: Stay below the red line. That's the only -- according to --

R.C.: I think this is --

mR. CLIFFORD: It's not out of the question. This is what was presented in RIL0401. They said with modern physics codes you would not have clad failure. This isn't something we're making up. It's well documented.

DR. ARMIJO: It would be unfortunate, though, if with modern physics codes, and all the tools you had at your command, fuel design and everything else, and you still had fuel failure, and then we force the licensees into a situation to analyze something that nobody knows how to do, we'd all be in a mess. So we have to be pretty confident that there is a way to address this thing, and close it to the staff's satisfaction.

CHAIRMAN SHACK: But, I mean, if you don't like this answer, you have to come up with a different -- you can make a risk-informed argument. There are various things, but if you get clad failure and you have this possibility, then you have to address it. That's all they're saying. Now they can avoid clad failure, we can come back for a different argument, but if you have clad failure, and if this happens, then you have to address it.

DR. WALLIS: Is it a problem? Do we know if it's a problem or not? If you have this clad failure, does it lead to a pressure pulse which will challenge the reactor, the vessel?

MR. CLIFFORD: There's empirical data out there shows the mechanical energy conversion of non-molten fuel significantly less than that of molten fuel. And by Criteria One and Two, we have a comfort level that mechanical energy is going to be a lot lower because we're precluding fuel melt. But at the same time, we can't say you don't have to address it. There's going to be some mechanical interaction. It's probably a lot less, but to what extent, we don't know.

DR. BONACA: Although, the old presumption was that if you were below 280 calories per gram, you wouldn't have to do anything else. It was assurance that you would have no pressure pulse.

DR. WALLIS: How about leading to further --

mR. CLIFFORD: That was on fresh fuel, so you didn't get -- the pellet didn't break apart, as it would in higher burn-up. Fuel pellets didn't disperse.

CHAIRMAN SHACK: We're just going to have to close this off. Can we go to the last slide, and we're --

DR. WALLIS: Damage to neighboring pellet, neighboring fuel elements?

MR. CLIFFORD: That's why we didn't say that has to be addressed with respect to fuel --

DR. WALLIS: But you don't know how to address it. We don't know how to predict how many fuel elements will be damaged if one of them fails, do we, by energetic - we don't know that, don't know how to do that. Is that true?

DR. CORRADINI: Yes, I think that's quite true. If you want to have a deterministic knowledge of it --

DR. WALLIS: Even probabilistics ought to be based on some physics.

DR. CORRADINI: Well, I wouldn't even try that. If I can't even calculate it for a set experiment, I doubt if I'd know what to do to put curves on it, and spreads, and stuff.

DR. WALLIS: This is somewhat extraordinary, it seems to me.

CHAIRMAN SHACK: Let's move on. Let's move on. We'll come back to this in our discussions.

DR. WALLIS: If we're already in the quicksand, how can we move on?

DR. CORRADINI: He's throwing us a life line, the Chairman is throwing us --

mR. CLIFFORD: Implementation. The interim criterion guides, as we discussed, will be applied to the new applicants, the COL applications.

DR. WALLIS: Poor fellows.

MR. CLIFFORD: Over the next 18 months or so, we'll complete further evaluation, taking in new data that's become available, and we'll finalize the criteria, and advise Reg Guides on the SRP again. And during this period, the purpose of the RIS is to communicate to the industry that here you have a target that you should aim for. You should start looking into developing a strategy for dealing with long-term cooling, you should develop methodology for dealing with short-term clad failure PCMI failures, and get that license reviewed because in 18 months when we issue the final criteria, then we'll have to address backfit of the current fleet.

DR. ABDEL-KHALIK: Would you be really ready to issue final criteria in 18 months based on what you presented today?

MR. CLIFFORD: We will be doing our own assessments, but the industry is also preparing further information to provide the staff for evaluating, or determining the final criteria. So we believe we will be in a position within 18 months to massage it. That doesn't mean that the more qualitative arguments for three and four can be thoroughly dispositioned.

DR. BANERJEE: What does --

mR. CLIFFORD: Those are gray areas, but as far as fine tuning when you get PCMI and when you don't, we'll have enough information.

DR. BANERJEE: What comments -- have you had interactions with industry about points three and four?

MR. CLIFFORD: We had two public workshops that were very well attended.

CHAIRMAN SHACK: We're going to have a presentation by industry after lunch, so it was supposed to be before lunch.

DR. ABDEL-KHALIK: We did get extra time.

CHAIRMAN SHACK: Yes, we have extra time.

DR. ABDEL-KHALIK: I'd like to thank --

DR. BONACA: I mean, the only way you're going to get values like this in a PWR is to assume zero power, all the rods are in, and you're ejecting a rod from that location. Okay? That's how you get these values.

MR. CLIFFORD: It's actually worse than that. Generally, you assume -- Xenon oscillation such that your ASI is the worst it could ever be, and then you eject a rod through --

DR. BONACA: Exactly. And then physically, you wonder where you're going to eject it, or whatever. I don't try right now tightening so much the criteria.

DR. KRESS: You're using a risk-informed approach.

DR. BONACA: If I went to risk-informed approach, this problem most likely would go away.

CHAIRMAN SHACK: I mean, that's also part of the original continuing justification for future -- of operation. I mean, with the results of the 3D neutronics and the realization that this was a relatively infrequent event.

We're going to adjourn now for lunch. Everybody knows we have interviews here starting in two minutes, and we'll be back here at 1:45, which we're going to have an industry presentation on the RIA stuff.

(Whereupon, the proceedings went off the record at 12:26 p.m., and went back on the record at 1:44 p.m.)

CHAIRMAN SHACK: On the record. Those of you are excited to hear about risk management technical specifications, Initiative 4B, we're running a little late from this morning and so we'll be starting in about 15 or 20 minutes.

(Off the record comments.)

DR. ARMIJO: You'll hear some very interesting stuff.

CHAIRMAN SHACK: Yes.

DR. ARMIJO: About what?

DR. POWERS: We're about to insert some reactivity.

DR. ARMIJO: Right. So the balance of the presentation will be given --

DR. POWERS: We've been pretty reactive so far, but we're going to look some new criteria for our reactivity insertion.

CHAIRMAN SHACK: All right. Dr. Ozer from EPRI will be speaking with backup by Rob Montgomery of

Anatech and discuss industry's position on SRP 4.2, specifically the RIA criteria.

MR. OZER: Thank you very much. I would like to thank very much the Committee for giving us this opportunity to present the industry perspective. This presentation has been put together with considerable input from a working group of the industry that consists of U.S. nuclear utilities, a large number of overseas utilities, all the major fuel vendors as well as our sister organization, NEI.

This is the outline of the presentation. I was originally planning on saying a few words about SRP 4.2 in general, then focus really on the Appendix B criteria and then finish with a couple of conclusions and recommendations. However, since we are so far behind, I will skip the discussion of the overall SRP 4.2 other than saying that we did identify a number of areas where we wanted to give you feedback to the NRC and that was presented two days ago at the subcommittee meeting and we'll be presenting them also in a letter to the NRC staff in the near future.

Then I would like to focus on the interim RIA criteria, our perspective on Appendix B. I'd like to reiterate that the evidence shows that the current RIA criteria, we agree that they are inappropriate at high burnups. They are okay at low burnups, but high burnup conditions, they need to be changed. NRC has stated that these criteria need to be changed, but there is no safety concern due to conservative methods. We agree with that and also would like to add that the risk is very low. This is a very low probability event and our evaluation of what would happen is also rather contained.

So our position on the interim criteria is that we consider them to be appropriate for new plants.

DR. APOSTOLAKIS: Keep going please.

MR. OZER: I'm sorry.

DR. APOSTOLAKIS: No. No problem. Okay. That's better.

MR. OZER: Sure. No problem. We considered the criteria to be appropriate. We had an opportunity to interact with the NRR staff in these couple of workshops that were mentioned before and I think some of our key concerns have been addressed. The key concerns that we had were really the ability to treat coolability separate from fuel failures. You can fuel failures, but you cannot exceed the coolability limit. That's the limit that is really the major limit.

We feel that, and I hesitate to say that after listening to all the difficulties that the previous speaker was put to, there are some excessive conservatisms in the criteria, the interim criteria. We feel that there is room for improvement, particularly in the failure thresholds and there is excessive work that needs to be done to address the coolability issue and we look forward to work with the NRC for the development of these final criteria that --

VICE CHAIR WALLIS: Is this conservatism in the failure threshold?

MR. OZER: Yes.

VICE CHAIR WALLIS: Can you give us a --

MR. OZER: I'll be coming to that. Yes, definitely.

We feel that we -- We were concerned about this issue when it first appeared in the early 1990s and since then, we've invested a considerable amount of effort, resources, into trying to understand what's going on and we have now a pretty good understanding of what's going on and we developed a mechanistic approach, a methodology for analysis and of the experiments that were carried out.

But we're not trying to develop a failure line for experiments. We're trying to develop a failure line for fuel in a reactor. So the experimental results have to be translated to how fuel would respond in a reactor and that's why we feel that we need to come from first principles. We have to know what's happening to that fuel during the experiments. The approach that we used is really based on that.

This is really sort of a bird's-eye view of our approach. We use a mechanistic code that follows the thermal mechanical changes that happen in a fuel rod as it's being hit by a power pulse and we have -- What happens, for example, during an RIA simulation test is we have a power pulse, an energy input, and the question is how will the pellet respond to that.

Now here is a graph of what we estimate is going to be the pellet response. What we have there is the cladding and over here from here on is the pellet. This is the pellet periphery and that's the pellet center. So you have to assume that's half of a symmetric diagram and what happens is initially as the pulse is starting you have the first response. This is high burnup fuel we're looking at.

The first response to appear at the pellet periphery, the pellet rim, which has this plutonium-rich region and it's a very narrow region and that's where the first -- We're plodding here the temperature. The temperature of the rim is going up very quickly. By the time we reach the peak of the pulse, the rim temperature is way up here. The pellet center tries to follow, but it follows at a slower rate and eventually --

VICE CHAIR WALLIS: And this is due to the plutonium enrichment on the outside.

MR. OZER: Yes, sir. But eventually, of course, this peak disappears and gets lower and we end up with the usual parabolic distribution way after the pulse. It's kind of interesting to see what happens to the cladding. You see the cladding temperature initially when the pulse first starts, the cladding is still at the ambient temperature because so early on it's still an adiabatic process. The cladding has not had a chance to heat up.

But as we hit the high peak in the rim, the cladding starts to heat up and the inside is getting reasonably hot, but the outside is still cold. So it's really a question -- It's a race really whether the cladding has enough time to warm up so that its ductility will improve to respond to this challenge without fracturing.

DR. ARMIJO: Just out of the record, are these number prototypical? In other words, are they consistent when you say a peak temperature of roughly 2500 Kelvin at 112 calories per gram?

MR. OZER: This is what we calculate for the tests that were carried out and it agrees with all the measurements. But there are no direct measurements of the temperature while this is happening.

DR. ARMIJO: No. I just wanted to make sure that these numbers are consistent.

MR. OZER: But we can only deduce. Yes.

DR. ARMIJO: Okay.

MR. OZER: And let me -- It's a good question to say "Well okay. So are you calculating this or what?" And really the proof of the pudding is can we predict what's happening in these tests and what we have in these tests at the end is the strain, the residual strain, and that can be measured and these are the measurements and this is our calculation of the residual strain. So we feel that all our results are consistent with what has been observed. We can explain mostly the non-failed, all the non-failed cases.

DR. ARMIJO: So this is an unfailed rod and you have measured versus predicted strain.

MR. OZER: Yes sir.

DR. ARMIJO: Okay.

VICE CHAIR WALLIS: It bulges our 5 mm, in other words, 5 X 10^{-2}. Okay. I see that. I didn't see that.

DR. ARMIJO: I wish it was that ductile. We wouldn't be here if it was that ductile.

MR. OZER: So we felt confident that we understand what's happening in these tests and then we used this methodology to determine what kind of a pulse one would need in a reactor situation to fail the fuel. We also developed a measure of when fuel would fail and we based that on a metric which we called the strain energy density or critical strain energy density. It's when the fuel is expected to fail.

On this basis, we proposed modifications to current criteria. This would be essentially our view of the current criteria. This is the range where Paul was saying that you don't have PCMI really. PCMI concerns really start at the higher burnup. At the lower burnup, you have ductility so that you have to go to really high enough enthalpies to melt the cladding. But at the higher enthalpies you start have the PCMI interaction and then the question is does the cladding have enough ductility to survive.

VICE CHAIR WALLIS: So what happens to have the curve change direction at around 36?

MR. OZER: Yes. At that point, the gap is closed. You start having the possibility of PCMI and as you go to higher burnups, you start losing ductility because of the hydrogen content in the cladding starts heating up.

VICE CHAIR WALLIS: Where does it level off? When it gets up 80?

MR. OZER: I'm sorry. When it levels off up here?

DR. ARMIJO: Yes. Why doesn't it just keep going down?

MR. OZER: Yes. It's because you need a certain amount of enthalpy just to close the gap and get over the elastic capability of the cladding. So the cladding will fail once it enters into plastic regime if it has no ductility whatsoever. So you still have enough room for deforming the cladding, closing the gap and deforming the cladding.

We were -- When we submitted this, NRC Research independently proposed a much more conservative approach and they used a completely different concept. They said rather than going through the first principles approach, we'll just take the experiments and recognizing that the experiments differ, the environment of the experiments differs, from the end reactor situation, we'll try to make some adjustments to do it and also there was some question about how we addressed uncertainties in the material properties and there were questions about our use of strain energy metric.

Our response was first of all that different approaches, independent approaches, if they come from first principles and even if they use a different metric like maybe total plastic elongation of total plastic strain as they measure when you start breaking the cladding you will end up with similar results. This was really justified or supported later on when there was a paper presented by the Swedish industry. The lead author here was from the Swedish Nuclear Power Inspectorate.

So we took this slide originally from them. It's a little complicated slide, but let me explain what we have here. First of all, this is their slide. So this is their estimate using a different code and using a different metric of where they think the failure limit ought to be at the higher burnups and that's why this is referred to as a present study. It is a present study for the Swedish paper and they're comparing it to what we proposed which is this red line which goes like this and it flattens off here and also they compared it to a study conducted by Battelle Northwest using FRAPTRAN and also a different metric and we see that, yes, there is some difference but generally there is agreement as compared to the NRC research curve which would lie down here. That's why we believe that there is a lot of -- That's why there is a disagreement.

The interim criteria gives us some room up to these intermediate burnups and then they start dropping down. The reason I don't have a single line here but just a region is because the abscessa here is burnup whereas the interim criteria are defined in terms of corrosion ratio. So we need to translate those into burnup space and in doing that, there is some uncertainty that comes in. So we think that the curve is going to lie somewhere in here.

DR. ARMIJO: But this is exclusively for PWR, right?

MR. OZER: This is exclusively for PWR. That's correct. For hot temperature.

DR. ABDEL-KHALIK: Your answer to the previous question regarding the asymptotic value at high burnup implies that there is a mechanistic basis for deriving that asymptotic valve.

MR. OZER: Yes, I think so.

DR. ABDEL-KHALIK: Now if that is the case, people can evaluate mechanistic models. Why couldn't you present that?

MR. OZER: I think that we thought there was some more room above that, but I think that's -- That would be our bottom line.

DR. CORRADINI: But can I ask Said's question differently? You get to an asymptotic value. So does your calculation decompose to essentially a model that gets you to a constant new enthalpy?

(Off the record discussion.)

MR. MONTGOMERY: Can I answer that?

MR. OZER: Yes, please do.

MR. MONTGOMERY: Robert Montgomery from Anatech. The asymptotic behavior of the line here is a combination of several factors and they basically are some of the assumptions that went into the analysis. The analysis is a combination of a best estimate methodology combined with some treatment of uncertainties through a deterministic way, not really a statistical way, and the saturation has to do with two primary parameters. One is the burnup dependency of the gap or the PCMI loading. That pretty much saturates after awhile. You don't really close the gap anymore. There's always a finite amount of gap that's pretty saturated after a burnup of about 45,000 or 50,000.

The second part comes in as we made the assumption that the material properties reached the worst possible state and stay there. They don't get any worst and that's based on the data we have at these burnup levels, that it doesn't reach a very low state. Improvements in cladding, material properties, will stay basically unchanged beyond a certain burnup. They won't continue to fall. That's where you get the asymptotic behavior primarily.

DR. ARMIJO: If the hydrogen content keeps growing with burnup, why don't the properties keep degrading?

MR. MONTGOMERY: What we assumed in this calculation here is that there will be a license limit on how high the hydrogen content can go and we took a bounding value and assumed that you reached it at about 45,000 gigawatt-days and you didn't exceed that anymore because there's a limit to envelope the number or the variation of hydrogen with burnup or really we did it with oxide data, but it would be the same.

DR. ABDEL-KHALIK: I guess we're talking maybe of different asymptotes.

MR. MONTGOMERY: This one here you're talking about.

DR. ABDEL-KHALIK: Yes, the flattening.

MR. MONTGOMERY: Right. So what happens in this range is there are two factors. One is you're reaching the maximum amount of cladding mechanical property degradation because we've reached the limit based on hydrogen. The hydrogen content is limited. We limited it to something like 800 ppm and said that's as far as we wanted to go in our model because it didn't make sense to allow it continue to go up beyond where we ever expected to go. So that's one factor going into contributing to why this is becoming asymptotic. The second is the role of burnup on the loading process, the PCMI loading process. That's saturated with burnup. So both of those come together to contribute to that asymptotic behavior.

DR. ABDEL-KHALIK: What's different about the PNNL model that it keeps going down?

MR. MONTGOMERY: This one here?

DR. ABDEL-KHALIK: Yes.

MR. MONTGOMERY: I believe primarily that's due to the mechanical properties that they used. They did not set a limit or saturated it. They allowed it to go down.

DR. ARMIJO: So their hydrogen kept going up and their ductility went down.

MR. MONTGOMERY: Kept going up. But I can't speak to that in detail because I did not do those calculations. That would be my estimation.

DR. CORRADINI: So one of the questions just since you have a graph up, did you put the data that NRC is using on that graph and it all lies above any of your lines or does it span the lines of your calculation?

MR. OZER: We used that same --

DR. CORRADINI: I'm sorry.

MR. MONTGOMERY: But it's going to be in a different space. What I can tell you is that in the data that was shown earlier, that's basically from RIA test from around the world. Some will fall below this line. Some will fall above that line and Dr. Ozer here will explain to you why some fall below and some fall above.

MEMBER CORRADINI: Fine. Thanks. I'll wait.

MR. OZER: So in view of this, our perspective on the interim criteria is that they are an improvement over our RIL401 but there are still areas of excessive conservatisms in there that seem to us to be unjustified. We feel that for the final criteria we need a strong technical basis that must exist. We need to improve, not only analytically, the assumptions that were made for the interim criteria but also need to incorporate additional experimental data. You have to keep in mind that again the Japanese NSRR data is at room temperature, ambient pressure, extremely narrow pulses, whereas the CABRI is somewhat more representative but it's in a sodium environment. The coolant is sodium and both of these will be -- the CABRI facility is being converted to a water loop and the NSRR facility will start having tests under pressure and representative temperatures. We feel that that has to be looked at and we also feel that there are some considerations for the BWRs that need to be address as well.

CHAIRMAN SHACK: Odelli, I would like if you could finish up in ten minutes.

MR. OZER: Okay. What I would like to say here is that we really wait until the data becomes available please, that the schedule should not be driven by calendar but really by the availability of data.

Now the reason we felt that the interim criteria need to be improved is because they still use a subjective lower bound to adjusted RIA simulation tests and we feel that the adjustments really were not sufficient and there were some assumptions that were made that we don't agree with, assumptions such as UO_2 and MOX fuel pellet responses identical or the same or there is no difference between UO_2 and MOX.

Assumption that room temperature and hot zero product ductility is the same and the assumption is that cladding that has high corrosion will behave the same whether it's spalled or unspalled if it has high blisters or has uniform distribution of hydrides. You disagree with that and we think that we need to address those. The impact of this is to result in a lower than necessary criteria.

Let me address these issues. The difference between UO_2 and MOX fuel pellets is that in a UO_2 pellet you have a rim formation at high burnups and it's really as we saw in the graphs earlier. It's the rim that's driving the stresses on the cladding primarily. In MOX pellet, there is no rim in the same sense as in UO_2. MOX you have plutonium oxide grains embedded in a matrix and you have rims developing throughout around each one of these grains. So when you have a challenge like the pulse that is experienced during an RIA, more of the pellets inside contributes to expanding the cladding. So given the same enthalpy input, MOX fuel responds much more strongly than UO_2. Next slide please.

This is further demonstrated in this slide. Here what we have is the sodium that is displaced during the experiment during the initial phase at the same enthalpy level. When you insert 70 calories per gram enthalpy, how much sodium was dispersed by three different uranium rods? And this is the displacement at this point which is primarily due to just the expansion of the cladding. This is uranium. This is the same thing for three plutonium rods and there's a significant change.

Going to our next argument that there is no improvement in ductility, these are burst tests that were conducted under the NFIR program. We see going from room temperature to operating temperatures a factor of 3 improvement in total plastic elongation. Next.

So what is our objection to the adjustments? This is the dataset that was used to fit the interim criteria. The interim criteria, next, this is the line. Now the round points are NSRR experiments that failed. The hollow ones are NSRR experiments that did not fail. These are CABRI experiments that did not fail and CABRI experiments that did fail.

VICE CHAIR WALLIS: And you've taken out the very low ones.

MR. OZER: Yes, we did take out the very low one. I mean, we did not take out the very low one. There was a committee that was set up by NRC to evaluate whether the lowest experiment was defective or not and we published a two volume report on that.

VICE CHAIR WALLIS: That one but not the one above it.

MR. OZER: No, just that one.

VICE CHAIR WALLIS: It's below the line.

MR. OZER: That was the very first experiment. It was conditioned differently than the other experiments and the NRC's consultant's opinion was that that contributed to its premature failure. But we did not remove the other ones. But what we noticed was that all the failures, these failures, these had something special about them and I'll address that later on.

Again, I remind you that there was no adjustment for the improvement in ductility due to temperature. Next. If we do that adjustment, this is what will happen. Those points that were done here are now up here, will move up here.

Now the reason we ware complaining so much about the use of MOX is because this is the one MOX point that is really driving down the curve. The only reason why the curve is so low at this point. If we take into consideration that MOX is a different beast and try to estimate how much enthalpy we'd need to insert into a UO_2 rod to produce the same effect we would see that this point would move up here and then if we do our fit, the fit will be over here.

VICE CHAIR WALLIS: Up to that one that's over there that didn't move.

MR. OZER: This one is really up here.

VICE CHAIR WALLIS: Over that, that purpley sort of --

MR. OZER: These two?

VICE CHAIR WALLIS: The bottom of the red.

DR. ARMIJO: Right at that.

MR. OZER: This?

VICE CHAIR WALLIS: That one. Shouldn't that move too?

MR. OZER: This. No. The diamonds. I'm sorry. Oh, this is the only MOX rod that --

VICE CHAIR WALLIS: No. What about the other one that hasn't moved at all?

DR. ARMIJO: That was tested at high temperature.

VICE CHAIR WALLIS: It was tested at high temperature. Okay.

MR. OZER: These are all high temperature, yes. So far the only corrections we made was for temperature and for MOX.

VICE CHAIR WALLIS: Okay.

DR. ABDEL-KHALIK: Now if I go back to that graph that you showed earlier with your asymptotic model, the asymptotic value in your model is 125 and if I draw that asymptotic value a lot of the data on the right beyond 0.12 would fall below that line.

MR. OZER: Yes.

DR. ABDEL-KHALIK: So what does that mean? Your model is not conservative.

MR. OZER: Okay. These points would fall below it. These points survived. These points would fall below it.

DR. ABDEL-KHALIK: So would the two to the left of those that you just corrected?

MR. OZER: These?

DR. ABDEL-KHALIK: Yes.

DR. ARMIJO: There are about 100, right? One hundred and ten? Something?

MR. OZER: Yes, I think that would be fairly close.

MR. MONTGOMERY: I should just point out one thing. The Y axis on this plot has changed from what we were showing before which was total enthalpy. This is non-enthalpy change. So there is about 15 to 20 calories per gram difference. These are going to be about 20 calories per gram lower than the other ones. So just note that. These are a little lower. So 125 is actually about 100 on this plot or 105.

CHAIRMAN SHACK: So they're close.

MR. OZER: But the question about these points, I think, is real easy to measure and unfortunately for time sake, I took out that the size that I had, in other words, these. These are rods that were highly spalled and here what we're doing is we're trying to develop a fit that will include a population of rods that are spalled. If we can claim that there is no spallation that, that the probability for spallation is negligible, then we -- What happened?

MR. MONTGOMERY: Sorry.

MR. OZER: Then we end up with this curve. Now these -- Keep in mind that spallation has only been observed in Zirc-4 so far. The advanced plottings, you're going to have high burnup, high corrosion levels, which have not indicated an spallation to the point where you have blisters or any spallation even when pushed beyond their design limits like in the rods that were used for testing which were irradiated for one extra cycle at very high duty in Spain and still they had very high corrosion but no spallation.

And keep in mind also that today in our inventory of all the U.S. plants 80 percent of the fuel is advanced cladding, M5 or ZIRLO. The 20 percent that you still use -- That slide is -- Back up.

DR. ARMIJO: Just leave that slide there while you're talking about I want one question later. Go ahead and finish that one.

MR. OZER: That's okay. That's 26. This is the distribution in today's population and what we see is that these two, this is M5, this is ZIRLO, 80 percent the Zirc-4. The Zircaloy-4 is 20 percent.

Also the plants that keep using Zirc-4 are the lower duty plants where the Zirc-4 is not likely to be challenged to the same extent that it is in the higher plants that have to use advanced claddings.

DR. ARMIJO: Okay. Now there's one of your red points that didn't move at all and that was right at about 150 and 0.05 or something.

MR. OZER: 0.05.

DR. ARMIJO: Keep going.

MR. OZER: This one.

DR. ARMIJO: That one didn't move at all with your temperature correction or --

MR. MONTGOMERY: That's correct.

DR. ARMIJO: Why didn't that move if it was a low temperature test?

MR. MONTGOMERY: We haven't completed all these assessments yet. So this is just kind of an illustration. That would move up, I bet, but we don't know exactly how much at this point.

DR. ARMIJO: Okay.

MR. MONTGOMERY: This slide primarily --

MR. OZER: This is primarily for illustration purposes.

MR. MONTGOMERY: Yes. We haven't done it yet.

CHAIRMAN SHACK: Odelli, can we hit Slide 17 and then your final slide?

MR. OZER: Sure.

CHAIRMAN SHACK: We'll give you a shot on the BWR and then a conclusion slide.

MR. OZER: Okay. For the case of BWRs, yes, there was a discussion. There were lots of questions about these points. We feel that even here there's room for improvement. First of all, there was a lot of concern about how much hydrogen can we expect in operation. I would like to point out that these tests were carried out on high burnup on the rods that were discharged from a BWR at high burnup. So the hydrogen content for these is typical for end of life. We may have some higher but I don't think that will be going much higher than maybe 300.

DR. ARMIJO: What was the burnup level for those rods?

MR. OZER: Do you remember?

MR. MONTGOMERY: Yes, those are 61. The solid black ones are 61.

MR. OZER: And also there was a --

MR. MONTGOMERY: Gigawatt-days.

MR. OZER: There was a question why dumb bells are not -- The reason why we have dumb bells here is because there is some uncertainty in how much hydrogen in that rod that was actually tested. So the hydrogen information is coming from the adjacent regions both above and below. So we have a range for that. We expect that actually the point will be in between.

Now we think that if we adjust the PWR data there is also an equivalent adjustment that should be made to the BWR. The adjustment is that this data has been obtained with a four millisecond pulse. In BWRs, the minimum pulse you can have is 30 milliseconds. So if you take that into consideration, these points will move up.

VICE CHAIR WALLIS: Now look. You have five points of failure and one point of no failure.

MR. OZER: Yes.

VICE CHAIR WALLIS: And you've drawn a red line or someone has drawn a red line and if you just look at it statistically, I mean, you haven't gotten very much information out of those six points and two of them are in conflict. So I would find it difficult to know where to draw that red line, such a small dataset there.

MR. OZER: It is a very small dataset, but you have to keep in mind that RIA simulation tests are extremely expensive. The ones at CABRI are about $1 million a piece. So one point to add a couple of points.

VICE CHAIR WALLIS: But expense is not the point. The point is what sort of probabilities are doing. If we drew the line more to be conservative, you would draw it with lower than that, wouldn't you?

MR. OZER: Yes, if you want to be conservative, you would draw it there.

VICE CHAIR WALLIS: But why not? If you're uncertain, you would be conservative.

MR. OZER: But first of all, you would need to adjust the data for the pulse width because again let me remind you. We're not drawing criteria for RIA simulation tests. We're drawing criteria for BWRs and in BWRs, the pulse is going to be much wider and we have to take that into consideration.

DR. ARMIJO: Is there an acceptable methodology for correcting for pulse width and does the staff recognize --

MR. OZER: I don't think there is an accepted methodology, but I don't think it's rocket science either. I mean we can discuss it with the staff and we can either convince them that our methods are good or work with them so that FRAPTRAN can be used to adjust for this.

DR. ARMIJO: But you haven't done that yet.

MR. OZER: No.

DR. ARMIJO: Okay.

MR. OZER: No, it's just an observation.

CHAIRMAN SHACK: Conclusion please.

MR. OZER: Conclusion. Okay. For conclusion, yes, we agree that RIA criteria should change but just the fact that a change is needed doesn't mean that we have a safety issue on our hands. We support the application of the interim criteria to new plants, we feel that the interim criteria conservative with room for improvement. We feel that final criteria should be technically well founded.

VICE CHAIR WALLIS: Does that mean that the interim criteria are not?

MR. OZER: I think that's the point. Well, the point that I was making is that there is still room for improvement there. They had to produce something quickly for the new plants to be designed, but we feel uncomfortable with those criteria if they were to be applied to current points because they are really conservative. The new plants can design so that they can bypass. They can not enter into a situation where this would be a problem.

But when we are to apply the criteria to operating plants, we need to consider the benefits versus costs. There are some hidden costs to this, not costs, but hidden results that are unexpected. If you try to design a course that you will never have a failure, you end up with flattening your flux to the point that now fluence on the pressure vessel starts to increase. You start using more and more assemblies less efficiently so you have storage problems.

So there are all these things that have to be taken into consideration. What is the benefit that we are gaining from requiring overly conservative criteria? Is it a smart thing to do? And again, the sales job will work gladly within NRC to reach a consensus.

DR. ARMIJO: I think that's all the time we have. Appreciate it. Thank you very much.

MR. OZER: Okay. Thank you.

DR. ARMIJO: It's all yours, Mr. Chairman. I failed again.

CHAIRMAN SHACK: We'll take up our next topic which is our Risk Management Technical Specification Initiative 4b, Flexible Completion Times and that's brings us back to George who is very good at staying on schedule. Right, George, so we can make up some time?

DR. APOSTOLAKIS: I have 45 minutes left.

DR. CORRADINI: Yes, that's what I told him. Forty-five minutes.

DR. APOSTOLAKIS: So we'll start right away.

CHAIRMAN SHACK: Yes.

DR. APOSTOLAKIS: Okay. As we know, 10 CFR 50.65(A)(4) requires the assessment and management of the risk from maintenance activities and the industry has developed a report, the NEI 06-09 rev. 0. And the staff has reviewed it. We received the safety evaluation report recently and essentially this initiative 4b allows the extension of completion times of selected limiting conditions for operation following certain rules that are based on risk assessment and provided, of course, that there are also some actions that are called risk management actions. So this is the subject of today's meeting and who is starting the meeting?

MR. TJADER: Dr. Apostolakis, Dr. Shack, ACRS Committee Members, thank you for inviting us here to present Risk Management Tech Spec Initiative 4b, Risk Informed Completion Times. We will be presenting the NEI 06-09 as Dr. Apostolakis said, the guidance document and its associated safety evaluation. The guidance document includes the process, the limits, the requirements, the guidance associated with implementing Initiative 4b, Risk Informed Completion Times.

As suggested by the subcommittee meeting which we were before on March 23rd, we will focus on providing an overview of Initiative 4b for the benefit of those who have not yet be introduced to it. We will highlight the benefits. We will discuss issues related to cumulative risk and other issues that we discussed and time permitting if we can discuss the one that was mentioned at the end of the meeting, operability versus functionality and we'll discuss PRA adequacy. And then, of course, we seek a letter to the Commission supporting this initiative.

Quickly, the purpose of the risk management tech spec initiatives in general and this one in particular is to align the tech specs with the Commission's 1995 policy statement on the use of PRA which encourages the use of PRA in decision making. The purpose is to make the tech specs consistent with the maintenance rule and other established guidance such as the regulatory guidance 1174, 1177 and the

NUMARC guidance 9301 which is endorsed by NUMARC 182.

The purpose is to enhance safety. Current tech specs are in general legalistic, prescriptive, rather rigid. They focus on single systems. Risk management tech specs would be flexible. They would be process oriented. They take into account the integrated plant considerations, integrated plant risk.

VICE CHAIR WALLIS: Do you have an estimate of the enhanced safety on some metric?

MR. TJADER: The metrics are included in the guidance document.

VICE CHAIR WALLIS: Do you have an estimate of how much safety will be enhanced or is this just an empty statement?

MR. TJADER: I don't believe it will be an empty statement, but we don't have anything quantified if that's what you mean.

VICE CHAIR WALLIS: Just a hope that it might have happen.

MR. TJADER: Yes. It's a hope. It's a --

MR. RUBIN: This is Mark Rubin from the staff. Let me give a perspective of that though I'll have to add that it indeed is a hope, but in this case, it's a more informed hope than the current tech specs would allow you to actually achieve. Because as everyone is well aware, the current specs with single AOT times would allow you to reenter them.

VICE CHAIR WALLIS: But there's an opportunity to enhance them.

MR. RUBIN: Yes sir.

VICE CHAIR WALLIS: But you might also decrease safety if you mismanage it.

MR. RUBIN: If you mismanage it, the potential would be there, but the control in place would hopefully prevent that. In fact, the opportunity here is a much more rigorous analytical method that would allow you to achieve the safety benefit if properly implemented.

MR. TJADER: Yes, we assume that it will be implemented properly and that it will not be abused to the extent that hopefully it cannot be abused. Initiative 4b, Risk Informed Completion Times, it uses configuration risk management assessment of the configuration of the plant to calculate a real time completion time, tech spec completion time, to restore systems to operable status based upon plant configuration and associated quantified risk assessment. It extends the completion time from the existing completion times of the tech specs which we call frontstops up to a risk-informed completion time not to exceed 30 days which ever is less.

The status, the guidance document is currently complete. The safety evaluation is complete and we expect it to be issued at the end of April. The South Texas pilot plant, its license amendment has been reviewed. It's been in-house for a couple of years. We expect to issue it this summer and the second pilot, Fort Calhoun, shortly thereafter.

The benefits, it's risk-informed. It's based upon the risk associated with plant configurations. It's real time. It allows for real time decision making. The benefits include enhancing safety and improving effectiveness. It focuses on the correct course of action to take. It focuses on repair of equipment, returning systems, operability and not necessarily on shutting down and thereby avoiding unnecessary plant transients such as shutting. It can avoid NOEDs in the future.

It takes into account integrated plant risk. It focuses on plant risks and as Mark Rubin just alluded to it manages the configuration. It manages multiple SSC component inoperabilities and while the current specs focus on single system inoperabilities, it takes into account once you're in a risk-informed completion time both tech spec systems and non tech spec systems that are addressed by the PRA.

DR. ABDEL-KHALIK: But depending on the level of detail of the PRA, the applicant can sort of pick and choose which ones to apply this methodology to while retaining the current prescriptive method in tech specs to other tech spec limits.

MR. TJADER: It can only apply it to the ones in which the PRA has been audited, certified to appropriate, acceptable to assume that.

DR. ABDEL-KHALIK: Right.

MR. TJADER: Yes, they can. It's a voluntary entry into a risk-informed completion time.

DR. ABDEL-KHALIK: Right. So the fact that someone can sort of pick and choose which tech spec limit to apply this methodology to rather than applying it in total to all tech spec limits raises in my own mind some concerns because the interaction between various tech spec limits might not be captured by this methodology.

MR. HOWE: Let me address that, Bob.

MR. TJADER: Sure.

MR. HOWE: Even if you only apply it to a certain subset of tech specs, the other systems that are still part of your PRA model, if they are unavailable, they're still considered as part of the risk calculation for risk-informed completion time whether they could operate under risk-informed completion time or not.

For example, the site wanted to apply it to -- For example, Fort Calhoun, our single system pilot for ECCS, their auxiliary feedwater would not be part of the risk-informed tech specs that they're proposing to apply this to, but if they were in an ECCS outage and they also had problems with auxiliary feedwater, that would have to be factored into the risk-informed completion time with ECCS. So even if you opt out certain systems for whatever reason and they are part of your PRA model, they still factor into the risk-informed completion times for the other systems are subject to risk-informed completion time.

MR. TJADER: In a sense, it's conservative not to apply it to everything that it could be applied to. It's only being -- We're extending --

DR. ABDEL-KHALIK: But that's what's not clear in my own mind that it is really conservative that you can look at a subset.

MR. TJADER: Well, as Andrew said, all of the systems that are in the PRA have to be considered in the calculation of the risk-informed completion time for the specs that it applies to. But by not allowing it to apply to certain systems that perhaps you don't think that the PRA would be conservative in in applying it to that one, then you are excluding it from that one being extended. In other words, you are limited to being within just that --

MR. RUBIN: This is Mark Rubin again. Perhaps I could give you an example or two. As Andy mentioned, regardless of which systems they plan to extend the completion time, all of the system interactions and the impact in a risk model are assessed when you look at extending a risk-informed completion time. What perhaps should be looked at in considering the benefits or even the negative attributes of this program, but I think that there are definitely benefits, is that the current tech specifications are not risk-based or risk-informed at all. They've come from historical precedent.

We've tried to level the playing field over a number of years by looking at the risk contribution of single AOTs, but they're definitely not risk-informed and by moving in that direction, we're certainly moving in what I think is a positive direction. So even if you just start extending some of the systems in a risk-informed manner, you still will consider all of the systems impacts vis à vis their unavailability in that risk model when you consider the changes to the systems that come under 4b.

DR. MAYNARD: And as I understand the process, an applicant for this application, they have to demonstrate that their PRA for those that they're applying this to does take the rest of that into account and that gets reviewed as part of the audit and the inspection and everything by the NRC. So they have to demonstrate that they do take the other factors into account, those things that they don't risk inform.

MR. HOWE: Two important things is they have, for the systems that they want to apply it to, to demonstrate that their PRA model actively reflects the design of the licensing basis whether it's conservative or whatever justifications. We also look at the scope of everything in their CRMP configuration risk management program looking for just those types of interactions when you're not dealing with a full scope on it, absolutely.

DR. ABDEL-KHALIK: Thank you.

MR. TJADER: Next slide. The guidance

document as I previously said, it includes the methodology, the decision making process. It includes requirements guidance. It includes requirements for PRA technical adequacy and configuration risk monitoring tool requirements. It includes metrics that are limits for quantified configuration and cumulative risk, documentation and training requirements.

The risk management guidance document, the word "guidance" is perhaps somewhat of a misnomer, but it is that the title is Risk Management Tech Spec Guidance NEI 06-09. It will be incorporated into the tech specs, the administrative control section of the tech specs. It will referenced by revision number and/or date. That makes the requirements that are listed in the guidance in the document and particularly in section two will make them tech spec requirements. I will require a license amendment to change the version of that guidance document that may be applied.

Now for an example, a couple of examples, the completion time, the frontstop is the current completion time as I mentioned. The risk-informed completion time is the configuration risk management program quantified as faced configuration completion time and the backstop is 30 days.

Let's go to the next slide to take a look at tech spec. A current tech spec would be B.1. Condition B, the system is inoperable. B.1, restore the system to operable status within 72 hours. The procedures B.2 are the required actions. B.2 are what would be added by the Initiative 4b. That is if a licensee determines within the existing completion time that they cannot restore a system to operable status and that they wish to apply, they voluntarily apply a risk-informed completion time, they would perform a quantified risk assessment within that existing 73 hours and determine whether an appropriate risk-informed completion time would be up to a max of 30 days. That completion time, that risk-informed completion time, then would apply until the status of the plant changed or until they exited the required actions. They had restored the system to operable status.

DR. ARMIJO: So they could do this while the plant is running. Something becomes inoperable and then step in and do this analysis.

MR. TJADER: Yes.

DR. ARMIJO: For how many systems could they do it?

MR. TJADER: For every -- As I said for every configuration, once you're in a risk-informed completion time, you establish the time that in essence is the time to restore the system, the entire plant, to a completely operable status. That time is associated with a configuration. When that configuration of the plant changes --

DR. ARMIJO: Another piece of equipment becomes --

MR. TJADER: Becomes inoperable. You must recalculate that risk-informed completion time and apply the new risk-informed completion time. We have a couple examples right after this which will get in and shows you how that applies. If things are restored, that completion time then could be extended.

DR. BONACA: The question I have is this, however, I didn't ask that question on the subcommittee, assume that you have calculated an acceptable RICT of 20 days and less than 30, but really to restore the piece of equipment, all you need is five days.

MR. TJADER: I think the motivation for restoring it at an appropriate time would be that they would minimize the accumulated risk that the plant would be exposed to. I don't see any benefit for them being in an inoperable status any longer than they would have to be.

DR. MAYNARD: The licensee has a lot of motivation to minimize the time that the safety systems are out of service.

DR. BONACA: I know that.

DR. MAYNARD: You have performance indicators. There are a number of things that rely on that.

CHAIRMAN SHACK: He's also going to be rolling up an accumulated risk.

DR. MAYNARD: You bet. Yes.

CHAIRMAN SHACK: That he has to track.

DR. BONACA: I'm trying to understand, however -- Okay.

DR. MAYNARD: But now they can take it out for the 72 hours and restore it to service, take it back out for another 72 hours.

MR. RUBIN: That's correct and you accumulate risk, of course, as you do that as well.

DR. MAYNARD: Yes.

DR. APOSTOLAKIS: If you have lost one train of, say, high pressure injection and you still have the others, you go through this. If during the time that you have determined, the new completion time, the second train fails, so the same system, so you have lost the system completely, you still continue and you have a new risk now.

MR. TJADER: If you have lost function.

DR. APOSTOLAKIS: "Function" means what?

MR. TJADER: If you've lost your specified safety function, your design -- First of all, there are a couple things you have to consider. You have to -- If there is an existing condition that addresses both trains inoperable, then you can consider extending that completion time. If there is not condition that addresses both trains inoperable, you cannot.

DR. APOSTOLAKIS: "Existing condition" means what?

MR. TJADER: In other words, there's a condition. Two trains of the system are inoperable. Restore one train within four hours.

DR. APOSTOLAKIS: Right.

MR. TJADER: If that condition exists, you can apply a risk-informed completion time to that if you have not lost total function, safety function.

DR. APOSTOLAKIS: And "safety function" is considered the function of that system because a function may be --

MR. TJADER: No. A system can have multiple functions, but the function we're talking about is the specified safety function required by tech specs that is encompassed by operability, the definition of operability.

DR. APOSTOLAKIS: Let's say the function is injection of water under high pressure.

MR. TJADER: And if the second train is inoperable because it cannot inject the specified required amount of flow into the loop, you cannot apply a risk-informed completion time.

DR. APOSTOLAKIS: Okay.

MR. TJADER: If it is inoperable because you've suddenly found out -- First of all, if it's inoperable and there is a condition that addresses both trains inoperable, you can apply it, let's say, if the reason for inoperability is not really because you've lost that specified safety function, that in addition, the PRA can address. You can apply this risk. You can apply it if you've not lost function. If the PRA accurately reflects the degree that functionality is retained, then you can apply it to extent the completion time. If you've lost function or the PRA does not address that capability even if you think you've retained that function, the PRA can't identify down to that level of detail, then you cannot apply that risk-informed completion time and all that is specified in the guidance document.

Let's go to the next slide here. These are the metrics, the limits. There are two times that we go to. One is called the risk management action time and that is when in a risk-informed completion time we've accumulated an ICDP or an ILERP of up to 10^{-6} or 10^{-7}.

VICE CHAIR WALLIS: What does an ICDP mean?

MR. TJADER: Incremental.

DR. APOSTOLAKIS: Incremental CDP.

MR. TJADER: Incremental core damage probability and incremental --

VICE CHAIR WALLIS: Is that based on the yearly average or the instantaneous state or what?

MR. RUBIN: Instantaneous integrated over time.

VICE CHAIR WALLIS: Instantaneous integrated over the whole year.

MR. RUBIN: No, for the period in question.

VICE CHAIR WALLIS: Only an anticipated period.

MR. RUBIN: Yes.

VICE CHAIR WALLIS: Okay.

MR. TJADER: It's the configuration specific risk since the component is inoperable.

VICE CHAIR WALLIS: So you could have $1E^{3}$ for one day.

MR. TJADER: That's instantaneous.

VICE CHAIR WALLIS: That's instantaneous.

MR. TJADER: That's a different one. That is another metric specified in the guidance document. And then there is the risk-informed completion time calculated to the 10^{-5} ICDP, 10^{-6} ILERF not to exceed 30 days and not exceed instantaneous CDP of 10^{-3} or LERF of 10^{-4}.

DR. APOSTOLAKIS: But that's something that the industry voluntarily has imposed.

MR. TJADER: That's right by adopting the guidance document. That's correct.

DR. POWERS: This just strikes me as very stringent numbers.

MR. TJADER: We believe it to be conservative.

VICE CHAIR WALLIS: Conservative?

MR. TJADER: The ICDP calculation.

VICE CHAIR WALLIS: Conservative to what?

DR. BONACA: Depending on risk.

DR. POWERS: Yes. Had they asked me off the top of my head to set those numbers I would have set them all higher. I mean I just did it while you were talking and your numbers surprised me.

MR. HOWE: Fundamentally, they were set to be consistent with the Maintenance Rule limits that were endorsed by Reg. Guide 1.182 and NUMARC 93.01.

MR. RUBIN: This is Mark Rubin. I could give a little historical insight that relates to those numbers. Back before the Maintenance Rule was even envisioned, we did some studies of maintenance logs and we looked at instantaneous plant risk just to get an idea of where we were and people were rather startled to see some plants in 10^{-2} CDF space for some periods of time. So I think it was felt to be prudent that that's maybe not a good number to target for. But you're right analytically --

DR. POWERS: 10^{-2} for three days is 10^{-4} for a year.

MR. RUBIN: Yes sir.

DR. POWERS: I find this just interesting. I'm delighted to see you capping that. I think that's --

CHAIRMAN SHACK: You made that statement, but you're not the one that introduced the cap. The industry did. In your own reg. guides, you have no cap.

MR. RUBIN: The cap was also identified in an industry PRA guides document. Biff, what's the name of that thing? The EPRI --

MR. BRADLEY: PRA PSA outlooks.

MR. RUBIN: Yes, and the staff specifically did not endorse that number. It's just an operating guidance, guideline, that the industry uses and we don't have a hard knife-edge determinator.

VICE CHAIR WALLIS: So these good future plans that claim to have CDF $1E^{-6}$ will have essentially the CDF governed by these risk management actions.

MR. RUBIN: Yes.

VICE CHAIR WALLIS: Which will overwhelm the --

DR. POWERS: Yes, exactly so.

DR. ABDEL-KHALIK: But if you have an action that would take a few hours, that means during that few hour period if you apply this criterion, the instantaneous value of the risk can be very high. Shouldn't there be a limit then on the instantaneous value of the risk?

(Several "There is.")

VICE CHAIR WALLIS: That's the $1E^{-3}$.

MR. TJADER: That's the 10^{-3} CDF and 10^{-4}.

DR. ABDEL-KHALIK: Okay. Thank you.

DR. APOSTOLAKIS: Now is that instantaneous?

VICE CHAIR WALLIS: Yes. That's what he means.

MR. HOWE: Configuration-specific core damage frequency.

DR. APOSTOLAKIS: If it were --

MR. HOWE: It stayed the entirety. It's from our pilot plants and from a proposed pilot plant we don't feel that those limits are going to be encroached upon very frequently especially for our South Texas pilot.

MR. RUBIN: Also, Mark Rubin again, if I could add the thought that when you put yourself in a very high instantaneous risk configuration even for short periods of time your assuming recovery. You're assuming that you'll get out of that state in a short period of time. What happens if what you're doing if you open a maintenance pack to restore a valve or a solenoid actuator and you find out the O-ring is missing? I can't restore that component for seven days.

VICE CHAIR WALLIS: Is there a cumulative limit? I mean, can you do this 20 times or something?

MR. TJADER: That's the last -- We're going to talk about that.

VICE CHAIR WALLIS: You're getting to that.

MR. TJADER: There is a periodic assessment of the cumulative risk in --

DR. APOSTOLAKIS: I'm just curious.

MR. TJADER: -- in accordance with that and we will address subsequent.

DR. APOSTOLAKIS: Is it possible that you can have the current completion, the frontstop, and let's say that's a week. But you don't do any calculations now, right, because now it's regulations and you know that for this component you have a week. Is it possible that five days into the week your ICDP and ILERF exceed these limits?

MR. HOWE: Possible? Yes. Likely? No.

DR. APOSTOLAKIS: And why would that be acceptable? What?

MR. HOWE: Possibly? Yes. Likely? No.

DR. APOSTOLAKIS: How do you know? I don't think we've ever done it. Biff.

MR. BRADLEY: Bradley NEI. I just wanted to mention that's why A4 of the Maintenance Rule was developed and issued was to address your situation and A4 applies to all plants so even within the frontstop.

DR. APOSTOLAKIS: No, but if I planned to stay with the existing completion time I don't have to do any calculations.

MR. BRADLEY: Yes, you have to do the A4 calculation. The same approach that's given here and the same metrics apply for the Maintenance Rule A4.

MR. RUBIN: You have to assess and manage risk according to A4, sir.

MR. BRADLEY: Yes.

DR. APOSTOLAKIS: No matter what?

MR. BRADLEY: Yes.

MR. RUBIN: No matter what but there is not a hard and fast numerical criteria. This is different. This establishes actual guidelines, numerical guidelines.

MR. BRADLEY: Part of this initiative is to establish consistency between the tech specs and A4.

DR. APOSTOLAKIS: I don't want to be risk informed at all. I follow the completion times that are in the regulations. You can't force me to do this.

MR. RUBIN: The regulation requires it, sir. Maintenance Rule.

DR. KRESS: It's the Maintenance Rule.

MR. RUBIN: But it doesn't give you a definitive number to say yes or no. It's up to the individual plants and the utility guidance. NEI set up some guidance to help them.

DR. APOSTOLAKIS: If they find that it's greater than these limits.

MR. RUBIN: As long as they can claim that they're managing it appropriately they skate the rule.

DR. MAYNARD: That's the key. You don't have to shut down, but you have to manage the risk. It means you maybe have to put some additional oversight, additional compensatory measures, in place.

MR. RUBIN: Yes, let me give you an example.

DR. APOSTOLAKIS: What if they don't even have a good PRA because they are not entering their risk-informed -- They have to do it.

MR. RUBIN: Everyone had a baseline inspection for employing the Maintenance Rule. Some had good PRAs. Some did. You're absolutely right. Some used precalculated charts. Some used a living top of entry faulty model to rerun their PRA every day. South Texas, St. Onofree, have very capable online risk monitors and a number of other plants do as well. But the thing to keep in mind is that they do have to assess it and manage it and besides compensatory measure, managing might be work three shifts instead of one shift to get it back into service.

DR. ABDEL-KHALIK: If we go back to my original question about allowing someone to pick and choose, by allowing people to pick and choose you're not really forcing them to go back and evaluate the appropriateness of that frontstop.

MR. TJADER: A couple things. A plant that will have adopted this Initiative 4B if they are within their frontstops they still have to prior to performance of maintenance have to assess and manage risk in accordance with A4. Furthermore, we expect and it's written in the guidance document that it is expected the licensee is implementing risk management tech spec 4B will use the same PRA models and risk assessment tools for assessing risk and for implementing initial 4B RMTS and for implementing A4. So if a plant is within the frontstops of multiple specs then we don't expect them to put on blinders and not do an appropriate risk assessment using the tools that are available to them, i.e., the configuration risk management tool that is developed to support initiative 4B. We expect them to utilize that and take appropriate action accordingly.

VICE CHAIR WALLIS: Can we go back to your --

MR. HOWE: I can only speak hypothetically, but as a reviewer if a licensee came in and said I would like to apply 4B to these six or seven subsystems, one of my questions is going to be why aren't you interested in these others and if it came out that I can get some benefit for these but the other ones it would kill me because I'm not conservative whether we have the authority to change things that would be another question. But it's not something that's going to be just slipping past me as a reviewer. I wouldn't expect any reviewer just to blindly ignore what the scope of the --

VICE CHAIR WALLIS: Aren't you enhancing safety? I mean, it seems to me that you have something which previously you had to do in three days and now you can look at it and say I don't really have to do it in three days. I can take two weeks because I can now make it -- It's not very significantly until two weeks. So you're letting them take longer to take the action which would seem to put it in a risky state for longer. Therefore, you're not enhancing safety. You're decreasing it.

MR. HOWE: If that's the way it was applied, you would be correct. That would not be enhancing safety. That's not what we --

VICE CHAIR WALLIS: You said you were enhancing safety with this rule.

DR. POWERS: I think you're looking at it maybe in the wrong way, Graham. Here's the situation that they're trying to avoid and we have encountered this many times is people will start to repair something that's down. They will get into a situation where they said they realized they cannot meet the 72 hour. They cobbled the thing back together, get it operational and then take it back down again and that cannot be a safer system than taking the extra ten hours that it would have taken to fix it.

MR. TJADER: Or they may come in and request a notice of enforcement discretion where we would have to quickly evaluate that and more often than not, we will grant them an extension of time.

VICE CHAIR WALLIS: That's true where they get into the situation where they can't fix it in the time available. But where they just don't want to fix it they just let it drag on and they say it's not risk significant. That is a possibility and that is not enhancing safety.

DR. MAYNARD: I really don't think that's --

MR. TJADER: Let me address that. If you go back to slide 20, one of the things that we are going to be developing is we're going to engage the resident inspectors of each plant to provide oversight for the implementation of Initiative 4B. But some of the things that must be documented that are required by the guidance document that will be incorporated in the tech specs that will be tech spec requirements is that they will have to document, log in, the date and time of entry into a risk-informed completion, the thing at exiting the risk-informed, PRA functionality assessment, i.e., it's inoperable however we're going to utilize its functionality capability in determining a risk-informed completion time, documenting that, configuration of risk specific data, what are you basing your quantified assessment on, what is the configuration of the plant so that we can perhaps reconstruct it if need be.

Risk management actions implemented if

they get to 10^{-4} ICDP. Emerging condition assessment additional systems become inoperable. What assessments then are taken. And accumulated ICDP and ILERF that is accumulated during that time. These are the things that are documented that we can subsequently go back and review and audit if need be and if hopefully it is being abused, in other words, they are lazy and don't want to restore the system for some unknown reason, then perhaps we can take subsequent action. I don't think they'll apply it like that. I think that --

DR. BONACA: The question wasn't about being lazy. What about the fact that there are components that either may come out. Okay. So therefore you may reschedule one system. You delay the other one, etc., because you have a window. Maybe you end up with several components that you're managing in the other service. Now --

MR. TJADER: It permits you to manage --

DR. BONACA: I understand that.

MR. TJADER: And keep in mind that the transitioning down through modes and shutting down there is some risk inherent in that.

DR. APOSTOLAKIS: But I think to evaluate Graham's, you've answered that. You really would have to look at the decision options inherent and calculate the risk of each one which includes in the case of complying with the frontstop shutting down what risk you entail there and take the whole thing.

VICE CHAIR WALLIS: If you have to shut down.

DR. APOSTOLAKIS: And what they are saying, the staff is saying, is that they haven't done the calculation but they believe that the benefit is --

VICE CHAIR WALLIS: I'm sure with the other plant which has a good management that pays attention to all these things, things will work out. But you do get some plants that let things slide.

MR. BRADLEY: Could I make a statement?

DR. APOSTOLAKIS: Yes please.

MR. BRADLEY: I just wanted to note that outside of tech specs there are a number of regulatory incentives to minimize unavailability of safety systems. It would be a very bad decision to arbitrarily extend an AOT. You're going to take a hit on the reactor oversight process. If it's a mitigating system, that's MSPI. The Maintenance Rule requires you to track and balance unavailability and unreliability. There are a whole number of other regulatory regimes that preclude someone from misusing this capability to extend the AOT. It would be a very poor decision to do that.

DR. MAYNARD: There is essentially no incentive for a licensee to just arbitrarily extend and take longer than necessary on the safety system. There are all kinds of incentives for them to get it restored just as soon as they can and if somebody were to do that, they could also just take a system out, put it back and take it back out again. I believe this is ultimately a much better way of handling these situations. Otherwise, they're going to have to come back for notice of enforcement discretion or like Dana said, they're going to cobble the system back together or you're going to live with the --

DR. BONACA: There is no doubt in my mind it's a better thing. But what we're looking for is are there any flaws in the process that is being licensed. That's the issue. So I'm not saying that comprehensively, as I said during the subcommittee, I'm extremely supportive of this. I'm only testing to see if the process that's being implemented has any pitfalls and you're convincing me that probably there isn't.

DR. APOSTOLAKIS: So shall we go back to

the example?

MR. TJADER: Okay. The next would be slide 11, but I think we've discussed the process.

DR. APOSTOLAKIS: Yes.

MR. TJADER: This is basically for the -- If we go to slides 12 and 3, gee whiz. Twelve and three go together. Twelve and 13 go together.

(Off the record comments.)

MR. TJADER: If you take a look at this, a plant is operating from time zero to 20, zero maintenance state. There are no inoperabilities and you're not in a risk-informed completion time. This first example takes the situation in which you are not exceeding your frontstop. Okay. At time 20, there's a planned maintenance activity which you're entering and the planned maintenance activity is expected to be 100 hours.

DR. APOSTOLAKIS: I think it's important though here, Bob, to point out that before you enter it you see the CDF is zero. Right? It's not the average CDP that the PRA calculates. It's a CDF with what? No maintenance. You explained it last night.

MR. TJADER: What this really represents is the delta CDF above the zero maintenance core damage frequency. In other words, there is some baseline risk.

DR. APOSTOLAKIS: Okay.

MR. TJADER: Even if everything has been serviced just from random failure. This is really riding on top of that if that helps.

DR. APOSTOLAKIS: So when you say zero, you mean there is no delta.

MR. TJADER: Delta.

DR. APOSTOLAKIS: Go ahead.

MR. TJADER: Okay. The planned maintenance activity is expected to be 100 hours. You take a train or the component out and you enter your tech spec condition and the completion time is to restore it within seven days. At this point, you enter a tech spec time zero.

At time 40, you have an emergent failure. You have another system fail that is reflected in the PRA and you calculate then the new risk management action times and the risk-informed completion times at time 40. Your risk management action time which is reflected by the purple bar, you would cross that threshold where you were required to take risk management actions, i.e., compensatory type measures at 47 hours and if you draw the line out, your risk-informed completion time would be 17 days. That is beyond the frontstop of seven days. So the frontstop of seven days, if you needed it, you could utilize the risk-informed completion time of seven days. But at time 70, you restore the emergent failure and then the CDF decreases instantaneous and the graph changes.

VICE CHAIR WALLIS: But it doesn't go down on 120. It stays up to where it was and you don't suddenly remove the ICDP and you --

MR. TJADER: The ICDP, the cumulative risk is --

VICE CHAIR WALLIS: It's cumulated. It doesn't suddenly disappear.

MR. TJADER: Right.

VICE CHAIR WALLIS: It stays up there.

MR. TJADER: Right, but the instantaneous goes down.

VICE CHAIR WALLIS: It's not as if it disappears after you've done the action. It's still there. You've still incurred it.

MR. HOWE: That's a valid point. The way we've set this program up is risk accumulates, but even after you restore components to service, you don't get to drop that --

VICE CHAIR WALLIS: Again, you don't know. You had to keep that.

MR. HOWE: Right. If you have an emergent failure that puts you in a particularly high risk condition and you accumulate risk very rapidly up towards the 10^{-5} ICDP limit, even if you restored it before getting to 10^{-5} but you were almost there, you may not have much time left because of the amount of risk you had accumulated.

DR. APOSTOLAKIS: But how many of these you're going to have will be taken care of later by comparing with the 1.174 criteria.

MR. HOWE: Which we're going to address in just a minute.

DR. BONACA: One thing that's interesting, I mean, clearly you're going to have a daily risk resulting from or weekly or whatever. But for the experience I had when I was supporting operation, every month we would look back and see what kind of curve we had for unavailability because life is not the way you plan it. Things happen in addition to with every other service. Is there any consideration of that in this? There isn't because this is just for a tech specs and I wonder if it's being done at the plants.

MR. HOWE: Are you talking about a look-back?

DR. BONACA: A look-back, yes, because you're projecting forward a certain risk profile that is affected by components out of service for maintenance, some tech spec actions taken from this. But in reality, you have other things happening there and when you look back, you find that in addition to the curve that you had, you have now additional components and you have a different kind of profile and a notice --

DR. APOSTOLAKIS: How can you have those?

MR. HOWE: If I understand what you said, the assumption is that they know what the specific configuration is as they occurred. If you're in a risk-informed completion time and you're managing it appropriately and then you exited it, then at some time through some of the program, you realize that wait a minute. Something else was broken that I didn't realize that would have changed my decision, that's not really part of this program. That would be part of the corrective action program --

DR. BONACA: No, in fact, I'm not expecting that this would have that element. I'm talking about in the aggregate. We have been reviewing a number of changes to regulation that allows risk-informed information to take components at the surface either for maintenance or because of through tech specs. And I'm wondering if the industry at large out there if it's looking back and seeing really what happened and trying to learn the lessons of events that they have no plan. Things happen that they didn't plan.

MR. HOWE: I don't know. I don't have an answer for that.

MR. TJADER: We have a slide that covers that.

MR. HOWE: South Texas will address that.

DR. BONACA: Okay. Great.

MR. TJADER: The second example is one in which the frontstop will be exceeded and slides 14 and 15 apply to that. At time zero, a tech spec system becomes inoperable and the risk management action time is calculated at seven days as reflected by the slope of the graph and the risk-informed completion time is projected to be greater than 30 days. The point at which the slope would exceed the 10^{-5}. So in entering, if utilizing a risk-informed completion time, the backstop in this case would apply.

At time five, a second component becomes inoperable. They are required to recalculate the risk management action times and the risk-informed completion times. It turns out that the risk management action time is relatively soon in the order of probably an hour or two and the risk-informed completion time recalculated would be 27 days, less than the backstop. So if entering a risk-informed completion time, it then would be 27 days and not the backstop of 30.

And this example here at Day 20, the second system is restored. You recalculate the completion time. It ends up being greater than 30 days. Thirty days would apply. You would then exit the risk-informed completion time. You would take actions to exit it either at 30 days or getting out of the mode of taking the appropriate tech spec actions that would apply if you exceeded the completion time as currently exist. You would get out of the mode of applicability of the spec or you would exit the risk-informed completion time by restoring the system or systems to operable status.

VICE CHAIR WALLIS: Now you're assuming you all can do the second in 15 days. You did do the second. B you would fix in 15 days, right?

MR. TJADER: That's the assumption in the example.

VICE CHAIR WALLIS: But it may be that it takes you longer. Suppose that you find that it's going to take 25 days to fix it. Then you're out of compliance there.

MR. TJADER: If they attempt to not follow required procedures, tech spec required actions of 30 days, exiting --

VICE CHAIR WALLIS: Maybe you can't do it. You can't get the shaft or whatever you need to replace something.

MR. TJADER: Then you have to get out of the mode applicability as you would now. You have to shut down.

VICE CHAIR WALLIS: You have to shut down. Okay.

MR. TJADER: Yes, you have to shut down.

DR. APOSTOLAKIS: I'm still troubled by delta CDF. I believe the point of reference -- because you know this is real time. It's not PRA on the average. You know what is out of service. So I think the zero is when everything is working.

MR. HOWE: Yes.

DR. APOSTOLAKIS: If I'm doing regular maintenance and I have removed something from service, then I will be a little higher than that. Right?

MR. HOWE: The zero in these graphs

represent the configuration of a plant where every PRA component is --

DR. APOSTOLAKIS: Working.

MR. HOWE: -- working and believed to be --

DR. APOSTOLAKIS: So it's not a delta from the average CDF.

MR. HOWE: No.

DR. APOSTOLAKIS: Not here and this is real time. Okay. Because that was a little -- So even if I'm doing line maintenance, then I have to enter risk, right, even though it's scheduled and everything and I know that I have to take this train out and work on it for a few days. Then I'm entering like what you have there 0.5.

MR. HOWE: If you're going to exceed the current frontstop completion time, yes.

DR. APOSTOLAKIS: Yes, if you --

MR. HOWE: You have to do these calculations.

DR. APOSTOLAKIS: But that's where you enter and you say I'm going to complete it by the given CT that's fine.

MR. HOWE: You can finish, if you want to, the existing tech specs and you would never have to do any of these calculations. However, if you were going to exceed it, you have to.

DR. APOSTOLAKIS: I was told you have to to manage risk.

MR. HOWE: For managed -- I'm sorry. I'm talking tech specs. From a tech spec point of view, you do not have to do any of this. From a Maintenance Rule A4 --

DR. APOSTOLAKIS: You have to do something.

MR. HOWE: -- you'll do exactly the same calculations of CDF and LERF and you'll manage that risk, but you wouldn't have tech spec limits associated with it.

DR. APOSTOLAKIS: Okay. Now it makes sense. I don't know why regulations have to be so complicated. There must be a reason. You have exceeded your time, Bob.

MR. TJADER: Fortunately, I'm done and the only thing that's left for backup slides that I need not go into unless you wish to discuss them.

DR. APOSTOLAKIS: I don't think we need them. So the next presentation --

MR. TJADER: Andrew was going to discuss the items that were suggested, PRA.

DR. APOSTOLAKIS: Adequacy and uncertainty.

MR. TJADER: Adequacy and the Reg. Guide 1.174.

DR. APOSTOLAKIS: -- of 4B. Class STP examples. Okay. Is that what you're going to do, Andrew?

MR. HOWE: No, I was going to wing it.

DR. APOSTOLAKIS: Okay.

MR. RUBIN: Does the Committee need that presentation? I mean we have so much on PRA quality and scope that has been presented on other venues.

DR. APOSTOLAKIS: To tell you the truth, I don't think we need it, but I don't know if any members --

MR. HOWE: It's very brief, but I'm happy to --

DR. APOSTOLAKIS: I would rather spend time on your examples and then the presentation from STP because this is really what's relevant to this.

MR. HOWE: I don't really -- That --

DR. APOSTOLAKIS: Okay. So we know this. Next.

(Off the record comments.)

DR. APOSTOLAKIS: You have examples?

MR. HOWE: No, I do not have examples.

DR. APOSTOLAKIS: It was just quality.

MR. HOWE: There was a slide from this presentation that got left in here.

DR. APOSTOLAKIS: No, but I am curious though how uncertainties are handled in these cases. Do you have a slide on that?

MR. HOWE: We can talk generalities about what the guidance document requires. I was going to present that.

DR. APOSTOLAKIS: Well, the guidance, the SER at least, says that they are expected to do some sensitivity analysis. I mean, who is going to do that in real time?

MR. HOWE: They're not going to in real time. Let me -- I might as well go through this real quick since it sounds like you have a couple of questions.

DR. APOSTOLAKIS: If you can enlighten. Okay. That we know.

MR. HOWE: Right. That's the PRA.

DR. APOSTOLAKIS: Uncertainty analysis.

MR. HOWE: I'll talk a little bit on uncertainty analysis.

DR. APOSTOLAKIS: Yes.

MR. HOWE: This is from our visit at South Texas. This was their plans as we discussed with them. Fundamentally, they're going to identify key uncertainties using industry guidance documents that EPRI has developed. They will take those key uncertainties for their PRA and look at the impact on the configurations in their plant where they have less than a 30-day completion. If they had configurations that were way beyond 30 days, it was assumed that any uncertainties in the PRA probably wouldn't significantly affect that decision and that seemed reasonable to us.

For those where the key uncertainties could affect configurations that were already less than 30 days, they planned to do sensitivity studies to see within the bounds of what we know about that uncertainty how could it affect the decision. Will 30 days become 28 days or 15 days? What was the importance of it?

And then in accordance with NEI 609, they propose any appropriate program restrictions or comp measures for those configurations that would be affected by the uncertainties. That's what South Texas presented to us when we did our site visit. The NRC team made some recommendations from additional areas to be considered. But the overall approach we felt was very reasonable for addressing uncertainty and is consistent with the NEI 609.

DR. APOSTOLAKIS: Now this is based on their assumption that all this will be precalculated, right? That there will be a library of states of --

MR. HOWE: It is for South Texas but not necessarily a requirement for another licensee. But it identified that this would be done as part of the license application process to use 4B for certain specs.

DR. APOSTOLAKIS: My point is that I can see how someone who develops this library like South Texas did can do this because they do it in their offices, no pressure and so on. If you haven't done that and if you're supposed now to do the analysis in real time, I'm not sure how they're going to take care of the uncertainties. I think it most likely will be something that will be the judgment of people as they go along. Why don't you ask people to do these things in advance and have them like South Texas? Have a pre -- You can't do that.

MR. HOWE: It could be done. I guess we could.

DR. APOSTOLAKIS: Wouldn't that make much more sense to have an analysis, a rigorous analysis, done in an air-conditioned office without pressure, you understand what's going on, rather than wait until I have a picture like the one Bob showed where now I have to calculate in real time what's going on? I think that would probably not be a very good idea.

But the second question that I would have is we keep talking about uncertainties in the context of PRA, but this is now real time decision making. I'm trying to figure out what uncertainties are we talking about here. Are we talking about the uncertainty in the estimate of completion? But then again, that doesn't really matter because I look at the clock. What else? Does it matter that I have uncertainties in the failure rates? Why would that matter?

MR. HOWE: The biggest thing that we're looking at and I'll ask Dr. Perry to chime in if I misspeak is really the modeling that you choose to build your PRA would be something that you make in your PRA. The exemption is the success criteria, not --

DR. APOSTOLAKIS: Andrew, I just don't see how anyone can take those into account in real time. I can see them doing it in advance but not in real time.

MR. HOWE: No, we don't ask them to do that. What we're asking for is for them to identify what the key uncertainties are and provide an assessment of how those uncertainties can affect the completion times for those systems that are subject to RITS, do the appropriate sensitivity studies to see what the effect is and if necessary put programmatic restrictions on it.

DR. APOSTOLAKIS: And I think that should be done in advance.

MR. TJADER: It is being done.

MR. HARRISON: This is Donnie Harrison from the PRA branch. The key thing that Andy mentioned and may have been glossed over a few minutes ago was all of this uncertainty analysis is occurring at the application phase when the applicant, the licensee comes in, and submits the application to do this. They must address all the tech specs that they're going to implement at that point, do these sensitivity studies at that time, not before they actually implement it.

DR. APOSTOLAKIS: You mean they're going to tell you actually for this component and this system, this is the analysis we would --

MR. HARRISON: Here's the model uncertainty or here is the issues that affect the key uncertainties that affect this PRA that would affect those tech specs and then all run sensitivity cases on those at the application if I'm understanding what you --

DR. APOSTOLAKIS: But this is how South Texas has done that.

MR. HARRISON: And again, South Texas has the advantage of they already have their pretty solved models, pretty solved results as well.

MR. HOWE: But I don't think the process is any different at this point for pretty solved versus simply solve the cases that you need to explore the impact of these uncertainties on the results you would get.

DR. APOSTOLAKIS: So you are pre-solving them. What is the difference? I'm missing the difference. You're saying they did it and they also pre-solved cases. The other guy is going to do what?

MR. HOWE: Everybody will identify what they consider to be the key modeling uncertainties that could affect this program. Every plant will identify a linkage between those uncertainties and the LCOs and the systems that it will apply to it. So that's no different whether I pre-solve it or not for my CRMP.

At that point, we need sensitivity studies that say given this uncertainty how do I quantitatively bound it and how would it affect those systems that I link to that. If you're pre-solved, you're going to simply look at the pre-solved cases. If you're not, you're simply going to run the new cases that you need to explore those sensitivities at that point and then you'll see what the impacts are and implement appropriate program restrictions. The only difference is once a plant has done this, we've reviewed it, we accepted whatever conclusions they've drawn, when they actually go to implement their configuration risk management program for this tech spec, we would have a pre-solved case with a number on it or they would simply exercise their PRA model in real time and generate that number.

DR. APOSTOLAKIS: It seems to me it would be cleaner to have the pre-solved cases.

MR. HOWE: I don't disagree with that. It's easier because you review it ahead of time.

DR. APOSTOLAKIS: Yes.

DR. MAYNARD: But I'm not sure that you can pre-solve every potential case ahead of time. I think you do the most likely and large number of them. But you also have to have the capability of if you end up in a condition that you had not anticipated --

MR. HOWE: You have to generate the case --

DR. APOSTOLAKIS: I don't have a problem with that. Biff.

(Off the record comments.)

MR. BRADLEY: That was the point I was going to make because the CRMP tool just looking at the scope of tech specs it's for the entire plant and all the components in the plant in the PRA and it's really impossible to pre-quantify all the uncertainties for all those combinations. So we're looking at the key ones in advance as Andy said and I think that's the difference. You can't on the fly do an uncertainty calculation for every configuration that could come up. There are too many permutations to do that. So we just look at the key components.

MR. TJADER: In the safety evaluation at the end, we've listed 13 things that at a minimum we expect to see in the license amendment request that a license proposes and No. 10 addresses this to some degree. It says, "The request will provide a discussion of how the key assumptions and the sources of uncertainty were identified and how their impact on the risk management tech spec Initiative 4B was assessed and dispositioned." So it has to be addressed in the license.

DR. ABDEL-KHALIK: Let me ask a slightly different question. Let's say somebody is going to embark on doing this and is going to do pre-canned scenarios and a lot of these pre-canned scenarios involve just one malfunctioning component, the first one, and then the others would follow and they can analyze those scenarios as well. Can they come to you and use these pre-canned scenarios to modify the frontstop in their tech spec?

MR. HOWE: The frontstop?

DR. ABDEL-KHALIK: Right.

MR. HOWE: Can they? They come in with a separate license amendment to say we think this frontstop needs to be changed and here's our risk basis.

MR. RUBIN: That's similar to current processes. You could just have a risk-informed tech spec change.

DR. APOSTOLAKIS: They've done it already

DR. MAYNARD: Yes, there's a current process in place for doing that and the guidance is

4B.

MR. HOWE: Guidance 1.177. But the risk managed tech spec program that we're presenting today has no impact on frontstops.

DR. MAYNARD: Okay.

MR. HOWE: The operation before the frontstop is unchanged. It's only if they want to go beyond.

DR. MAYNARD: Beyond that. Okay.

DR. APOSTOLAKIS: If they want to change the frontstop, then they would have to go to regulatory guide 1.174. Right?

MR. HOWE: 1.177.

DR. APOSTOLAKIS: Okay. The next presentation then. Is that what it is?

MR. HOWE: That was what I had to say on uncertainty. Where the -- There must be another one. Did you want the reg. Guide 1.174 limitations?

DR. APOSTOLAKIS: Yes, I think that's important.

CHAIRMAN SHACK: George, we're --

MR. HOWE: It's there somewhere.

CHAIRMAN SHACK: We're 3:45 p.m. here.

VICE CHAIR WALLIS: We have an industry presentation too.

CHAIRMAN SHACK: Yes.

DR. APOSTOLAKIS: We'll move onto that one. What they do is there is an interesting -- Let me talk about it and -- If you do this too much over the year and you calculate your average CDF, then you may end up with a delta CDF above your baseline which violated 1.174.

MR. HOWE: If it's significantly --

DR. APOSTOLAKIS: What?

MR. HOWE: If it's above the --

DR. APOSTOLAKIS: If it's above, yes. So they have this extra criteria that says look back over the year. How many times did you do this? How many triangles did you have? Do your arithmetic and find out. It's a very interesting application of 1.174 because here 1.174 is used after the fact. Right?

MR. HOWE: At least the first one we tried to do.

DR. APOSTOLAKIS: Yes, it's after the fact. Usually you have it in advance. You say if I want to make this change --

VICE CHAIR WALLIS: But don't you have to keep track of this cumulative thing throughout the year?

DR. APOSTOLAKIS: Yes.

VICE CHAIR WALLIS: Not just for backup at the end?

DR. APOSTOLAKIS: Yes, and at the end of the year, you go and say my average delta CDF now was acceptable according to 1.174. I just want to sensitize the Committee. This is a different use of that.

VICE CHAIR WALLIS: Suppose it was not acceptable.

DR. APOSTOLAKIS: It's after the fact, but it's not permanent.

VICE CHAIR WALLIS: Is it really after the fact, George? Don't you have to anticipate what you're going to get?

DR. APOSTOLAKIS: No, they don't anticipate. During the year, they --

VICE CHAIR WALLIS: You may have used up your delta CDF already at half a year.

DR. APOSTOLAKIS: During the year, they use the incremental ones.

VICE CHAIR WALLIS: But halfway through the year, you may have violated 1.174.

DR. APOSTOLAKIS: At the end of the year, they look at the average and you make a violation.

VICE CHAIR WALLIS: But you may have

violated it halfway through the year.

DR. APOSTOLAKIS: Oh, I see what you mean. I don't think they do, but I'm sure if there is a case like that, somebody will stand up and say "Hey guys. What's going on here?"

VICE CHAIR WALLIS: I think you have to look at it all the way through as you go along.

DR. APOSTOLAKIS: I mean if six months into the year you have done it so many times that you have violated --

DR. MAYNARD: You would have had a lot of attention for that.

DR. APOSTOLAKIS: -- somebody is going to pay attention to that.

DR. ABDEL-KHALIK: Could you get around that problem by doing a running average?

VICE CHAIR WALLIS: Yes, do a running.

DR. APOSTOLAKIS: Do a running average?

MR. HOWE: I'm going to show what our expectation is and we'll get the Committee's input.

DR. APOSTOLAKIS: Good.

VICE CHAIR WALLIS: Yes, I think you should do a running average.

DR. APOSTOLAKIS: I think the expectation is that this is not going to lead you to that. Right?

MR. HOWE: Fundamentally, when this was presented to the staff for review, it was said that it would comply with Reg. Guide 1.174. It should result in no more than a small increase in risk. The question came up "Well, how given that any one entry into this is limited to 10^{-5} ICDP and a small risk increase in Reg. Guide 1.1174 is 10^{-5} per year?" It would seem like that's out of balance.

DR. APOSTOLAKIS: You have to have too many of these. As Otto said, somebody will pay attention.

MR. HOWE: So what we asked the licensees to do or excuse me, NEI, is to put in a program app. requirement for a periodic assessment of this program, its implementation, not just an individual LCO extension which is very clearly addressed and has limits and tech spec enforcement, but look at once you've put this in place, how has it affected the way you actually operate your plant and your risk profile. So hopefully this isn't too simplistic because I've tried numerous ways to present this and this seemed to be the best way. I apologize for the readability, but basically if this is time --

DR. APOSTOLAKIS: No. You can't do that.

MR. HOWE: I can't stand up. Okay.

DR. APOSTOLAKIS: Unless we wire you. Can you wire him?

MR. HOWE: Wait a minute. Don't do that. I have a pointer right here. This is core damage frequency on the Y axis with time going on the X axis. So a plant is operating with nothing out of service. It still accumulates a baseline of risk, the zero maintenance risk we talked about.

DR. APOSTOLAKIS: Right.

MR. HOWE: And over about a one year period, the area in the curve represented in red would be the core damage frequency that year. So even if they did no maintenance, they would accumulate this amount of this core damage risk that year and if they did that year after year the same, that would be their average core damage frequency zero maintenance.

Of course, we know in reality plants do maintenance and they have some average CDF which again --

VICE CHAIR WALLIS: When we see a CDF quoted for a plant, it includes this increase.

MR. HOWE: It includes the contribution for maintenance and it's smeared out over the years, the average CDF. We know in reality --

VICE CHAIR WALLIS: It zigzags around.

MR. HOWE: -- typically they're at zero. They take things out. It goes up. They bounce around. But theoretically, the area of each of these green rectangles which is accumulating an amount of risk would average out to the average annual CDF.

VICE CHAIR WALLIS: But if it's more than that --

MR. HOWE: It could be more than that. If they do a little bit more maintenance that year, then their CDF would trend up. If they start doing less maintenance or better maintenance, it will swing down. So what are we asking for or what is going to happen to a plant in RMTS phase when they implement extension of the LCO? So now these LCOs may be extended as permitted by tech specs.

VICE CHAIR WALLIS: So you're increasing the risk.

MR. HOWE: Possibly.

VICE CHAIR WALLIS: You're increasing --

MR. HOWE: That's what we want to see to make sure we have programmatic controls in place to cover this. So what happens is a plant may extend the risk of one or more of these LCOs and as a result, the amount of green that you have here which is affecting your change above the zero maintenance may increase with time. So basically what we're asking them to do is to look at their programmatic use of RMTS, basically to look for these, times when they extend the LCOs and how much risk did they accumulate which they would otherwise not be permitted to accumulate and to assess what that change is every two years on an average per year basis.

VICE CHAIR WALLIS: So you're not enhancing safety, are you?

MR. HOWE: If the only thing that happened when a plant implementing RMTS was to do this, plant risk would go up on average.

VICE CHAIR WALLIS: Right.

MR. HOWE: What we've been told is and we believe is that that's not going to be the only impact. What might happen is you may extend this LCO and do extra maintenance.

VICE CHAIR WALLIS: That helps you to avoid having --

MR. HOWE: And then maybe you don't have to do this outage over here.

VICE CHAIR WALLIS: Good. Yes. There has to be a payoff.

MR. HOWE: Or maybe you have two or three planned maintenance outages on the diesel generator here and now you're combining the one and you don't have the time taking out and restoring three times. You do it once.

VICE CHAIR WALLIS: Is there a reward for that?

DR. APOSTOLAKIS: -- increasing risk with that.

VICE CHAIR WALLIS: There should be a reward for that.

MR. HOWE: Maybe we'll get into the regulations here. But fundamentally, the licensees need to assess these increases in risk if they exist and compare them to the Reg. Guide 1.174 limits and assure that they're below the 10^{-5}. If they find that they are not, they are increasing risk, they need to address that through the corrective action programs.

DR. APOSTOLAKIS: Do we ever given any rewards to the licensees?

MR. HOWE: Mark, you know the history. Have we ever given rewards to licensees?

MR. RUBIN: Have we ever given rewards?

MR. HOWE: For good performance.

MR. RUBIN: Oh, yeah. We don't cite them for violations.

(Off the record comments.)

DR. APOSTOLAKIS: Okay. Maybe STP is next. That was very good.

(Off the record comments.)

DR. MAYNARD: While they're coming up here, on the last topic we discussed, you do have to be careful in what's done with these results because the fact that you've used it it may have been an increase in risk. It may have actually been a reduction in risk. So I think you have to do some qualitative looking at the -- stuff because you're not seeing a total change in risk associated with that. I think it's a good exercise, something to do, but you need to be a little careful in how the results are handled there.

DR. APOSTOLAKIS: Okay. So we have our usual visitors from South Texas, fairly new to the PRA business. Please.

MR. HEAD: Okay. We'll start. My name is Scott Head. I'm the Manager of Licensing at the South Texas project and with me is Rick Grantom, the Manager of the Risk Analysis Group of South Texas Project. For the subcommittee, you gentlemen are normally used to seeing Jay Phelps, one of our operations managers, who is here. He's on night shift right now helping run our outage. I would note also that Rick Grantom is on night shift right now and is here basically off the night shift.

I'm mentioning that because some of the answers I'm going to give if we're asked those questions are -- Jay Phelps as an operations manager would give you a very emphatic answer. I'm going to try to replicate those because there is an operation's perspective to the answers of some of the questions that have been asked.

This is pretty much an implementation overview of what we're about to do at South Texas if the license amendment is approved and we're get through very quickly and answer any questions that you all have. So the overview, we are the pilot for the risk-informed tech specs using the configuration mismanagement process. It's a (a)(4) approach and we will apply like was mentioned before. We state that we will implement the guidance of 0609 NEI and that's embedded in technical specifications.

As a part of this process, we were also one of the pilots for the Reg. Guide 1.200 assessment process. Very important for an operation's perspective as Jay would say is we keep the current tech specs the way they are. We don't make exotic changes to the technical specifications. This is an option that we can use periodically if we need to, but the frontstops and the way the tech specs look for the operators right now are the same.

We've added some additional actions to take, but the tech spec fundamentally looks the same and we mention in the next bullet here that it allows us the option to use this if we need to and it imposes a backstop time limit to return applicable equipment to services. I'm going to stop right here and give you the licensee's perspective on the 30 days because we got real close to it in the previous discussion.

VICE CHAIR WALLIS: Can I ask you something?

MR. HEAD: Sure.

VICE CHAIR WALLIS: If you really followed this through and you allowed the operators to use risk management options for everything, maybe you don't need the tech specs in quite the form they are now. Maybe you can relax the tech specs themselves if you're from day to day looking at your risk management.

MR. HEAD: That's a possibility.

DR. APOSTOLAKIS: You need to eliminate a frontstop?

VICE CHAIR WALLIS: Maybe you can cut back on the tech specs.

MR. HEAD: Take it out of the tech specs. That's a possibility and we think those thoughts. This was the initiative we elected to go after first.

VICE CHAIR WALLIS: Get some things out of the tech specs, right?

MR. GRANTOM: I think them more than Scott does. But yes.

VICE CHAIR WALLIS: You're thinking of doing or --

MR. HEAD: We are but that would be something that's further down the line.

VICE CHAIR WALLIS: But it's a possibility.

MR. HEAD: It's a possibility -- Containment spray is one that often gets some interest in that area, but that's not what we'll be doing with this one.

With respect to the backstop, my perspective on the backstop is, and operations would say also, that having something out of service for 30 days would just be unacceptable. There are some regulatory requirements between MSPI and the oversight process and even if you could say this new safety culture initiative. If utility embarked upon that sort of process, I think they would run into a number of regulatory impacts that would make it an unacceptable place to be.

From a licensing manager's perspective what 30 days allows me which we have in fact done at South Texas, if you're near maintenance and you're working on a pump and you find out that the shaft is destroyed and the shaft is 60 days away from being built for your site, that 30 days allows me to go get an emergency tech spec change from the NRC to allow us to operate that 60 days. So it's a regulatory window that we can re-engage the NRC if we need some other sort of relief via the tech spec route as opposed to even the notice of enforcement discretion route.

Like I say, we've done that before at South Texas with one of our diesels where we had a significant moment with it. So the 30 days I would say from my perspective is more of something we would exercise if there was some significant damage to a component.

The next slide, this is the scope of the stuff that we currently have in our tech specs with the tech spec amendment that we have in the NRC for review. You can see it's very encompassing. It's a number of different components, a number of different systems, and I'd say we have visions, something along what you were talking about before, to include other stuff in here in the future once they're in the mode, once they're firmly entrenched in the model. Then we might go back and submit another tech spec change to include more components in there. But right now, this is the scope of what's in the model and within the amendment we have with the NRC.

To the question that was asked earlier, the next slide, one of the reasons we're doing this is that we have been doing it for many, many years. This is how we've tracked risk at South Texas project for many, many years and it's our (a)(4) assessment that we do in the work week and the slide, the graphs, look a whole like what we're doing in tech spec space.

But to the question of do people go back and look and see how they did, here, this was one of our work weeks. The straight line is what we had planned to work which includes some aux feedwater work and a power operator relief valve work. The dotted line ends up is what actually happened that week. The week after this week takes place. The word group gets together and says what happened. Why did this happen? What do we need to do? How would we do that week differently next time? Quite often at South Texas, the line in fact is below what we had originally planned and that's obviously good. But if we have situations like this, we go back and look at it and assess that week in terms of work processes or other things, planning or otherwise. With respect to the year, I'll let Rick talk about what we do with respect to monitoring the risk over the year.

MR. GRANTOM: This is kept. We keep a record of all these and you can see on the actual times over here these are based on down to a minute of when operations returns something to service at that point in time. So what we do is we collect these over 52 weeks and we contiguously place these together and we have what's called a rolling 52 week average. So six months into the year it looks back at the previous 52 weeks and determines what the weekly average was and you see this and I could have actually shown this plot right here, the rolling 52 week average, and you can see where the average core damage frequency as Andy had shown on the previous graph and you can see where the actual configuration risk is occurring for both units.

DR. BONACA: On a weekly basis you can see what components caused the curve to --

MR. GRANTOM: There is an incredible

amount of ticking and tacking and accounting that can be done. You can see what maintenance state you were in the most. What were the maintenance states that contributed to most of the risk? What was the down time? All of this stuff feeds to the Maintenance Rule at STP also.

DR. BONACA: This is valuable information for the operators if you could show them what happened there. So I'm sure that you communicate somehow the important components of that and availability to them, right?

MR. GRANTOM: I can give you an important point in history right now. When we had first started doing -- I would say we have done this right at a decade right now we've been performing this. When we first started doing planned and actual risk everybody had the good plan. But when we started showing the actual risk and what was really occurring, we used to come to the threshold which is 1E-6. We would come to border that quite often. It got people a lot nervous. They started looking at it and we started looking at it and our scheduling is done along the lines of what we call functional equipment groups.

So we started looking at the functional equipment groups with this and it turns out that they were taking things out in series. They would take essential cooling water out which makes the diesel generator inoperable. Later in the week, they took the diesel generator out which makes the diesel generator inoperable. So they were taking these double hits on risk. But once they could see it, then they worked the functional equipment groups where they started essential cooling water diesels on the same day and work those. The risk just came down. Now that was not the risk group doing that. That was work window coordinators being able to do exactly what you said, seeing the impact and realizing there was a way that they could risk manage this.

DR. BONACA: The reason I was asking was because it's true that he makes the decision. But you make it visible to him. For example, you show me this curve here, it's an -- curve. There is a limitation to the amount of information it gives me. If you have it on a daily basis of what components you have out, I'm sure you have that kind of information and provide that.

MR. HEAD: And this is a plant tool now. This is not just the risk group. The plant generates this. The plant looks at it. Operations reviews it real time before we've embarked upon that work week and after. So Operations is involved with all of this.

MR. GRANTOM: It's important to note that the risk management group, the PRA group, of South Texas is not making these plots. Operations and Work Control are making these plots and you're correct. This opens up a whole new field of evaluation to be able to look at what the impact of removing equipment from service, what the impact of making decisions on configurations. It's an incredible -- The opportunity for management to build risk management actions for certain specific conditions, we've opened this up before which in previous tech specs you had no clue what configuration you were in to even apply these kinds of risk management treatments. So it's a really dynamic process that seems to work good.

MR. HEAD: That was an attempt to answer your question and it's also to give you the perspective that we've been doing what we're talking about in many ways for a long period of time. Although at the same time this was happening, obviously tech specs was there also and so --

MR. GRANTOM: See this right here is something that they do as part of the actual risk too that Scott alluded to a minute ago. The ability now to go take a look at this and see where we were relative to the plan and if it gets too far off they'll write condition reports to try to determine what happened in there.

MR. HEAD: Okay. And the other slide, the other graph over here, is what we do with the trip risk and it's just our way of assessing the secondary side of the plant to see if we take a feedwater pump out or something what sort of trip risk we've accumulated.

The next slide is with respect to the culture at STP and we have robust PRA obviously that meets the technical adequacy requirements as one of the reasons that we believe in the pilot. We have processes and procedures and I've showed you an example of that that effectively communicate the risk thresholds and identify the main actions to take when thresholds are reached. We have trained operators. We've talked about we've doing this for a decade. What we're about to do with this new tech spec is not that big a change from the operation's perspective. You'll see the new program that we're going to use. But using the risk insights, taking risk management actions, is something that we've done a lot of at South Texas Project and we have a management team that has supported this process, that understands the process and using this as a decision-making tool.

If and when this is approved for South Texas, we expect to implement it in a timely manner. In essence, all of the procedures that we need to implement this are built. There are some last adjustments that we're going to make based on the safety evaluation report. There are some recommendations in there for some risk management actions and we're making sure those will be in the procedures that we have.

Starting last summer, we've been training on risk management tech specs for three years at least with the senior reactor operators during requal. Starting last summer, we got into -- Okay. This is going to happen. You need to really understand the process, what's going to happen, the computers, how the process will work. So we've been training almost since last summer. We believe the operators are ready for this.

As I mentioned, the procedures are in essence approved, ready to go, or not approved, but they are ready to go. We have already had the pilot class to introduce this to management. Rick and I taught a four hour pilot class that introduced this to the management level above Operations, but including Maintenance and Work Control. Supervisors all the way up to Joe Sheppard, our Chief Nuclear Officer, will have this training because we recognize that this is a significant cultural moment for a station to adopt something like this with respect to tech spec. So it's not just a licensed operator kind of thing. Everyone needs to understand it. Everyone needs to understand the basis for it. Everyone needs to understand the limitations of the PRA and the importance of risk management actions and like I say, there's a wide body of people that do but all the way up to the top. People in the decision making chain need to understand that.

We've had a couple of meetings with the region and a number of discussions with the residents to make sure that they understand what this is going to look like, what actions we'll take on the station. I've had some interesting discussions with a senior resident along the -- I guess, the topic that we alluded to earlier about abuse. What could a station do with this that would be inappropriate or not what was expected by the regulator when it was approved and like I said, we agreed that between the oversight process, the safety culture initiative, MSPI, that there are a number of ways for the regulator to take action if a station were to be perceived as abusing this change. So we've had those discussions with the residents.

And I think what's very interesting about this particular tech spec change is to invoke it the senior resident will immediately know or he'll know the next day when he comes to the morning meeting or he'll know when he goes to the control room. It will be in the log and at that point in time he can engage into whatever level he wants to. So it's something that the NRC will have real time involvement. From that perspective, it's clearly transparent as something we can obviously engage on real time.

DR. BONACA: I wouldn't worry so much in intentional abuse because it's just simply that as you proliferate the use of Reg. Guide 1.174 to get relaxation through tech specs, through online maintenance, through so many different means and applications, you have to be concerned about the fact that each one of them even in a small way provides or has an increasing risk and therefore you may not see the interference for that -- if that's --

MR. HEAD: And I think speaking of that the assessment that we're going to be required to do every two years that's embedded within the guidance, that's an important thing. Right now, there's no official way to share that with the NRC. We will certainly share it with the senior resident, if nothing else, because they'll want to look at it from a corrective action standpoint. Here was a couple of interesting things that have happened. Have you taken the appropriate corrective actions with respect to those incidents that occurred? So it's something that we will share with the regulator. We will expect the region to review it as we go forward and implement this.

Crucial to how we're going to be doing work we've alluded to it before, the precalculated set of calculations, is that we're going to have what we call a RICT calculator and this is based on STP's existing configuration risk management tool, the thing that you saw earlier that generated the curves for years. We've taken that tool now and put it more or less in a tech spec environment. It meets the guidelines. It's based on greater than 20,000 configurations or maintenance states that have been already pre-quantified and it will be using CDF and LERF as its pre-quantified limits.

It's user interface. It's a friendly

environment or at least it has been the users and the senior reactor operators have been involved in building this so that it solves and answers their questions and puts it in a format that they can use and we'll show it to you in a second. To be used by Operations real time is if something becomes inoperable that's outside of the planned work week but maintenance will be using it to plan the work week.

It's our vision that we don't challenge the South Texas 10^{-6} very often and we would not expect that the change would with risk-informed tech specs because one of the things that we do in almost all nuclear plants is the work week is how you do your work and to schedule something past the work week more or less, it really impacts the rest of the work schedule. So the maintenance people or the maintenance planners are important to understand what's going to happen that work week and if we're going to be using risk managed tech specs as part of that work week, there will be opportunities for management and others to get involved and go, is that the work week we want to plan and if it is, then we'll go forth and do what's required. It comes with risk-managed tech specs.

Periodically, what happens is they'll

encounter a configuration that does not exist within the database and when that happens, it could happen two ways. One is we're planning a configuration for a work week that does not exist and before that work week happens, the risk management, the risk individuals, get involved, calculate that work week or calculate that configuration and that's now available to the risk planners or the maintenance planners.

What could happen also though is that a non-calculated configuration could exist during the work week? What will happen now if it involves tech specs equipment is that we will have to go back and recalculate that and within the guidelines, there's a requirement that that happens within 12 hours. We're set up at South Texas, we believe, to be able to do that quite easily within 12 hours to make sure that we understand the consequences of that configuration had it not been precalculated. Anything to add to that, Rick?

MR. GRANTOM: Yes, just a couple of quick things. Scott is right. The work planners, the maintenance planners, take a look and they'll have a risk profile planned for the week. That has to go up through management and gets approved by the plant manager at T-2 is what we call it, two weeks prior to the work week and this gives you an opportunity to find out where the risk significant window is during that work and they have the opportunity now to start doing other risk management compensatory measures. It may be as simple as some pre-job briefs or some other areas. But it gives you the opportunity to go and post that ahead of time. It's an important facet of that.

The other part of that is the database of the 20,000 maintenance states, just an interesting datapoint that we know of is that only about 500 maintenance states have actually occurred in either unit. Most of these maintenance states occurred as Scott said due to planning. They think they're going to do something and then all of a sudden we calculate a whole bunch of maintenance states and we'll add a bunch of maintenance states to go calculate. Just things will overlap and flip and they won't quite come out the way they exactly planned to do that. But it is an interesting kind of thing when we see that you have 500 maintenance states that have actually occurred over the 20,000 that you have. I like to think of it somewhat as margin in that regard.

MR. HEAD: Okay. And just real quick, this is the tool that we developed. What you see here is this is where the operators would go in and based on the declaration time when their equipment was rendered inoperable, they would enter the time that it was inoperable. This is safety injection train A common. This is taking out the whole safety injection train A. Here is when they took out a central cooling water. Here's when they took out chilled water and here's when the diesel went out. Now, in fact, the diesel became inoperable when the DW went out.

So let's go to the next slide. This is -- So once they've entered that, here's what they'll be looking at and I'll ask you to look at the work week. That's the first four items on here because they're all train A. And this example what happened is during the rounds, these hypothetical rounds, we discovered something wrong with diesel generator C. Right now at South Texas, this would be as 303 and if whatever we found would render it inoperable, that would be a 303 situation.

What we would do now is we would enter that configuration's time in and we would now calculate the new risk completion time. What we would find is that within an hour and 12 minutes we're going to cross E^{-6} and so we basically need to immediately start implementing risk management actions because now we're going to be crossing this threshold and we now have 174 hours to get us out of this configuration before we cross E^{-5}.

There are many ways to do that. We can get out of this train work week quickly or we can get out of whatever is causing the diesel generator C to become inoperable. But this would be now his tech spec moment and this configuration is I have this diesel generator C is now inoperable. I have to start taking risk management actions because of this number which is very, very short. And here is my new risk-informed completion time in this configuration if we were to stay in that configuration for that whole time.

As stuff started becoming -- If we got safety injection or background information in that case, if the chiller became operable, if you got it operable, then the curve that you saw before would decrease. The slope would decrease. Once EW became operable, the slope would decrease again and then all that would be left at that point in time is the diesel and the clock is starting back though from when we first took safety injection out of service.

MR. GRANTOM: A couple of things to maybe just -- You have to keep in mind. This is an operator in the control room entering these components and entering these times in or out of service. The other point over here too to look at is when they calculate the risk-informed completion time you can see that it will calculate the 30-day backstop and it also has the risk-informed backstop that will pick the most limiting item out of that configuration. So this would be the tool they would use to be able to apply a risk-informed completion time. This would be documented. This would be available to be retrieved by the regulator, whatever, for evaluating these conditions.

And then as Scott indicated, there are several different ways that one could get out this. I mean, this diesel generator may be really broken, functionally broken, or it could have just a small problem possibly with something, some calculation or some other item that makes it indeterminate in the definition of what operability is.

So this tool works well. This was designed by both planners and by the operating crews. This screen is made because that's the way they wanted the screen to look.

DR. MAYNARD: But if you end up in a configuration that had not been pre-analyzed.

MR. GRANTOM: Right here.

MR. HEAD: If that happens, then you get warned in the previous screen. You would have seen it. In another one, you would have seen an email is immediately sent to risk management. In this configuration if that were to happen, then they would be called.

DR. APOSTOLAKIS: That's why they're on night shift now.

MR. HEAD: That's why we're on night shift.

MR. GRANTOM: No. Really, in fact, he managing the circ water structure on night shift right now. But we have people available 24 hours. They're on call to do something like this and fortunately, this sort of activity all happened during the work week because we only do this sort of work during an actually Monday through --

It's a typical process. The way it works is there's a duty-risk engineer always on call. They'll get the page. They know their own duty. They have the capability even at their own homes to be able to calculate that. We've made that tool available to them and we can usually turn these things around literally within an hour or two hours and then what happens is we upload the new information, the new maintenance state, to the database and then the database is read over the station's LAN and then it's available to the operators then at that point in time and we've contacted them. That's pretty simply how it works.

DR. ABDEL-KHALIK: Now the 4.62 X 10^{-4} number, that's the instantaneous value of the risk?

MR. HEAD: Yes. For that state.

DR. ABDEL-KHALIK: So that's how you keep track of the 1 X 10^{-3}.

MR. HEAD: Right. And what we expect to do there is that screen is going to turn red if it goes over E^{-3} is what we think the operators are going to want. We don't have a annunciator for it. We're just going to have that one turn red if it goes past and the procedures all will be for what you do, how you react to that.

VICE CHAIR WALLIS: Shouldn't one of those column be ILERF instead of --

MR. HEAD: Right here, LERF.

VICE CHAIR WALLIS: No, over there. The two LERF columns.

MR. HEAD: Yeah.

VICE CHAIR WALLIS: One is ILERF, isn't

it?

MR. HEAD: This is still going through some beta testing right now. We just recently changed these. Yes, that should have been an "I" in there.

DR. APOSTOLAKIS: Can we wrap up now?

MR. HEAD: Conclusions are we're poised to implement the tech spec --

DR. BONACA: You do have a QA problem, right?

MR. HEAD: Yes sir.

DR. BONACA: You, for example, have an independent review of the calculation being done by --

MR. GRANTOM: Yes, the process for uploading the maintenance states is we go -- What we do is we do it through a sampling. We made the maintenance state changes and we do a review and a verification of those and then we can sample the other ones and see if we're getting expected changes the way we expected to. Obviously with 20,000 we can't check every one of them. But they are all archived. All the calculations are archived there and all of the software that you've seen obviously goes through a software quality assurance program for the software itself.

MR. HEAD: Which is stipulated in the

guidance document on how you do that.

Like I said, I summarized what I've said before. The model is ready. The procedures were reviewed. Operations is trained. Station management is very much aware of this and will be trained before we implement it and we do believe it is a significant industry milestone we --

VICE CHAIR WALLIS: The second bullet here. When it's all over, are you going to demonstrate having done this over the two years on what you're doing that you have actually gotten a significant improvement in safety?

MR. HEAD: What we're going to do is continue to monitor the 52 week average.

VICE CHAIR WALLIS: You will. So you intend to demonstrate that there is a significant improvement in safety.

MR. GRANTOM: I would tell you that, yes, we are going to demonstrate that there is an improvement in safety because there's an improvement in measuring safety.

VICE CHAIR WALLIS: Otherwise, it's an empty statement. This is a pilot plant. You're running an experiment. You're going to show it as an improvement in safety.

MR. RUBIN: I'd like to put it this way. Apparently right now, you don't know where you are.

VICE CHAIR WALLIS: So why are you making this statement?

MR. MONTGOMERY: Say. Excuse me. I mean, you've been operating with this in parallel with tech specs for ten years.

MR. GRANTOM: Right.

MR. MONTGOMERY: You can go back and show that after Year 2 and Year 3 after having implemented that you have realized an improvement in safety.

MR. GRANTOM: If you were to take a look at our relative 52 week average versus what our average CDF and we'll have to make the assumption that the average CDF calculation is truly an average, what we find is that the average of the configurations that we've been in since we've been able to measure this and see it has always been lower than the average CDF.

MR. RUBIN: However, let me add from the staff's perspective that the staff criteria for this program is not a reduction in risk. It's not a necessary criteria. It's an expectation.

VICE CHAIR WALLIS: What's it for?

DR. BONACA: I would like to add that just one avoided shutdown, it's a big reduction in risk.

MR. RUBIN: It's a smarter way of operating the plant, smarter way of controlling --

DR. BONACA: The current tech specs may force you to shut down, but this will allow you not to have.

MR. HEAD: I don't know that we'll demonstrate it, if I could, quantitatively because we don't know what shutdowns we would have had or missed if we had this. But it is such a much better way of running the plant in avoiding those shutdowns that we believe that is an improvement --

VICE CHAIR WALLIS: I like the idea. I think it's a great idea. But I think if you're going to do the pilot, you're going to have some measure of success when you run the pilot compared with what you would have done if you hadn't run the pilot and it should really be presumably improving safety, one of the measures, or cost or something.

DR. KRESS: Plant economics and not affecting and not reducing.

DR. MAYNARD: But there are other benefits and a lot of it is to the NRC staff too. Because a typical process now is if you find yourself in a situation, something happens in the middle and you're not going to be able to get it done, typically you will go for enforcement discretion which means you're on the phone at night making a call and putting together a lot of information and the staff having to take that information and decide whether they believe that it is safe enough to go ahead and extend that. This goes ahead and puts it in more of a pre-approved decision making process on when it's appropriate to extend an LCO versus when it's not. So it has benefits to the staff and to the decision making process on when it is safe or not safe.

DR. ABDEL-KHALIK: Do you have enough historical data that would allow you to quantify the running average of the risk under the current tech specs prior to implementation of this like for the five years prior to starting and then you can see how the running average changed over time?

MR. GRANTOM: Yes, we do. It's based on Maintenance Rule though which is based on functionality. But, yes, you can definitely see that once we've been able to start to manage it, there's been a reduction in that. Plus the other factor of this, one of the other safety benefits and I haven't really heard anybody say this yet, in each of these quantifications, there's non tech spec equipment and even some non safety-related equipment that's being calculated in the risk-informed completion time time frame here. That's currently not done at all under tech specs for that and just that by itself to me in my way of thinking is a safety improvement.

MR. BRADLEY: There's another safety improvement we haven't discussed and that is that this program provides an incentive to have a better, higher quality, greater scope PRA model that you will not only be using for this, but you'll be using for all your other risk-informed decisions including (a)(4) and that is a definite benefit to this effort.

MR. HEAD: That's the way I was going to answer. Biff, I'm glad you did. This is a global statement. It's for the industry is the way this was oriented.

MR. TJADER: As far as the pilot question goes though, you are a pilot plant and the staff will go out in a year, probably not even two years. We'll go out sooner and observe and actually we'll be observing on a continuous basis through the resident inspectors how it's being implemented.

VICE CHAIR WALLIS: It would help a great deal if you had measures of improvement because there's a significant fraction of the public out there that believes that risk-informing is simply going easier on industry and there is no benefit to the public. If you could show that there is a real safety benefit from using this risk-informed regulation, I think you would do a tremendous amount of good.

MR. RUBIN: I think in actuality there's a potential here for the type of improvement you're talking about. But from the staff's perspective, the criteria guidelines we're using is no more than a small increase in risk that's fully in line with Reg. Guide 174, the Commission's guidance --

VICE CHAIR WALLIS: But that's an increase.

MR. RUBIN: -- and the ACRS guidance.

VICE CHAIR WALLIS: That's an increase in risk.

(Off the record comments.)

MR. RUBIN: At the worst, no more than a small increase in risk. The reality is you'll be operating the plant in a much smarter way and the potential for reducing risk is very apparent and very doable because the analytical methods are going to be applied here.

MR. MONTGOMERY: The point I wanted to make previously is that early on, and in fact you just alluded to it, Rick, is where you said that when we started implementing this we realized that we were doing things in series and that we have higher accumulated risk before we implemented this in parallel. We now have significantly reduced through the application of this program through actually doing it though not being required to do it in parallel with tech specs. Basically, they've had the existing completion times, operating with those, and in conjunction operating with a risk-informed completion time and observing the appropriate, voluntarily observing, the implications of that on their own. They have already realized a reduction of risk. Is that correct, Rick?

MR. GRANTOM: Yes, the point I was trying to get to is the fact that currently you don't know where you are.

(Laughter.)

CHAIRMAN SHACK: We're going to call it quits.

DR. APOSTOLAKIS: The best statement was by -- Improving the quality of PRA by itself improves safety.

CHAIRMAN SHACK: It's an end in itself. Right, George?

DR. APOSTOLAKIS: And that's the end.

VICE CHAIR WALLIS: An end in itself.

DR. APOSTOLAKIS: Thank you very much. It was really very helpful.

CHAIRMAN SHACK: Time for a break, a 20 minute break. Off the record.

(Whereupon, at 4:04 p.m., the above-entitled matter recessed.)